PRESERVATION OF FRUITS AND VEGETABLES

BY

GIRDHARI LAL, Ph.D. (Lond.), D.I.C. (Lond.)
Assistant Director, Division of Fruit Technology
Central Food Technological Research Institute, Mysore

G. S. SIDDAPPA, M.A. (Hons.), Madras,
Ph.D. (Bristol), A.R.I.C. (Lond.)
Senior Scientific Officer, Division of Fruit Technology
Central Food Technological Research Institute, Mysore

AND

G. L. TANDON, M.Sc. (Hons.), Punjab
Senior Scientific Officer, Division of Fruit Technology
Central Food Technological Research Institute, Mysore

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A Battery of Vertical Retorts in a Fruit and Vegetable Preservation Factory

FOREWORD

Fruits and vegetables are among the most important foods of mankind as they are not only nutritive but are also indispensable for the maintenance of health. From the point of view of the agriculturist also, they are of great importance as he is assured of high returns from their cultivation even on a small area. The total estimated production of fruits in India is about 129 million maunds, but as a substantial quantity is wasted, only about one ounce per individual per day is the net availability. This contrasts markedly with the consumption in other advanced countries which ranges between 4 to 16 ounces per day. Development of horticulture will be uneconomical in a country with poor communications and marketing facilities, unless the fruit and vegetable preservation industry keeps pace with the developmental work. Its progress in India has been rather slow, mainly because of lack of adequate scientific knowledge about the various processes of food preservation. It is, therefore, very necessary that this knowledge should be disseminated on a country-wide scale.

It is only a hundred years since Pasteur's discovery of the microbes which cause spoilage of food revolutionised the canning industry in the West. But during this short period the industry has been developed to such a degree of perfection that fruits, vegetables and other foods produced by any country in any season are available all over the world at all times. Over 350 different kinds of canned foods are found in the market, and the total annual pack of the major producing countries of the world is estimated at more than 15,000 million pounds. The production of canned fruits and vegetable products in the U.S.A. alone is over 7 million tons.

The canning industry in India has yet to exploit its full potentialities. A number of entrepreneurs have no doubt established modern plants for the manufacture of various food products, but considering the great scope which exists for the development of the industry, the pace of progress is not as fast as it should be. The Central Food Technological Research Institute, Mysore, is striving hard to find solution for the problems which stand in the way of development of the industry.

The book *Preservation of Fruits and Vegetables* is the outcome of long experimentation and study in which three of the senior officers of the Central Technological Research Institute have been engaged. I congratulate them and the Indian Council of Agricultural Research for bringing out this valuable book. It embodies the results of the research conducted on various aspects of the preservation of fruits and vegetables, and aims at providing practical guidance both to the cottage worker and the large-scale producer. The book will also be of great use to the Extension Workers and teachers as well as students in Home Science Colleges in popularising scientific methods of preparing fruit juices, squashes, cordials, jams, jellies, marmalades, pickles, etc., and of preserving seasonal vegetables. I am sure it will serve a long-felt need for a comprehensive treatment of the subject and will promote the interests of the horticulturists in the country.

S. K. Patil
Minister for Food and Agriculture
Government of India

New Delhi
October 20, 1959

PREFACE

Preservation of food in one form or the other has been practised in all parts of the world since time immemorial, though scientific methods for it came to be developed only about a hundred years back. However, as in the case of many other industries, technological progress in food preservation gained momentum mainly after the outbreak of the first World War when supply of large quantities of vegetables, fruits, meat, etc. had to be arranged for the armed forces. World War II provided another strong impetus to the growth of the industry. The wide assortment of the canned products available in the market and their easy portability have created a fast increasing demand for preserved foods. In many advanced countries today even the poorer sections of the population have become used to consuming canned or bottled fruits and vegetables as these are available all the year round, and are often cheaper than even the fresh commodities. Thus, an industry which had its beginning in the scarcity conditions of war, is now considered to be of perennial importance. It also assures a stable market to farmers and horticulturists, and enables them to expand their production without fear of a fall in demand.

Fruit and vegetable preservation industry is still in its infancy in this country. The total annual production of all kinds of preserved fruits and vegetables does not amount to more than Rs. 2 crores in value, and most of the products are too expensive for a majority of the people. Again, the preserved products consist mainly of jams and pickles which continue to be produced by traditional methods. Till only about 20 years ago, other well-known methods of preservation, such as making of juices, squashes, cordials, jellies, marmalades, etc., were confined only to a few larger industries. In the early thirties, the Indian Council of Agricultural Research financed a number of schemes under which a band of workers started pioneering work for the popularisation of these methods. It is a matter of great satisfaction that rapid progress has been made since then, and the production of fruit preserves of all types is now carried on even on cottage scale.

One of the main difficulties in the way of the growth of the fruit and vegetable preservation industry has been the inadequacy of knowledge of the modern methods and techniques of preservation. To overcome this difficulty, the Central Food Technological Research Institute, Mysore, has been undertaking intensive studies and research on various aspects of preservation methods. Research workers in other parts of the country have also been devoting attention to these problems. But most of the available knowledge is scattered in scientific papers, departmental reports and other highly technical publications. This information has to be disseminated on a country-wide scale so that full advantage of it can be taken by all those interested in the industry. To meet this need, the Indian Council of Agricultural Research has brought out *Preservation of Fruits and Vegetables* which is a comprehensive book on the subject. The authors, Dr. Girdhari Lal, Dr. G. S. Siddappa and Shri G. L. Tandon, who are senior officers of the Central Food Technological Research Institute, and are known for their experience and knowledge, have made the book highly useful by treating the subject in all its essential aspects in a simple and interesting style. I congratulate them for this, and hope that the book would meet the needs of Extension Workers, Home Science Colleges, manufacturers of preserved fruits and vegetables, and others interested in this subject.

M. S. RANDHAWA, D.Sc., F.N.I., I.C.S.
VICE-PRESIDENT
INDIAN COUNCIL OF AGRICULTURAL RESEARCH

New Delhi
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GIRDHARI LAL
G. S. SIDDAPPA
G. L. TANDON

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CHAPTER 1

CANNING AND BOTTLING FRUITS AND VEGETABLES

It is a common experience that fruits, vegetables, meats, and many other articles of food spoil rapidly unless specially cared for. Various methods for preserving these, such as pickling in salt or vinegar, drying, smoking, preserving in sugar or honey, etc., have been developed since time immemorial. But canning is comparatively a modern technique. It developed under the stress of war conditions towards the close of the 18th century. During the Napoleonic wars, the French Government announced a prize of 12,000 francs for the discovery of a satisfactory method of preservation so that food could be transported to the fighting forces over long distances without spoiling. In 1810, Nicholas Appert, a Paris confectioner and distiller, invented a process for preserving foods in glass containers, took out a patent for his process, and won the prize. He also published a book entitled *The Art of Preserving Animal and Vegetable Substances for Many Years* which is the first known work on modern canning. In honour of its discoverer, canning is still known as 'Appertizing'.

Appert packed his food in glass containers, added sufficient water to cover the food, placed the corks loosely on top and heated the containers in a water-bath to obtain a temperature of 190°—212°F. at the centre of the containers. The containers were finally sealed air-tight by driving in the corks. By this method, he succeeded in preserving several kinds of foods. He ascribed this preserving action to the exclusion of outside air. Gay-Lussac, who studied Appert's process at the instance of the French Government, concluded that spoilage in foods was essentially a process of oxidation which could be prevented by the exclusion of air from the container. This hypothesis was universally accepted till the time of Louis Pasteur who provided correct explanation of the change through his discovery of microbes round about 1860. By his experiments on heat treatment, he proved that micro-organisms are the real cause of spoilage, and that by destroying these, foods can be preserved in suitable containers. He introduced the word 'Pasteurization', which means heat-treatment of a food at a sufficiently high temperature to kill the majority, though not all, of the micro-organisms thereby prolonging the normal keeping quality of that food. What Appert did was to destroy, by heating, micro-organisms such as bacteria, moulds and yeasts present in food, water and air, which were responsible for fermentation and decay, by preventing their access to the food inside the container by sealing it hermetically.

In England, Thomas Saddington, who had picked up the general principles of the method of Appert while travelling in France, was the first to describe the method of canning of foods in 1807. According to Bitting, Peter Durand, another Englishman, obtained in 1810 the first British patent on canning of foods in tin containers.

Canning of fruits on a commercial scale was introduced in the United States of America in 1817 by William Underwood, the founder of the present William Underwood Company of Boston, Mass, who had learnt the technique in London. The Civil War in America, and later the Boer War and the Great European War of 1914, with their enormous requirements of preserved foods gave a great impetus to the canning industry. The Second World War provided a further fillip, and the canning industry witnessed unprecedented developments in both technique and scope. At present the variety and range of canned foods are enormous. Over 350 different kinds of canned foods are to be found nowadays; and the total pack of the major producing countries of the world even as far back as 1935 has been estimated at 14,442 million pounds. According to the Canning Trade Almanac 1954, in 1952 in the U.S.A. alone, the total production of canned fruit and vegetable products of all categories was of the order of 7 million tons.

PRINCIPLES OF FOOD PROCESSING

The fundamental principle of preserving foods by heat is known as 'Processing'. It consists basically in the application of heat in varying degrees to the food in closed containers, for a sufficiently long time to sterilize the contents before these are hermetically sealed. The method of processing varies from food to food.

In the early days of canning, the 'open-bath' processing in boiling water was the one commonly used. This was also the method adopted by Appert. By this method, fruits which were naturally acidic and the more acid vegetables like rhubarb and tomato could be satisfactorily preserved as most of the spoilage organisms present in them were easily destroyed at the temperature of boiling water. Non-acid vegetables, however, required processing at higher temperature to be rid of the more resistant organisms present in them. In earlier times, prolonged processing in boiling water for 5-6 hours or heating the canned food for short periods of 3-4 successive days to sterilize the product completely, was adopted in the case of non-acid vegetables. This was, however, cumbersome. In 1861, Isaac Winslow used calcium chloride in the open-bath to raise the temperature as high as 250°F. Calcium chloride, however, discoloured the tin can and made it look unattractive. In 1874, a pressure cooker or retort, in which steam is let into a closed vessel under pressure, was invented by A. L. Shriver, a canner of Baltimore. This was a big step forward in the technique. Several improvements have since been introduced in this highly useful equipment. Pressure cookers are now available in various designs and capacities to suit different requirements.

The original simple 'open-bath' method also has been improved greatly. The continuous-type open cooker is a notable addition. In earlier days, the cooker consisted of a long iron or wooden tank, sometimes as long as 100 feet, containing boiling water through which sealed cans were moved in crates suspended from a moving overhead conveyor. These being bulky and inconvenient, continuous agitating sterilizers were introduced. In these, the sealed cans were conveyed on a continuous belt passing through a closed steam chamber with a device to constantly roll and agitate the cans. Bitting estimates that in these sterilizers the processing time is reduced by as much as 75 per cent. These sterilizers are in common use in many of the modern canneries.

CONTAINERS FOR PACKING

Tin and glass containers have been successfully employed for packing foods. As stated already, Appert made use of glass jars or bottles, while Peter Durand employed metal containers. A great deal of development has since taken place in the manufacture of both types of the containers. Jars and bottles of clear white flint glass that can withstand heating and can give perfectly air-tight seal, are now available in a wide variety of designs and capacities.

The open top or sanitary tin can is made of sheet metal with a thin coating of tin. In early days, cans were made entirely by hand, the body being cut out by shears and the lids with a die, and the components soldered together afterwards. Later on came the 'hole and cap' cans in which a circular hole about half the size of the top was cut and provided with a circular disc that would fit the opening. This disc was soldered after filling the can with the food. In the centre of the lid was a small hole which was closed after preliminary heating of the can to drive out the air. This type of can was in use for a long time for canning fruits, vegetables, meats, etc. It gave way to the modern 'Sanitary Can' in which there is practically no solder except for the slight solder on the side seam, and in which the top and the bottom lids or ends are lined round the rim with paper or rubber gaskets to give an air-tight seal. These cans are closed by means of a special type of sealing machine called a 'Double Seamer'. One great advantage of these sanitary or open-top cans is that they have a large opening which facilitates the packing of all kinds of foods without crushing them. These cans are turned out by the million on automatic assembly-line basis.

Recently, cans made from black steel plate have been successfully employed for packing several processed foods. This development, like several others, had its origin in the Second World War when there was shortage of tin. The black-plate cans are coated on both sides with a special type of lacquer. Much work has been done in England in developing this type. Investigations carried out by the authors of this monograph on similar cans which were made available by the Metal Box Company of India Ltd. (Calcutta), have given very promising results as regards their suitability for canning products like jams, jellies, marmalades and preserves.

In addition to the tin and glass containers, other new types of containers have also been introduced. One of these is the plywood container which has been recently used successfully for packing dairy products like butter, sweetened milk, milk powder and a variety of other products like lemon cheese, minced meat, confectionery, etc. These containers might also be useful for packing jams, jellies and marmalades. Quite recently an Indian patent has been granted to the Director of Scientific and Industrial Research, for containers made from modified shellac-laminated plastic. Although these containers have been found suitable for packing fruit and vegetable products in dried or semi-dried condition, it is too early to predict whether they can replace the tin containers entirely for packing all kinds of products. Aluminium and silver-lined containers have also been used for packing certain kinds of foods. The tin container, however, still continues to be the most important in the field.

In recent years, the Metal Box Company of India Ltd. have developed a new string-opening composite container which is easily opened by sharply pulling a rip-cord fixed to the body of the container. This type of container is said to be ideal for packing only such products as baby and invalid foods, custard powders, confectionery, biscuits, etc.

A novel development in canning is the self-heating can. Several millions of this type were used by the British and American forces especially during Commando raids by invading forces. Although the idea of a self-heating can is not new, its practical application became a reality with the discovery of a suitable non-bulky gasless composition which ignited readily and heated the contents of the can to about 50°C in 4-5 minutes. In a self-heating can, a mixture like calcium silicide plus Fe_2O_3 or Fe_3O_4 which is placed in a central tube fixed to the inside of the can, is ignited through a primer and a fuse by means of a lighted cigarette end or match stick. The heat of reaction warms the contents of the can quickly. At present these cans are highly useful for packing liquid products like thin soups, cocoa, milk shakes, etc., required for use in the field, in air travel and in picnics and other outdoor activities.

CHAPTER II

COMMERCIAL CANNING

Before dealing with the various processes involved in the canning of fruits and vegetables on a commercial scale, it is necessary to consider certain important factors such as investment, site, building, water supply, staff, labour, etc., which are essential for the successful running of a large-scale cannery.

Investment

The capital outlay includes investment on land, factory buildings, and machinery. The running or operational expenses include the cost of raw material, labour, processing, storage, transport, and distribution. As a first step, the entrepreneur should plan carefully the type and size of production which would be most advantageous. He should then decide about the plant and other requirements.

Factory Site

In selecting site for the factory, the following points should be considered carefully:

1. Adequate quantities of the right type of fruits and vegetables should be readily available in the locality, for fruits and vegetables are highly perishable and deteriorate in long distance transport.
2. There should exist proper transport facilities for the movement of raw materials and finished products.
3. The environments should be clean and free from debris, dust, etc., as far as possible. The site should be at a considerable distance from other industrial factories spreading soot, smoke and disagreeable odours which would affect adversely the quality of the canned product. There should also be facilities to dispose of the cannery wastes.
4. There should be scope for future orderly expansion of the factory.

Factory Building

The factory building may be single-storeyed or multi-storeyed. Where the factory is a comparatively small one and works for short periods during the year, a single-storeyed building of light construction will do. In the case of larger plants, that have to run almost throughout the year, multi-storeyed construction is desirable as it would facilitate and cheapen the movement of raw and finished products. Flooring should be firm and of good cement to withstand the constant use of water and the movement of heavy-wheeled trucks. A slope of about one quarter of an inch per foot is necessary for proper drainage. All doors, windows and ventilators should be provided with fine wire-gauze to prevent entrance of flies, wasps and other insects. The roof of the building should be high and well ventilated to provide outlet for vapours and steam. The windows should have large glass panes, and part of the roof should be of ground glass to permit a gentle light inside. There should be provision for efficient artificial lighting also, as the cannery will have to work at night also quite often.

A sufficient number of dressing and toilet rooms should be provided separately for men and women workers in the factory premises. The workers should be taught the importance of personal hygiene. These are important considerations for handling food stuffs for human consumption.

Water Supply and Drainage

There should be abundant supply of potable water. Large quantities of water are required for cleaning fruits and vegetables, making syrup and brine, washing floors and machinery, etc. The water system should work at sufficiently high pressure so that supplies can be had at different points in the cannery without a break. The water should not be alkaline or very hard, and should be free from organic matter. Presence of iron and sulphur compounds in it renders it unsuitable for making syrups or brines. Saltish water should be avoided as it would affect the taste of the product. If supplies of the desired quality are not available, it would be necessary to instal a water-softening plant.

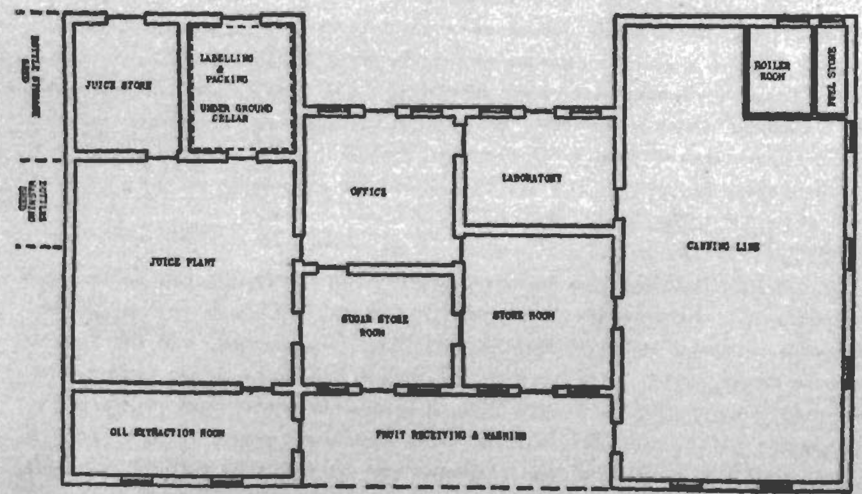


FIG. 1. PLAN OF A FRUIT PRESERVATION FACTORY

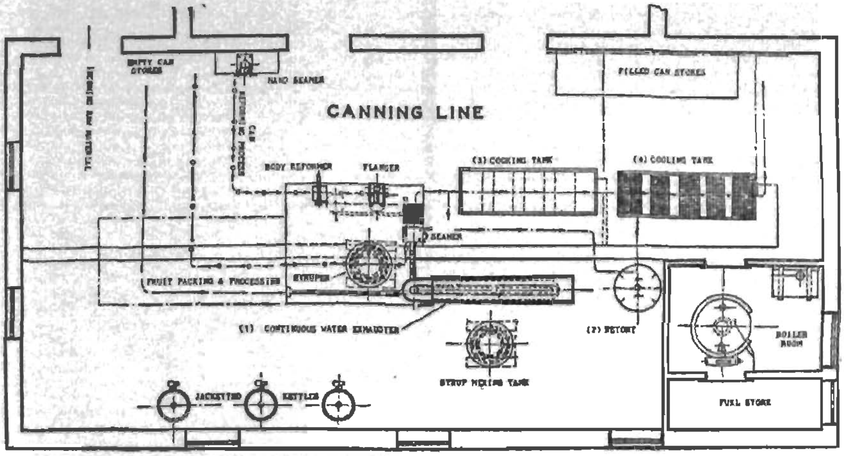


FIG. 2. LAYOUT PLAN OF A CANNING LINE

Labour

All the workers in the factory, whether employed on regular basis or recruited during rush periods, should have clean clothes and aprons to ensure hygienic conditions. They should be medically examined at regular intervals as precaution against infectious diseases. An efficient system of chemical and microbiological control at various stages of the manufacturing process should be maintained to guard against the risk of contamination and food-poisoning. A trained chemist with assistants should be there to supervise the work and to ensure the desired standard of production.

Equipment

Great care is needed in the selection of machinery and other equipment. Different types of units are in use, but every manufacturer will have to determine his own requirements. However, as a rough guide, layout plans of a small fruit preservation factory with a canning line with an output of about 2000 A2 size cans per day and a juice plant with a capacity of about 1000 bottles are given in Figures 1, 2 and 3.

The whole equipment should be arranged in a proper order so that minimum time and effort are needed in handling the product at all stages of manufacture. In short, the raw product should move practically in a straight line till it emerges as finished product ready for labelling and packing. During the off-season, the entire machinery should be overhauled, greased, and painted.

CANNING PROCESS

For canning, fruits and vegetables should be absolutely fresh. "An hour from the field to the can" is the accepted ideal.

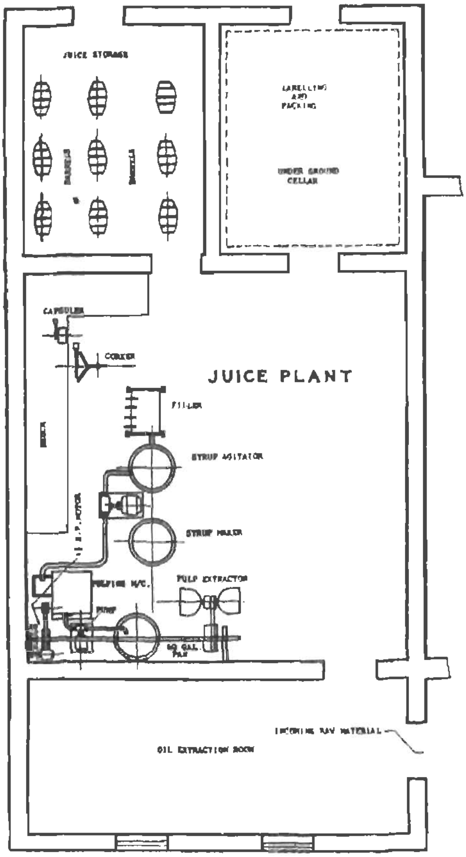


FIG. 3. LAYOUT PLAN OF A JUICE PLANT

The fruit should be ripe, but firm, and evenly matured. It should be free from all unsightly blemishes, insect damage, and malformation. Over-ripe fruit is generally infected with micro-organisms, and would yield a pack of poor quality. Under-ripe fruit will generally shrivel and toughen on canning. The vegetables should be tender, except that tomatoes should be firm, fully ripe, and of deep red colour. They should be reasonably free from soil, dirt, etc.

The fruits and vegetables selected for canning pass through several processes before they are turned out as finished products. The main processes are described below.

Sorting and Grading

After preliminary sorting, the fruits and vegetables are graded. This is necessary to obtain a pack of uniform quality as regards size, colour, etc., and is done by hand or with the help of grading machines. There are several mechanical graders, like the screen graders, roller graders, rope or

FIG. 4. PREPARATION AND GRADING OF FRUITS IN A CANNING FACTORY

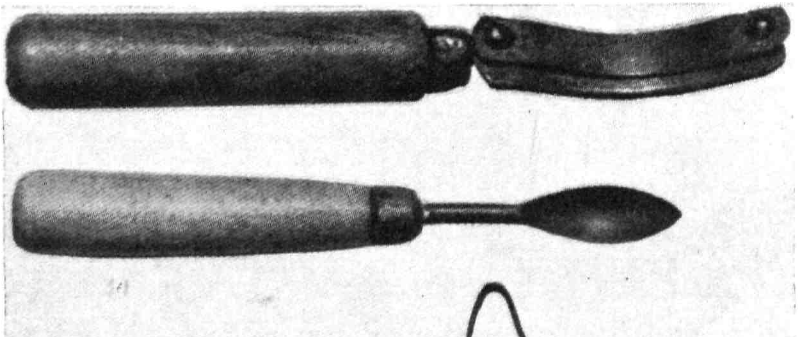


FIG. 5. PEELING, PITTING AND CORING KNIVES

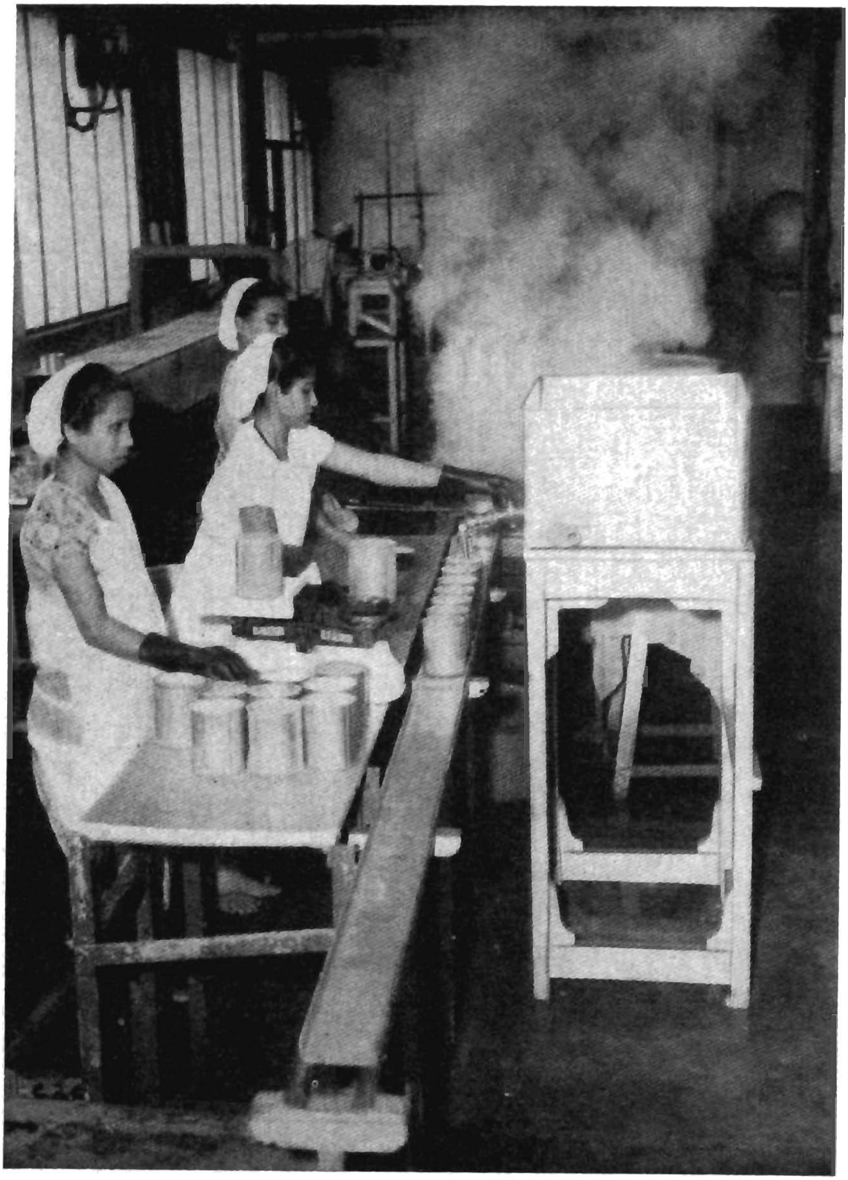


FIG. 6. FILLING CANS WITH SYRUP IN A CANNING FACTORY

cable graders, etc. Screen graders which are fitted with vibrating screens of copper with circular openings are most commonly used. A set of about six screens is generally provided to deal with different sizes. Soft and berry fruits are generally graded by hand picking.

Fruits like berries, plums, cherries, and olives are graded whole, while peaches, apricots, pears, mangoes, etc., are generally graded after cutting them into halves or slices (Fig. 4).

Washing

The graded fruits and vegetables are washed with water in different ways, such as soaking or agitating in water, washing with cold or hot water sprays, etc. A thorough wash is most essential for good results. Vegetables may preferably be soaked in a dilute solution of potassium permanganate to disinfect them. Agitation of the washing water is effected generally by means of compressed air or a force pump or a propeller-type equipment. Spray washing is, however, the most efficient method.

Peeling, Coring and Pitting

The washed fruits and vegetables are prepared for canning by peeling, coring, blanching, etc. Fruits and vegetables are peeled in a variety of ways: (i) by hand or with knife; (ii) by machine; (iii) by heat treatment; and (iv) by lye solution. Cores and pits in fruits are removed by hand or by means of a machine.

Hand Peeling. Many of the fruits and vegetables are peeled and cut by hand with the help of special knives (Fig. 5). The peeling knife with a curved blade and a special guard to regulate the depth of peeling is of special interest as it can be employed universally for many of the fruits and vegetables. Coring and pitting knives of typical peeling are illustrated in Fig. 5.

Peeling, Coring and Pitting by Machine. Recently, mechanical peeling, coring, and cubing machines for pears, apples and other fruits and vegetables have been introduced (Fig. 7). There are also automatic machines for peaches and cherries. Mechanical peelers are also used for root vegetables like carrots, turnips, potatoes, etc.

Peeling by Heat. Some fruits and vegetables, particularly certain varieties of peaches and potatoes, are scalded in steam or boiling water to soften and loosen the skin which is subsequently removed easily by hand. The latest development of this method consists in exposing the fruit or vegetable to a high temperature of 1050°C for 10-60 seconds, whereby the skin bursts and retracts facilitating its easy removal by means of pressure sprays. For work on a large-scale, a furnace fitted with a variable speed conveyor and temperature control device is employed. To get good results, the fruit or vegetable should be of uniform size and maturity. It is claimed that in this method there is little loss of flavour, and the product is of uniform colour free from any blemish. The heat-peeled fruit absorbs sugar more readily than fruit peeled by other methods.

Lye Peeling. Fruits and vegetables like peaches, apricots, quinces, sweet orange and tangerine sections, carrots, and sweet potatoes are generally peeled by dipping them in boiling caustic soda or lye solution of 1-2 per cent. strength for short periods, ranging from 30 seconds to 2 minutes (depending on the nature and maturity of the fruit or vegetable). The strength of the boiling lye is adjusted from time to time. The hot lye loosens the skin from the flesh underneath. The peel is then removed easily by hand. Any traces of alkali would be removed by washing the fruit or vegetable thoroughly in running cold water, or preferably by dipping it for a few seconds in a very weak solution of hydrochloric or citric acid. This method is quick and reduces the cost of peeling and wastage.

The lye-dipping equipment varies from a simple open iron pan for the lye solution with iron baskets or cages for holding the fruits and vegetables to fully automatic machines. Use of aluminium in the lye-dipping equipment should be avoided as it reacts with sodium hydroxide.

Blanching. Treatment of fruits and vegetables with boiling water or steam for short periods, followed by cooling prior to canning, is called 'blanching'. This loosens the skin—which process is of particular importance in the case of beets and tomatoes—facilitates close filling in the can, and drives out the air from the tissues. Further, it helps to clean the fruit or vegetable and to eliminate micro-organisms. It also inactivates the enzymes, thus preventing possibility of discolouration. By removing undesirable acrid elements and astringent taste of the peel, it also improves the flavour.

In a small cannery, the fruit or vegetable to be blanched is placed in a wire basket, which is first dipped in hot water for a short period, ranging from 2 to 5 minutes, and then dipped in cold water. Hard water should not be used for blanching, as it toughens the tissues and destroys the natural texture. In large canneries, blanching is done on belt conveyors passing through boiling water or steam.

Can Filling

The cans are washed with water or subjected to a steam jet to remove any adhering dust or foreign matter. In large canneries, the cans are washed with jets of compressed air or water. In India, where the canning industry has not developed so much as to warrant the use of costly machines, washing the empty can in open tanks containing hot water is the usual practice. In some factories, however, devices have been made to sterilize the cans in steam before use. Plain cans are used generally, although in the case of coloured fruits like red plums, black grapes, straw-berries, etc., it is desirable to employ fruit-lacquered cans. Automatic can filling machines are in use in large canneries in many countries, but choice grades of fruits are generally filled by hand to prevent bruising as also to ensure a properly graded pack. In India, hand filling is the common practice.

Syruping or Brining. The cans are filled with hot sugar syrup for fruits, and with hot brine for vegetables. The object of adding syrup or brine is to improve the taste of the canned product, to fill up the inter-space between the fruits or vegetables in the can, and to facilitate further processing. The syrup or brine should be filled at a temperature of 175°-180°F. and suitable head space should be left in the can so that when the closing end is fitted, the space left inside ranges from 1/8″ to 3/16″.

In some of the large canneries in other countries, syruping or brining is done on automatic machines. These machines are available in various designs and capacities. A simple syruper consists of a 50-gallon capacity tank of stainless steel or aluminium metal fitted with a closed steam coil inside, and provided with a delivery valve for filling the cans (Fig. 6). In another type, the syrup is drawn into the cans through a horizontal pipe having a row of small holes. The cans travel on a continuous belt in an inclined position below the syrup pipe and get filled, the overflowing excess syrup being pumped back into the syrup tank by a centrifugal pump.

Lidding or Clinching. Formerly the cans after being filled, were used to be taken to the exhaust, with the top lids loosely placed. In large-scale practice this had certain disadvantages, such as spilling of the contents, toppling of the lids, etc. Lidding has now been modernised by the 'Clinching' process in which the lid is partially seamed to the can by a single first roller action of a double seamer. The lid remains sufficiently loose to permit the escape of dissolved and free air from the contents as well as of the vapour formed during the exhaust process. Counting and coding devices are also generally incorporated in the clinching machine.

Exhausting. Before sealing the cans finally, it is necessary to remove all air from the contents. The process by which this is achieved is known as 'exhausting' (Fig. 8). By removing air from the container, risks of corrosion of the tin plate and pinholing during storage as also of discolouration of the product are reduced, for oxidation is prevented. To be effective, the temperature of the syrup or brine in the can should be at least 175°-180°F. Removal of air also helps in better retention of vitamins, especially of vitamin C. Since some fruits and vegetables have a tendency to expand or shrivel during heating, the exhaust process will be of assistance in avoiding over-filling or under-filling of the can. For instance, corn and peas expand when boiled in brine, and strawberries shrivel when heated in sugar syrup. The other advantages of the exhaust process are: prevention of bulging of the cans when stored at high altitudes or in hot climates; reduction of chemical reaction between the container and the contents; and prevention of excessive pressure and strain during sterilization. Fruits and vegetables sometimes react slowly with the metal of the can producing hydrogen gas which builds up pressure. If there is no vacuum inside the can to start with, bulging will take place before long, and the marketability of the canned stuff would suffer.

The vacuum in the can after exhaust depends on several factors, such as the time and temperature of exhaust, the head space in the can, altitude, etc. The higher the temperature of exhaust, the more the volume of the water vapour formed, and consequently the greater the vacuum left inside the can. It is, however, preferable to exhaust the cans at a low temperature for a longer time to secure uniform heating of the contents without softening them into a pulp. The head space left after sealing the can affects the vacuum: the smaller the head space the greater the vacuum. Further, the vacuum in a can, which is governed by the difference in pressure outside and inside, is affected by the altitude of the place. A can sealed at a lower altitude will show a lower vacuum inside at a higher altitude, and *vice versa*. Cans with a low vacuum generally become 'springers' at high altitudes though the contents remain fit for consumption.

Cans are exhausted in two ways: (i) By heat treatment; and (ii) by mechanical methods. The heat exhaust method is generally used in the case of cans. The can is passed through a tank of hot water at about 180°-190°F. or through a covered steam box on a moving belt. In the water exhaust box, the cans are placed with the level of the water kept 1/2"-1" below their tops. The time of exhaust varies from 5 to 25 minutes, depending on the nature of the product. At the end of the exhaust, the temperature at the centre of the can should be about 175°F. In the case of glass jars, vacuum closing machines are generally used. The jar is placed in a closed chamber in which a high vacuum is maintained.

Sealing. After 'exhausting' the cans are sealed by special closing machines known as double seamers (Fig. 9). These are of various designs and capacities. There are hand-operated as well as semi-automatic and fully automatic seamers. The principle of working of these machines is explained in the chapter on tin containers.

PROCESSING

The term 'processing', as used in canning technology, means heating or cooking of canned foods to inactivate bacteria. Absolute sterilization is difficult to attain as many bacteria can form very minute and highly heat-resistant bodies called 'spores', which can be killed only by either very high or very low temperature treatment or prolonged cooking. Such a drastic treatment, however, injures the quality of the canned product. Processing consists in determining just the temperature and the extent of cooking that would suffice to eliminate all possibilities of bacterial growth. Over-cooking should be avoided as it spoils the flavour as well as the appearance of the product. Since fruits and vegetables vary considerably in their composition and texture, it is difficult to lay down any hard and fast rule about the temperature and time required for processing. Generally

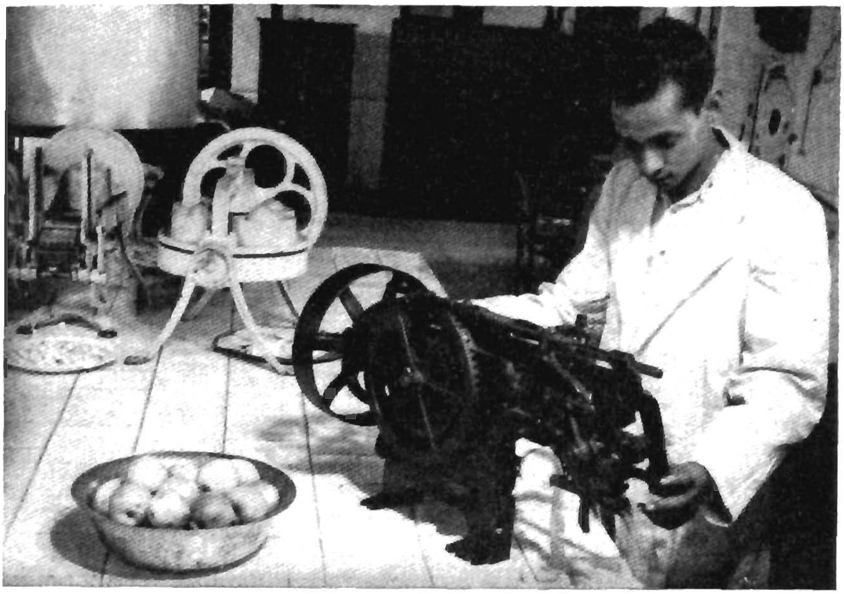


FIG. 7. PEELING, SLICING AND CORING MACHINES

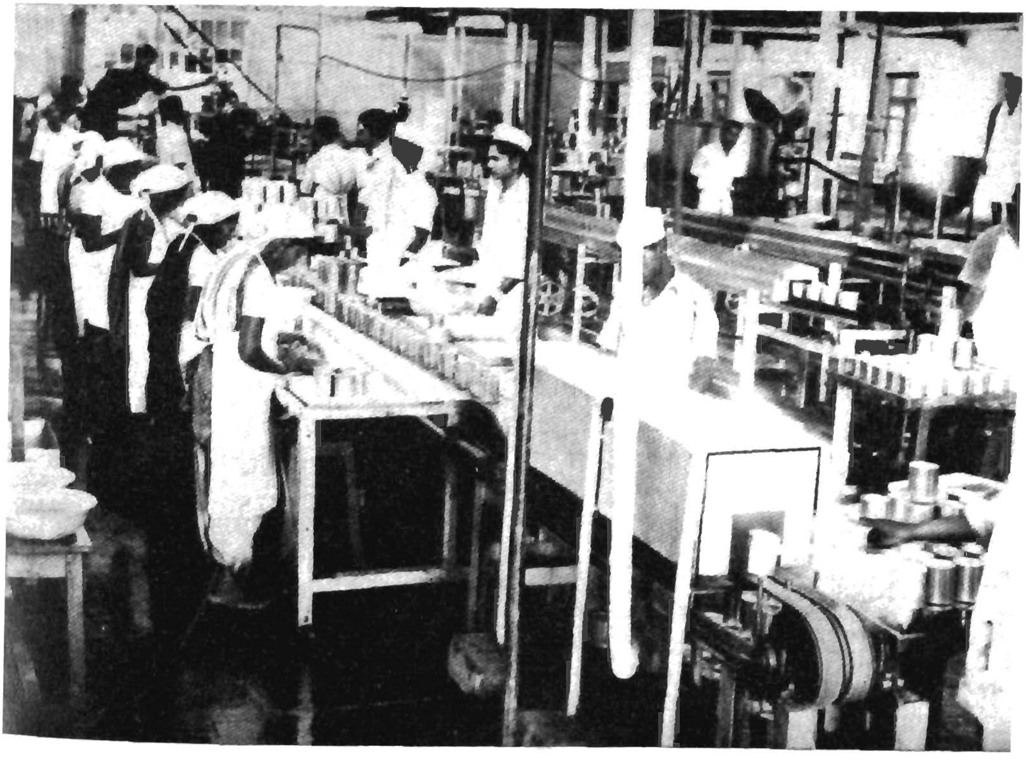


FIG. 8. STEAM EXHAUST LINE IN A CANNING FACTORY

FIG. 9. A DOUBLE SEAMER IN A CANNING FACTORY

speaking, however, almost all fruits can be processed satisfactorily at a temperature of 212°F., i.e., in boiling water, as the presence of acid retards the growth of bacteria and their spores. Further, they do not thrive in heavy sugar syrups which are normally used in canning fruits. However, vegetables (except the more acidic ones like tomato and rhubarb) which are non-acidic in nature, require to be processed at higher temperatures of about 240° to 250°F. The centre of the cans should reach these high temperatures. The processing time in their case is, therefore, of great importance. The temperature at the centre of the can should be maintained for a sufficiently long period to destroy the spores of the more resistant bacteria. The temperature and time of processing, therefore, vary with the size of the can—the larger the can, the greater the processing time and *vice versa*.

Heat Penetration in Cans

Before a process for any particular product can be adopted, it is necessary to study the rate of heat penetration in the can. This is done by means of a thermocouple fixed to the centre of the can. In the U.S.A., extensive studies have been carried out with special reference to the size and kind of the containers, the nature of the filler, i.e. sugar or brine, the consistency of the product, etc. Based on these studies, processing times for many kinds of non-acid vegetables have been worked out by the National Canners' Association. Ball, Olsen and Stevens also have done useful work in determining the time for which a given size of can of a particular food should be processed at a temperature at which all the heat-resistant spores are destroyed. Similar type of work has been done in England also at the Fruit and Vegetable Preservation Research Station at Campden. Cruess, Fong and Liu, who investigated the role of acidity in vegetable canning, have shown that brines acidified with a small amount of acetic or citric acid greatly reduce the resistance of the heat-resisting spores of bacteria, and that in acidified brines the time and temperature required to sterilize vegetables could, therefore, be reduced considerably. This process, however, is not to be recommended for home-canning of vegetables as there is always an element of uncertainty in the strict application of the conditions prescribed. Pressure processing is the safest course.

Processing Methods

Fruits and Acid Vegetables. There are generally three types of cookers used for canning of fruits. They are the open type cookers, continuous non-agitating cookers and continuous agitating cookers.

1. *Open Cookers.* These cookers are very simple in construction, and consist essentially of wooden tubs or galvanized iron tanks of any desired capacity (Fig. 10). The sealed cans are placed in crates of galvanized iron and immersed in the tank containing boiling water. Water is kept boiling by letting in jets of steam through steam pipes placed underneath the false

bottom of the tank. An improved type of this cooker is a galvanized iron tank with a cover, false bottom of perforated galvanized plate, and steam pipe with perforation for jets of steam.

2. *Continuous Non-agitating Cookers.* In these cookers, the cans travel in boiling water in crates carried by overhead conveyors in single file on a continuous moving belt (Fig. 11). The cookers are fitted with temperature controlling and recording devices also.

3. *Continuous Agitating Cookers.* These cookers are of various designs and are generally used in big production units. The sealed cans move as in the non-agitating cookers, but are at the same time rotated by special mechanical devices to agitate the contents of the cans. By this technique, the processing time is reduced considerably. These cookers may either be filled three-fourths with water which is kept hot by steam, or processing may be carried out in steam itself. They are fitted with automatic temperature control devices so that they can be easily adapted for pasteurization at temperatures well below 212°F., the boiling point of water. These cookers have an advantage over other types in that they accelerate the output of the factory to a considerable extent. They are in common use in large canneries in the United Kingdom and the U.S.A.

Non-acid Vegetables. Due to lack of acid, hard texture, and proximity to soil which may infect them with spore-bearing organisms, vegetables require much severer sterilization than fruits do. They require to be processed at temperatures much above 212°F., under steam pressure in closed iron retorts.

These retorts vary in shape and size, with capacities ranging from about 50 cans to nearly 2,000-3,000 cans. They are generally of the batch type. The more modern ones, which are known as automatic pressure cookers, operate continuously. The retorts are either vertical or horizontal. In the U.K. vertical retorts are generally used, but in the U.S.A. horizontal retorts predominate, some of them being as long as 60 feet, and in these, trucks are wheeled out at one end as the new batch enters through the other end. To these large commercial retorts, automatic steam and temperature controlling and timing devices with recording equipment are fitted to avoid any human slip. Bitting has described various types of open cookers and pressure retorts generally used in the U.S.A.

In India, small vertical stationary retorts are generally used (*Frontispiece*). They are made of cast iron cylinders of varying sizes, and are fitted with a lid which can be bolted steam-tight. Necessary steam and water-feeds, air vent, drain cock, safety valve, pressure gauge, and thermometer are fitted. The sequence of operating these retorts is as follows: The sealed cans are put in crates which are placed inside the retort. The lid is placed in position and bolted. The vent and drain cock are opened and steam let in until it blows freely through the vent-hole removing all entrapped air. The vent and the drain are then partially closed till the temperature reaches 212°F. These exits are then closed, leaving a small opening for a fine jet of steam to escape, and the steam pressure and temperature allowed to rise to the desired extent. During the cooking period, the thermometer and pressure gauge records should show close agreement. For instance, if the cooking temperature is 240°F., the steam pressure should be a little above 10 lb. (Table 1). If at this temperature, the pressure is higher than 10 lb., presence of entrapped air is indicated. On the completion of the cooking period, steam is cut off, and the release valve at the top opened gradually to let off steam, avoiding any sudden release as it is likely to burst the cans inside. When the pressure becomes normal, the retort is opened and the cans are removed for subsequent cooling to prevent any over-cooking.

TABLE 1. RELATION OF STEAM PRESSURE TO TEMPERATURE OF CANNING RETORTS

(*Cruess, 1948*)

Pounds pressure per square inch	Temperature Deg.F.
1	215.2
2	218.3
3	221.3
4	224.2
5	226.9
6	229.5
7	231.9
8	233.3
9	236.6
10	238.8
11	241.0
12	243.0
13	245.3
14	247.3
15	249.1

Effect of Altitude on Processing Time

The boiling point of water decreases with increase in altitude. The processing time for different kinds of canned fruits and vegetables, as standardised at places about 500 feet above sea level, have to be relatively increased with further increases in the altitude. As a rule, for every increase of 500 feet in altitude, the boiling point of water decreases by about 1°F., and the normal processing time has to be increased by about two minutes. Table 2 gives the additional time required at different altitudes over and above the normal period of processing for canned fruits and vegetables at sea level.

TABLE 2. EFFECT OF ALTITUDE ON BOILING POINT OF WATER AND STERILIZATION TEMPERATURE OF CANNED FRUITS AND VEGETABLES

Elevation: Feet above sea level	Boiling point of water (°F.)	Extra time in minutes for boiling water	Extra lb. pressure added to pressure given
500	211	2	1
1,000	210	4	1
2,000	208	8	1
3,000	206	12	2
4,000	204	16	2
5,000	202	20	3
6,000	201	25	3
7,000	199	30	4

Thus, an A2½ size can of pears, which requires processing for 30 minutes at sea level, will require a total processing time of 30 + 25 = 55 minutes at an altitude of about 6,000 feet above sea level.

Effect of Altitude on Processing Pressure and Temperature

As the altitude above sea level increases, the pressure required to maintain the specified processing temperature, say 240°F. or 250°F., will also increase. Since process time schedules are based on the exposure of the canned food to specified temperature in steam, it may be necessary to maintain higher gauge pressure if the processing is done at altitudes substantially greater than 1,000 feet above the sea level. Table 3 gives details of increased gauge pressure necessary to attain a specified temperature at various altitudes.

TABLE 3. GAUGE PRESSURE CORRESPONDING TO SPECIFIED PROCESS TEMPERATURES AT VARIOUS ALTITUDES

(*After Bulletin 26-L of National Canners' Association*)

Temperature °F.	Gauge pressure (pounds) Feet above sea-level						
	Sea-level	1,000	2,000	3,000	4,000	5,000	6,000
212	0.0	0.5	1.0	1.5	2.0	2.4	2.9
220	2.5	3.0	3.4	3.9	4.4	4.9	5.3
230	6.1	6.6	7.1	7.6	8.0	8.5	9.0
240	10.3	10.8	11.3	11.7	12.2	12.7	13.1
250	15.1	15.6	16.1	16.6	17.1	17.5	18.0

Effect of Acidity on Sterilization

Acids in solution owe their acidic properties to the hydrogen-ion. The hydrogen-ion concentration is a measure of the intensity or potential of acidity rather than of its quantum. It is generally expressed in terms of what is known as the *p*H value. The *p*H value of a solution is equal to the logarithm of the number of litres of solution which contains 1 gram of hydrogen-ion. The *p*H value of water, which is neutral, is 7 on this scale. *p*H values rising above 7.0 represent progressively increasing alkalinity, and those falling below 7.0 indicate increasing acidity. The more acidic the substance, the lower is the *p*H value. The acid property or sources of fruits is due to the presence of hydrogen-ions.

The *p*H value has great influence upon the destruction of micro-organisms. The lower the *p*H, the greater is the ease with which a product can be processed or sterilized. According to Cameron and Esty, foods can be classified as follows:

1. **Low acid—*p*H 5.0 and higher.** This class includes peas, beans, corn, asparagus, etc. These are subject to spoilage by all the three groups of thermophilic and mesophilic putrefactive anaerobes, including *Clostridium Botulinum*.

2. **Medium acid—*p*H 0.5-4.5.** Meat and vegetable mixtures, spaghetti, soups and sauces, whose ingredients produce a partially acid product, come under this category. These also are subject to spoilage by the same organisms as in group 1. The thermophilic anaerobes (not producing hydrogen sulphide) which may cause flat sours are of increasing importance in this group.

3. **Acid—*p*H 4.5-3.7.** In this group are included tomatoes, pears, figs, pine-apple, nectarines and other fruits subject to spoilage by non-sporing aciduric types, butyric anaerobes of the *Clostridium Pasteurianum* and *Winogradskyi* types and thermophilic anaerobes.

4. **Highly acid—*p*H 3.7 and below.** This group includes sauer-kraut, pickles, berries, citrus juices, grapefruit and rhubarb.

To be more precise, bacterial spores are much more easily destroyed in fruits at *p*H 3.0 than in vegetables at *p*H 5.0-6.0. These spores do not germinate and grow at *p*H values much below 4.5. They do not, therefore, do any harm even if they are not destroyed in canned fruits. Thus *p*H 4.5 is regarded as a dividing line between the acid and the non-acid foods. A canned product, having a *p*H value of less than 4.5, can be processed in boiling water at 212°F., but a product with a *p*H value above 4.5 requires processing under pressure of 10-15 lb.

Effect of Processing on Strain in the Can

When a can is closed, the pressure inside it is equal to that of the atmosphere, irrespective of the temperature at closing. Any increase in the temperature after the closing of the can develops pressure inside the can.

This internal pressure depends upon several factors of which the following are important:

1. Pressure due to water vapour inside the can.
2. Pressure due to expansion of any enclosed air.
3. Pressure due to the expansion of the contents of the can.
4. Pressure due to the liberation and expansion of gases inside the vegetable.
5. The expansion of the can by the doming of the ends and the compensating effect of the expansible rings on the lid.

Among these, water vapour produces the greatest effect. Water vapour has a pressure of 2.9 lb. per square inch at 140°F., and 25.0 lb. at 240°F. This would indicate that very high pressures develop at higher temperatures.

The pressure inside the can during processing can be regulated by taking into consideration the following points:

1. Internal pressure in the can is equal to vapour pressure at the processing temperature minus the vapour pressure at the closing temperature.
2. The nearer the closing temperature to the processing temperature, the less the internal pressure during processing.
3. Small cans withstand much greater internal pressure than large cans.
4. To avoid buckling, cans larger than No. A2½ should be cooled under pressure.
5. To get a good vacuum, the closing temperature of the can should not be less than 160°F.

Cans closed at 160°F. and processed at 240°F. show a maximum pressure above that of the atmosphere, i.e. 20-21 lb. These pressures are near to the theoretical value for water vapour alone.

Cooling

After processing, the cans are cooled rapidly to stop the cooking process and to prevent stack-burning, especially in cans at the centre of large stacks, where they may remain hot for several hours, if not for several days. Prolonged heating results in an inferior and uneven pack. In extreme cases, peaches and pears become dark in colour, tomatoes turn brownish and become bitter in taste, while peas become mashy with a cooked taste. In the case of many of the vegetables, prolonged heating due to improper cooling may result in the development of 'flat sour' by the heat resistant spore-forming bacteria which survive ordinary commercial processing. In this case, the cans do not show any bulging but the contents will be sour.

Cooling is done by: (i) immersing or passing the hot cans in tanks containing cold water ; (ii) by spraying with jets of cold water ; (iii) by turning cold water into the pressure cooker in the case of canned vegetables ; or (iv) by exposing the cans to air in small lots, when water supply is scarce. The cooling equipment varies with the method as well as the output.

Various types of equipment, from simple open galvanized iron tanks to the complicated automatic coolers, are available. A simple cooling tank useful in this country is an ordinary galvanized iron tank fitted with water connections for constant overflow of cold water. The cans are placed in crates for cooling in this tank where the circulating water is fairly cold. In very hot places, it may even be necessary to cool the water by adding ice.

Testing for Defects

In a factory, batches of finished cans should be finally tested for leaks or imperfect seals. A simple way of doing this is to tap the top of the can with a short steel rod. A clear ringing sound indicates a perfect seal, while a dull and hollow sound shows a leaky or imperfectly sealed can. This method is very rapid, and an experienced workman seldom fails to detect a defective seal.

The other method commonly used for testing the vacuum inside the can is by means of a simple vacuum gauge fitted with a sharp point which is protected with a thick rubber gasket. The sharp point is pierced into the lid of the can, and a short twist given, when the rubber gasket presses against the puncture made and gives an air-tight seal. The vacuum in the can is directly read on the dial of the gauge. Faulty cans do not show any vacuum. The vacuum can also be determined with a vacuum tester without puncturing the can.

Labelling, Storing and Packing

The outer surface of the cans should be perfectly dry as even small traces of moisture are likely to induce rusting. When canning is done near the sea or in damp and moist regions, it is advisable to lacquer the cans on the outside to prevent rusting during storage. The cans are then labelled by hand or by machine, and packed in strong wooden cases. Till they are despatched, they should be stored in a cool and dry place. In a hot country like India, where the atmospheric temperatures are quite high during several months in the year, basement stores are useful, especially during summer months as the temperature in these is lower by about 10°-15°F. compared to the outside temperature. Storage of cans at high temperatures should be avoided as it shortens the shelf-life of the product, and often leads to the formation of hydrogen swells and perforations.

CHAPTER III

CONTAINERS

Both tin and glass containers are employed in the canning industry, although the tin ones are more common in use on account of the following reasons: these are fabricated readily, and are strong enough to withstand processing; they are light in weight, easy to handle, and fairly cheap; they can be handled on high speed machines. Glass containers are fragile and require extra care in handling and during processing. They, however, possess two advantages over tin cans: the contents being visible can be easily displayed; and the containers can be used over and over again.

TIN CONTAINERS

Tin cans are made of thin steelplate of low carbon content, lightly coated on either side with tin metal to a thickness of about 0.0001 inch. The composition of the steel used is as follows:

	Per Cent.
Carbon	0.04 -0.12
Sulphur	0.015-0.05
Phosphorus	0.015-0.06
Copper	0.020-0.20
Manganese	0.20 -0.60
Silicon	Trace-0.08

Since corrosion behaviour, strength and durability of the tinplate depend in some measure on the chemical composition of the steel base, the base plate is made according to the specific use for which it is intended. In the U.S.A., the following designations have been adopted:

Type L.	Low metalloid steel for critical and highly corrosive packs.
„ MR.	Similar in metalloid content to Type L, but less restricted in residuals.
„ MC.	Rephosphorised or Bessemer steel to give higher temper. (All the above are cold-reduced)
„ M.	Similar to MC, but hot rolled.

Tinplates

Tinplates are of several grades. The usual weight of tin coating is 1.5 lb. of tin per base box, which gives a thickness of tin coating of 0.00009 inch. However, variation in weight from 1 to 5 lb. of tin per basis box is common. One basis box is equivalent to 112 sheets, each 20″ × 14″, or 31,360 square inches of tinplate weighing 108 lb. net. These are called I.C. plates. Plates

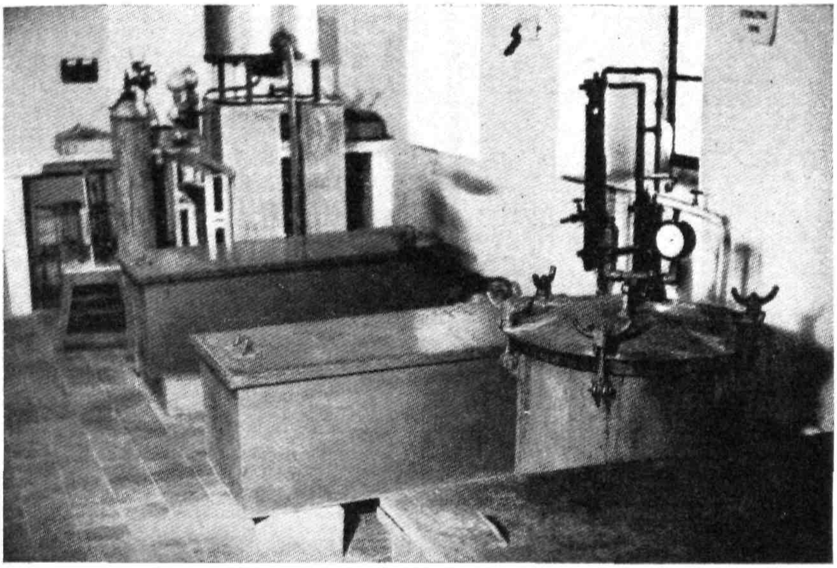


FIG. 10. OPEN BATCH-TYPE EXHAUST, COOKING AND COOLING TANKS

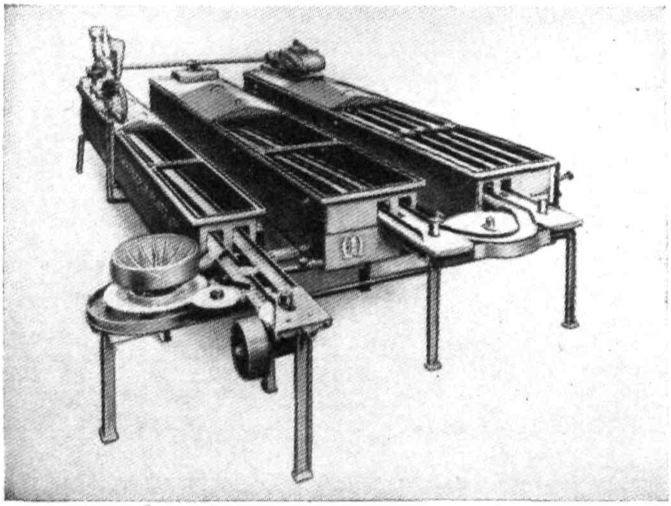


FIG. 11. CONTINUOUS MOVING BELT, EXHAUST, COOKING AND COOLING TANKS

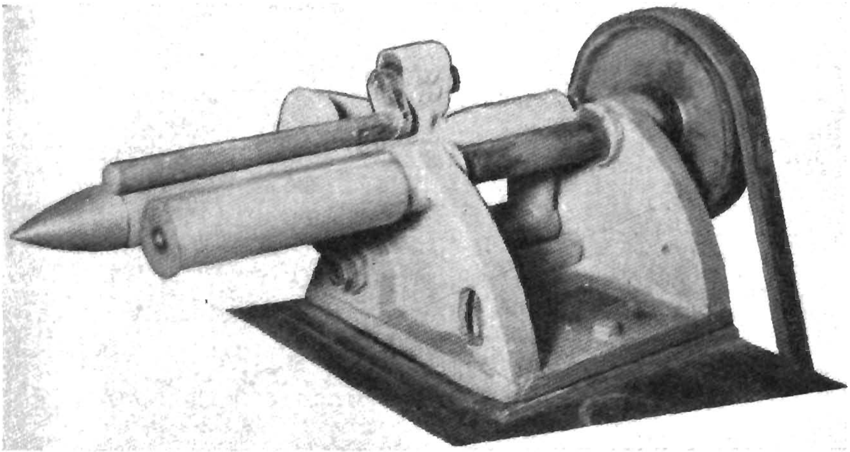


FIG. 12. CAN REFORMING UNIT: CAN BODY REFORMER

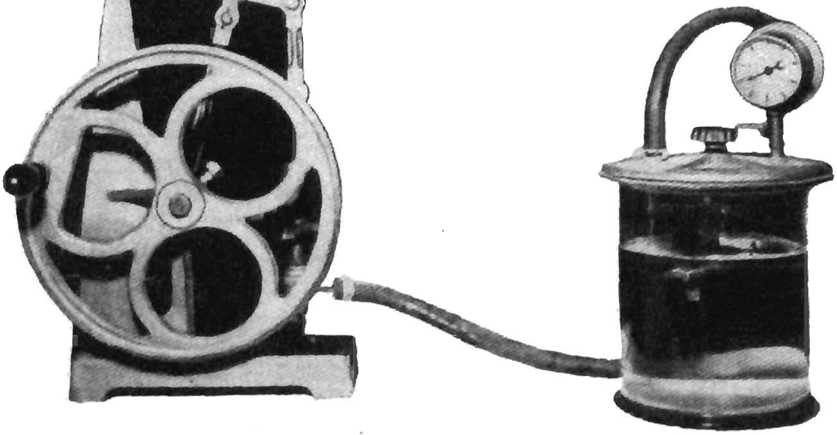


FIG. 13. VACUUM CAN TESTER FOR DOUBLE SEAM

thinner than I.C. are called 'lights' and those thicker than I.C. 'crosses'. The following are the equivalent weights:

Type	Weight (lb.)
IXL	122
IX	136
IXX	156
IXXX	176
IXXXX	196

There are several types of tinplates, such as 'coke', 'best coke' and 'charcoal'. 'Cokes' are ordinary coated plates. 'Best cokes' are graded between 'cokes' and 'charcoals.' The 'charcoals' are coated with a heavier layer of tin than common 'charcoal' plates.

Lacquering

It is difficult to coat steelplate uniformly with tin during the process of manufacture. Small miscroscopic spaces are always left uncoated, although the coating may appear perfect to the eye. The contents of the can may react with these exposed parts and cause discolouration of the product or corrosion of the tinplate. When corrosion is severe, the steel is attacked and black stains of iron sulphide are produced. It is necessary, therefore, to coat the inside of the can with some product which would prevent discolouration, but would not impart its own flavour or injure the wholesomeness of the contents. This is achieved by what is known as lacquering.

There are two types of lacquer—(*a*) acid-resistant and (*b*) sulphur resistant. The acid-resistant lacquer is ordinary gold coloured enamel, and the cans when treated with it, are called R-enamel lined cans. These cans are used for packing fruits of the acid group with soluble colouring matter. Acid fruits are of two kinds: (*a*) those in which the colouring matter is insoluble in water, and (*b*) those in which it is water-soluble. In the first group are included fruits like peach, pineapple, apricot, grapefruit, etc., and in the second, fruits like raspberry, strawberry, red plum and coloured grapes. Fruits of group (*a*) are packed in plain cans, and those of group (*b*) in lacquered cans.

The sulphur-resistant lacquer also is of a golden colour, and the cans, coated with it, are called C-enamel cans. These cans are used for non-acid products like peas, corn, lima beans, red kidney beans, etc., to prevent discolouration of the contents and the staining of the inside of the container. They are meant only for non-acid foods and should not be used for any highly acid product, as acid eats into the lacquer.

Manufacture of Cans

Tinplate is cut to proper size with a trimming and slitting machine. The pieces provide body blanks. After notching and slitting, the flat can-body is passed through an edging machine where hooks are formed. It is then bent into a cylindrical shape, and the side seam soldered. Flanging is done next. Can ends are stamped out from the plates, and the edges curled. A rubber gasket is mounted on the curled edge of the end. The lining compound is generally a water emulsion of rubber or rubber composition in benzene or toluene. Sometimes paper gaskets and plastic gum are also used. One end of the can is fixed to the flanged can-body by means of a double seaming machine. The action of the double seamer is shown in Fig. 14. Sometimes, to cut down transport costs, can-bodies are flattened and supplied to the cannery along with the end pieces. These can be made into cans readily at the factory by using a set of machines consisting of a can-

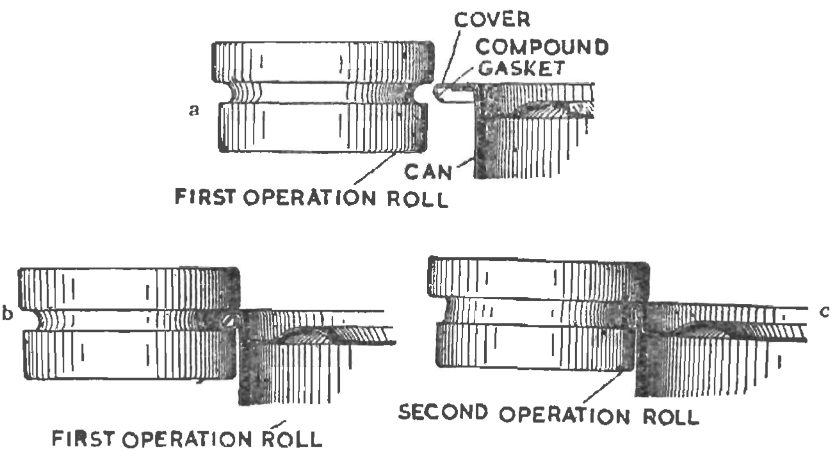


FIG. 14. ROLLER ACTION OF A DOUBLE SEAMER: *a*. Lid in place before sealing. *b*. Lid and edge of can after first operation. *c*. Appearance after second operation.

body reformer, flanger, and double seamer (Figs. 14, 17 and 18). The finished cans should be stored upside down in a clean dry place.

TESTING CANS

The finished cans are tested for leaks with a vacuum or air-pressure tester (Fig. 13). When working on a small scale, hand testing equipment will suffice.

Several types of mechanical defects may be found in cans. These are given briefly below.

Mechanical Defects

1. **Long seam with normal countersink.** It is due to (i) insufficient first operation; (ii) short cover hook.

2. **Long second seam.** It may be due to (i) insufficient first operation allowing second operation roller to flatten the seam too much; (ii) second

operation roller being too tight and thus flattening the seam too much; (iii) worn out chuck; (iv) worn out second operation roller; (v) excessive base pressure; (vi) grease or dirt on the base plate causing the can to slip during seaming process; (vii) uneven spread of the lining compound in the lid; (viii) chuck being off centre due to worn machine bearings.

3. Narrow rounded seam. It may be due to (i) excessive first operation resulting in a strong curl being formed which resists subsequent pressure of the second operation roller; (ii) not enough second operation to press seam down full length; (iii) countersink too deep.

4. Lined seam. It may be due to worn or scoured second operation roller.

5. Cut seam. It may be due to (i) too much base pressure, (ii) rollers too high in relation to chuck; (iii) too tight second operation roller; (iv) excessive solder on the side seam; (v) slipping of can or spinning on chuck.

6. Fractured or polished seam. It may be due to: (i) slipping of rollers; (ii) flat spots on rollers; (iii) too tight rollers; (iv) lack of lubrication.

7. Partial false seam or knockdown. It may be due to (i) damaged cans; (ii) dented and damaged lids; (iii) bent down flange on the can; (iv) can not centering on chuck.

8. Loose first seam. It may be due to: (i) loose first operation roller; (ii) worn first operation roller.

9. Loose second seam. It may be due to: (i) loose second operation roller; (ii) worn second operation roller.

10. Uneven seam. It may be due to: (i) worn rollers, roller pins, or other parts of the machinery; (ii) excessive first and second operations.

11. Wrinkled first seam. It may be due to: (i) loose first operation roller; (ii) worn first operation roller.

12. Wrinkled second seam. It may be due to: (i) loose second operation roller; (ii) worn second operation roller.

13. Short can hook. It may be due to: (i) insufficient base pressure; (ii) too tight first operation roller; (iii) too loose second operation roller; (iv) excessive clearance between rollers and chuck.

14. Long can hook. It may be due to excessive base pressure. It always results in a corresponding decrease in cover hook. 'spurs' may be formed.

15. Short cover hook. It may be due to: (i) insufficient first operation not turning sufficient cover stock into the seam; (ii) insufficient second operation which will not flatten the cover hook to its full length; (iii) short covers; (iv) body hook normal. 'Spurs' may occur.

16. Long cover hook. It may be due to: (i) excessive first operation; (ii) shallow countersink; (iii) insufficient base pressure. There may be 'cutovers' at top inside of seam.

17. Wrinkled cover hook. It may be due to insufficient second operation. Seam may be loose and hooks curved.

18. Deep countersink. It may be due to: (i) short cover hooks; (ii) chuck being too low for the rollers; (iii) excessive base pressure; (iv) excessive clearance between rollers and chuck ; (v) chuck flange too thick ; (vi) vertical play in seaming head allowing rollers to rise up from the chuck ; (vii) base plate setting not parallel with the chuck ; (viii) base plate worn more on one side than on the other thus causing uneven countersink (deep on one side).

19. Shallow countersink. It may be due to: (i) chuck being too high for rollers, which would cause the rollers to wear away the face of the chuck, making it thinner, thus affecting the countersink ; (ii) chuck flange being worn.

20. Lips or spurs. They frequently occur at overlap. Coverhook is deficient at the side of the spur. It may be due to: (i) insufficient first operation ; (ii) excessive second operation ; (iii) too much base pressure : (iv) worn first operation roller ; (v) too much solder at the overlap ; (vi) tough plate.

21. Skidding and 'spinners'. Sometimes a portion of the seam becomes unduly wide and very loose. This may be due to: (i) worn chuck ; (ii) insufficient base pressure ; (iii) greasy base plate or chuck ; (iv) excessive first and second operation ; (v) worn serration on base plate.

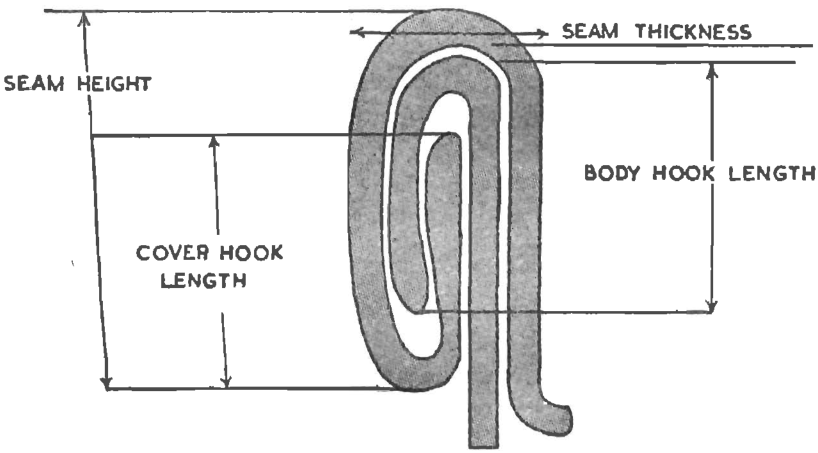


FIG. 15. DOUBLE SEAM MEASUREMENTS

22. Cut-overs. Sharp edges or cuts on the top inside edges of the seam are known as 'cut-overs'. They are especially found at the overlap. They may be due to: (i) worn chuck ; (ii) worn rollers ; (iii) excessive first operation roller ; (iv) excessive base pressure ; (v) side seam having too much solder ; (vi) spinning of the can due to slip between cover and the chuck ; (vii) maladjustment of second operation roller, especially due to the chuck being too low in relation to rollers, when plate is cut through completely with the result that leak occurs.

23. Bell-mouthed or oval cans. They may be due to excessive table (base) pressure.

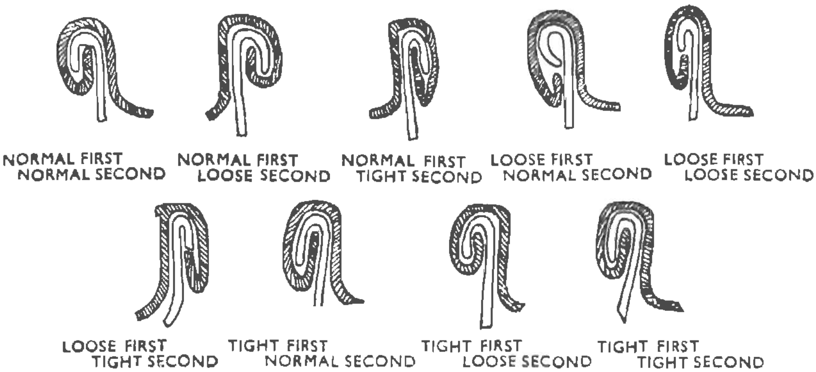


FIG. 16. CAN SEAMING TECHNOLOGY: GRAPHIC EXPLANATION OF SEAMS

24. Over-rolling. In the case of excessive roller pressure, whether first operation or second operation, or both, there is an overloading of the machine causing excessive wear on bushes, chucks, rollers, and all working parts. The life of the spindle bearing is shortened by as much as 50 per cent. resulting in bad seaming, and constant replacements, and necessitating complete overhaul of the machine after a much shorter production life than normal.

Since perfect seaming of the can is of prime importance in any cannery, it is essential that the rollers in the seamer should be in correct order. If the setting is not correct, a thorough check-up must be carried out to determine the correction needed (Figs. 15 and 16) the following hints would be found useful:

To correct :

1. Short can hook—give more base pressure.
2. Short coverhook—give more first operation.
3. Wrinkles in hook—give more second operation.
4. Countersink too deep—give less base pressure.
5. Seam too wide, or broken down at point where meeting body side seam—give less second operation or base pressure as the case may be.

Don'ts :

1. Don't use worn chucks, rolls or pins.
2. Don't roll too tight.
3. Don't use poor grades of grease.
4. Don't proceed with production if seam is doubtful.
5. Don't neglect to keep parts clean.
6. Don't attempt to seam over-filled cans.

Experience has shown that though minor neglect in observing the above instructions may not make it impossible to secure sufficiently tight seams, every departure from the basic standards increases risks and makes for insufficiency.

Sizes of Cans

According to the American system, which is widely followed in trade, cans are usually referred to by a letter and number, and the size is denoted by a digital symbol. The first number of the symbol denotes the diameter, and the second the height of the can. The first digit represents integral inches, and the last two indicate measurement in sixteenths of an inch. Thus A 1 Tall can which is $3\frac{1}{16}$ inch in diameter and $4\frac{11}{16}$ inch high would be shown as 301×411. The popular sizes of cans in use are given in Table 5.

TABLE 4. WEIGHT OF TINPLATE REQUIRED FOR FABRICATION OF 1000 CANS

(According to Metal Box Company of India—1954)

Size of Can	Weight of tinplate
A $2\frac{1}{2}$ (401×411)	0.1572 Ton.
A 2 (307×408)	0.1172 „
1 lb. Butter (401×300)	0.1249 „
12 oz. Butter (401×207)	0.1162 „
16 oz. Milk (301×406)	0.0946 „
1 lb. Jam (301×309)	0.0863 „
11 oz. Jam (301×303.5)	0.0798 „
8 oz. Flat (301×206)	0.0724 „
509×703	0.3154 „
700×900	0.5139 „

GLASS CONTAINERS

Various types of glass jars, such as glass top jars, 'Mason jars' with metal top, economy jars, Golden-state wide-mouth Mason jars with zinc tops, 'Sutax jars', 'Ball perfect Mason jars', etc., are in use in the United Kingdom and America. A good rubber ring is essential for success in bottling. These rings should be fairly thick, free from odour, and capable of withstanding processing. With each processing, a new ring should be used as old rings make defective seals. The rings should be stored in a cool, dry, and dark place. Before use, they should not be boiled, but dipped momentarily in boiling solution of 1.0 per cent. sodium bicarbonate.

TABLE 5. STANDARD SIZES OF OPEN TOP (PACKERS) CANS AVAILABLE IN FLATTENED FORM

Trade Name	A1	1-lb JAM	A1T	A2	1-lb BUTTER	2-lb JAM	A2½	7-lb JAM	A10
1. Size:									
(*a*) in inches	$2^{11}/_{16}\times 4$	$3^{1}/_{16}\times 3^{9}/_{16}$	$3^{1}/_{16}\times 4^{11}/_{16}$	$3^{7}/_{16}\times 4^{1}/_{2}$	$4^{1}/_{16}\times 2^{3}/_{4}$	$4^{1}/_{16}\times 4$	$4^{1}/_{16}\times 4^{11}/_{16}$	$6^{3}/_{16}\times 5^{13}/_{16}$	$6^{3}/_{16}\times 7$
(*b*) in millimetres	68 × 102	78 × 90	78 × 119	87 × 114	103 × 70	97 × 114	103 × 119	157 × 148	157 × 178
2. Trade size	211 × 400	301 × 309	301 × 411	307 × 408	401 × 212	401 × 400	401 × 411	603 × 513	603 × 700
3. Approx. Freight measurement factor	.1371	.1446	.1701	.1994	.1632	.2172	.2384	.5311	.7125
4. Capacity:									
(*a*) in fluid oz.	11.13	12.53	16.87	20.39	16.56	25.41	29.89	89.59	108.12
(*b*) in cubic cm.	316	356	479	579	470	721	848	2543	3069
5. Approx. number of ends per carton	270	350	355	180	337	225	200	65	65
6. Approx. number of ends per case	6000	4800	4800	3600	2800	2800	2800	1600	1600
7. Approx. gross weight per 1000 bodies									
(*a*) in lb.	105	109	140	162	139	188	213	450	565
(*b*) in kg.	48	50	64	74	63	85	97	204	2[illegible]6
8. Approx. net weight per 1000 bodies									
(*a*) in lb.	97	100	131	147	127	170	193	417	500
(*b*) in kg.	44	45	60	67	58	77	88	189	227
9. Approx. gross weight per 2000 ends									
(*a*) in lb.	51	63	63	90	120	120	120	280	280
(*b*) in kg.	23	29	29	41	55	55	55	127	127
10. Approx. net weight per 2000 ends									
(*a*) in lb.	45	55	55	80	106	106	106	248	248
(*b*) in kg.	21	25	25	37	48	48	48	113	113

TABLE 6. TYPES OF CANS USED FOR VARIOUS PRODUCTS

R-Enamel Cans		C-Enamel Cans	Plain Cans	
Fruits‡	Vegetables	Vegetables	Fruits	Vegetables
Blackberries	† Beets	Corn, whole kernel	Apples	Asparagus
Dewberries	* Pumpkin	Corn, cream Style	Apples, Baked	Beans Green, or Wax
Logan berries	Rhubarb	Corn, on the Cob	Apple, Butter	* Beans, Lima
Raspberries	* Squash	Succotash	Apple, Cider	* Beans, Red Kidney
Cherries			Apricots	Carrots
Grapes (coloured)			Blueberries	Cauliflower
Strawberries			Figs	Corn and Tomatoes
			Grapefruit	Eggplant
			Gooseberries	Mustard Greens
			Guavas	Spinach
			§ Litchies	Turnip Greens
			§ Oranges	* Hominy
			§ Mangoes	Mushrooms
			§ Papaya	Okra
			Peaches	* Peas, Blackeyed
			Pears	* Peas, English
			Pineapple	Potatoes, Sweet
			Plums, Yellow	† Sauerkraut
			Prunes	Soup Mixture
				Tomatoes
				Tomato Juice
				Tomato Paste
				Vegetable Soup

* These products may also be packed in C-enamel cans.
† These products also may be packed in R-enamel cans.
‡ For Fruit juices, use the same type of cans as recommended for the fruit from which the juice is made.
§ Unpublished data of the authors.

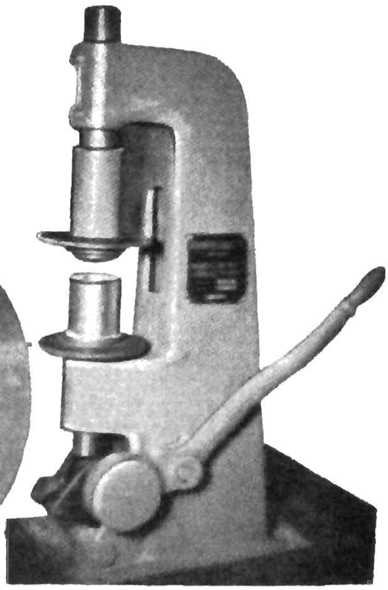


FIG. 17. CAN REFORMING UNIT: FLANGER

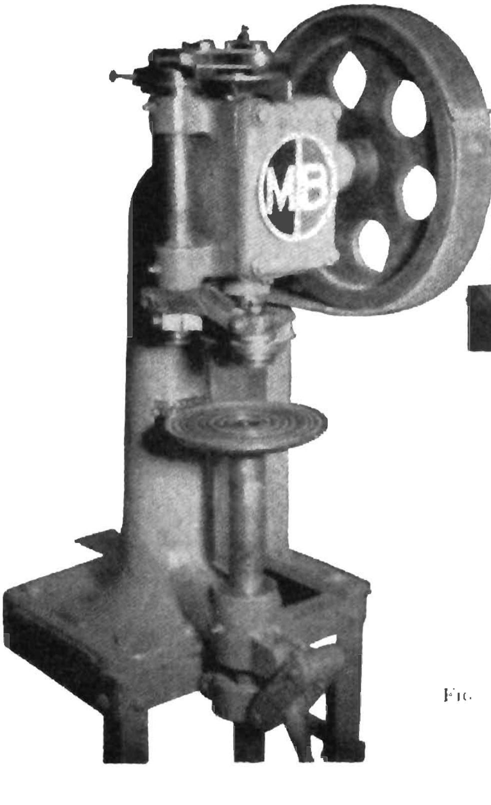


FIG. 18 CAN REFORMING UNIT: M.B. 1A DOUBLE SEAMER

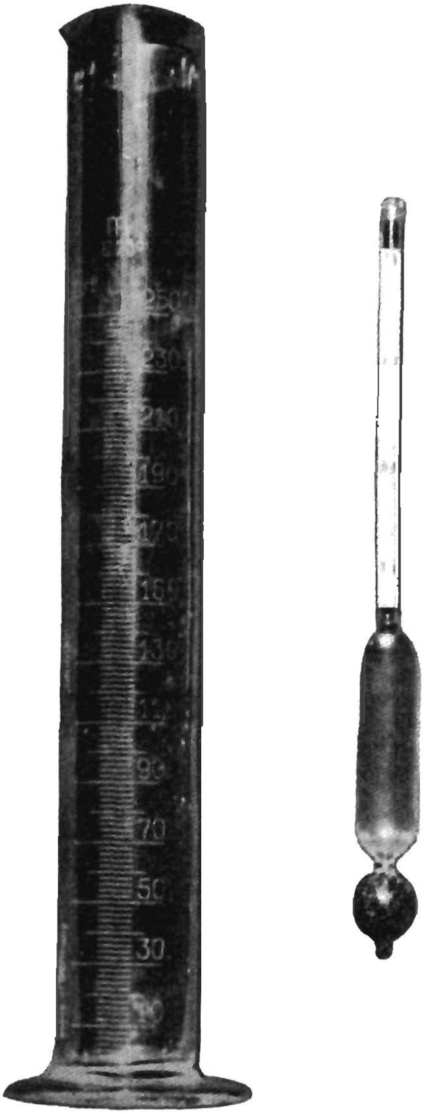


FIG. 19. A BRIX HYDROMETER FOR MEASURING SYRUP STRENGTH

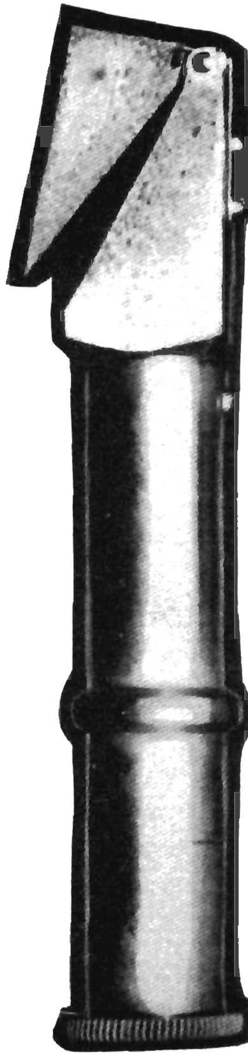


FIG. 20. A POCKET REFRACTOMETER FOR MEASURING SYRUP STRENGTH

CHAPTER IV

SYRUPS AND BRINES FOR CANNING

For canning fruits and vegetables different covering liquids are employed. Syrup of sugar, glucose, or corn is used for fruits, whereas brine is suitable for vegetables. The processes of preparing these for different requirements, on commercial as well as domestic scales, are dealt with below.

SUGAR SYRUPS

In canning fruits, sugar in the form of syrup is used to bring out the full flavour of the fruit, care being taken not to make the contents very sweet. Strength of the syrup would depend on the kind and variety of fruit. Generally, the more acidic fruits require denser syrups.

Only pure white crystalline sugar should be used. Chemically, this sugar is known as sucrose ($C_{12}H_{22}O_{11}$) and is found to the extent of about 99.5 per cent. in cane and beet sugars. In some canneries in the U.S.A. corn syrup or glucose syrup is also used for canning the cheaper grades of fruit and in preparing jams and jellies. Until Hirst and Adam of the Fruit and Vegetable Preservation Research Station, Campden, (U.K.), showed that beet-sugar was as satisfactory as cane sugar for canning purposes, it was not popular.

In India only cane sugar is employed. However, the possibility of using glucose and corn syrups should also be explored as these are being manufactured in the country nowadays. In the case of Indian cane sugar, several brands have been found to contain appreciable amounts of sulphur dioxide. When these are used for canning, fairly profuse black deposits, due to hydrogen sulphide, are formed inside the can during shortage. These spoil the appearance of the canned product. Cane sugar made by the Carbonation process is, therefore, to be preferred.

Preparation

Syrups can be made either by the 'cold process' or by the 'hot process'. In the cold process, sugar is placed in a tank and cold water poured over it and stirred. The solution is then filtered through a thick flannel bag, muslin cloth, or fine brass wire gauze to remove insoluble impurities. Sometimes, warm water may also be added to facilitate the dissolving of sugar. In the hot process, sugar and water are placed in a steam-jacketed kettle and boiled and the scum removed. The syrup is clarified further by filtration. Steam helps to sterilize the syrup and to prolong its preservability. The quantities of sugar and water required to prepare syrups of a given Brix are given in Table 7.

TABLE 7. RELATIONSHIP BETWEEN BRIX READING AND COMPOSITION OF SYRUP

Degrees Brix 68°F.	Weight of sugar to be added to each gallon of water lb.	Volume of syrup from one gallon of water gal.	Weight of sugar contained in one gallon of syrup lb.
10	1.11	1.067	1.04
11	1.23	1.076	1.14
12	1.36	1.085	1.25
13	1.49	1.093	1.36
14	1.62	1.101	1.47
15	1.76	1.111	1.58
16	1.90	1.119	1.70
17	2.04	1.127	1.81
18	2.19	1.137	1.93
19	2.34	1.146	2.04
20	2.50	1.157	2.16
21	2.66	1.167	2.28
22	2.82	1.176	2.40
23	3.00	1.187	2.52
24	3.17	1.198	2.64
25	3.34	1.208	2.76
26	3.52	1.220	2.89
27	3.70	1.231	3.01
28	3.89	1.243	3.13
29	4.09	1.256	3.26
30	4.30	1.269	3.38
31	4.50	1.281	3.51
32	4.72	1.294	3.64
33	4.94	1.309	3.77
34	5.17	1.323	3.90
35	5.40	1.338	4.03
36	5.64	1.353	4.17
37	5.89	1.369	4.30
38	6.14	1.384	4.44
39	6.41	1.401	4.58
40	6.69	1.419	4.71
41	6.97	1.437	4.85
42	7.26	1.454	4.99
43	7.56	1.474	5.13
44	7.88	1.494	5.27
45	8.20	1.514	5.42
46	8.55	1.536	5.57
47	8.90	1.558	5.71
48	9.26	1.580	5.86
49	9.64	1.604	6.01
50	10.03	1.628	6.16
51	10.44	1.654	6.31
52	10.86	1.681	6.45
53	11.31	1.710	6.61
54	11.77	1.739	6.77
55	12.26	1.770	6.93
56	12.77	1.803	7.08
57	13.29	1.837	7.23
58	13.85	1.871	7.40
59	14.43	1.907	7.57
60	15.05	1.948	7.73
61	15.69	1.988	7.89
62	16.37	2.032	8.05
63	17.08	2.077	8.21

TABLE 7. *Continued*

Degrees Brix 68°F.	Weight of sugar to be added to each gallon of water lb.	Volume of syrup from one gallon of water gal.	Weight of sugar contained in one gallon of syrup lb.
64	17.84	2.124	8.39
65	18.62	2.174	8.57
66	19.47	2.229	8.75
67	20.39	2.287	8.92
68	21.32	2.344	9.10
69	22.23	2.411	9.27
70	23.40	2.480	9.44

In commercial practice, syrups of desired Brix are prepared either according to a formula by which a known weight of sugar is added to a given volume of water, or by adding sufficient water to a known weight of sugar to get the desired volume of syrup. For example, addition of 5 gallons of water to 50.15 lb. of sugar will produce 8.14 gallons of syrup of 50 degrees Brix. Similarly, to get 5 gallons of syrup of 50 degrees Brix, using 30.80 lb. sugar, sufficient water is added to obtain the required quantity. Generally, to avoid unnecessary weighings, a 2 cwt. (224 lb.) bag is taken as the measure and a known volume of water added to the sugar.

Testing Syrup Strength

Uniformity of the canned product depends on the accuracy of measuring and mixing the syrups because any mistake in syrup-making cannot be rectified later. Since the cost of syrup forms an important item in the total cost of the finished product, it is essential to control the syrup strength and avoid wastage. Accurate thermometers and hydrometers are necessary for this. The different kinds of hydrometers used are Brix or Balling, Baume, Specific Gravity, and Twaddell (Fig. 19). A refractometer also can be used (Fig. 20).

The Brix or Balling hydrometer gives directly the percentage of sugar by weight in the syrup. It is calibrated at 68°F., and corrections are needed for other temperatures (Table 9). On the Baumé hydrometer, the divisions range from 0 to 70 degrees. The relation between the Brix and Baumé scales is given in Table 8. Specific gravity in the case of Baumé reading may be calculated by the formula: Specific gravity $= \frac{145}{145 - \text{Baumé reading}}$ Twaddell hydrometer is usually calibrated at 60°F., the divisions ranging from 0 to 200 degrees. One degree corresponds to 1.005 sp. gravity. Relationships between different types of hydrometers are shown in Table 8.

TABLE 8. COMPARISON OF BRIX, BAUME, TWADDELL AND SPECIFIC GRAVITY SCALES AND REQUIREMENTS OF SUGAR

Degrees Brix (per cent. sugar by weight) 20°C. (68°F.)	Degrees Baumé 20°C. (68°F.)	Degrees Twaddell 20°C. (68°F.)	Specific Gravity 20°C. (68°F.)	Approximate weight of sugar to be added to each Gallon of water	
				lb.	oz.
10	5.6	8	1.040	1	2
11	6.1	9	1.044	1	4
12	6.7	10	1.048	1	6
13	7.2	11	1.053	1	8
14	7.8	12	1.057	1	10
15	8.3	12	1.061	1	12
16	8.9	13	1.065	1	14
17	9.5	14	1.070	2	1
18	10.0	15	1.074	2	3
19	10.6	16	1.078	2	5
20	11.1	17	1.083	2	8
21	11.7	17	1.087	2	11
22	12.2	18	1.092	2	13
23	12.7	19	1.096	3	0
24	13.3	20	1.101	3	3
25	13.8	21	1.106	3	5
26	14.4	22	1.110	3	8
27	14.9	23	1.115	3	11
28	15.5	24	1.119	3	14
29	16.0	25	1.124	4	2
30	16.6	26	1.129	4	5
31	17.1	27	1.134	4	8
32	17.7	28	1.139	4	11
33	18.2	29	1.143	4	15
34	18.7	30	1.148	5	3
35	19.3	31	1.153	5	6
36	19.8	32	1.158	5	10
37	20.4	33	1.163	5	14
38	20.9	34	1.168	6	2
39	21.4	35	1.173	6	7
40	22.0	36	1.179	6	11
41	22.5	37	1.184	7	0
42	23.0	38	1.189	7	4
43	23.6	39	1.194	7	9
44	24.1	40	1.199	7	14
45	24.6	41	1.205	8	3
46	25.2	42	1.210	8	9
47	25.7	43	1.215	8	14
48	26.2	44	1.221	9	4
49	26.8	45	1.226	9	11
50	27.3	46	1.232	10	0
51	27.8	47	1.237	10	7
52	28.3	49	1.243	10	14
53	28.9	50	1.248	11	5
54	29.4	51	1.254	11	12
55	29.9	52	1.260	12	4
56	30.4	53	1.265	12	12
57	30.9	54	1.271	13	5
58	31.5	56	1.277	13	14
59	32.0	57	1.283	14	7
60	32.5	58	1.288	15	1
61	33.0	59	1.295	15	11
62	33.5	60	1.301	16	6
63	34.0	61	1.307	17	1

TABLE 8. *Continued*

Degrees Brix (per cent. sugar by weight) 20°C. (68°F.)	Degrees Baumé 20°C. (68°F.)	Degrees Twaddell 20°C. (68°F.)	Specific Gravity 20°C. (68°F.)	Approximate weight of sugar to be added to each Gallon of water	
64	34.5	63	1.313	17	13
65	35.0	64	1.319	18	10
66	35.6	65	1.325	19	8
67	36.1	66	1.331	20	6
68	36.6	67	1.337	21	5
69	37.1	69	1.343	22	5
70	37.6	70	1.350	23	6

Temperature Corrections

The syrup is placed in a tall glass cylinder. The hydrometer is lowered in it, and reading on the scale noted carefully at the lower meniscus of the syrup. The temperature of the syrup is also noted. Corrections for temperature are made according to data giiven in Table 9. Thus a syrup testing 30 degrees Brix at 20°C., will test only 26.88 degrees Brix at 55°C. For syrup temperatures above 20°C. corrections have to be added to, while for those below 20°C. these have to be subtracted from the observed readings.

Syrup Calculations

Sometimes it will be found necessary in practice to dilute a syrup or to increase its strength. This is facilitated by what is known as the 'square method' given below.

Draw a square ABCD with the centre marked E. At A note the Brix reading of the heavy syrup, and the pounds of sugar present per gallon of the syrup. At D write the Brix degree of the light syrup and the pounds of sugar per gallon of the syrup. This is marked zero when water only is to be added for dilution, and 100 when sugar is to be added. At E write the Brix degree and the sugar present per gallon of the desired syrup. Now work diagonally across the square. Subtract the smaller number from the larger and write the difference at the opposite corners C and B. These numbers represent the ratio in which the two syrups are to be mixed by volume to get the desired strength of syrup written at E.

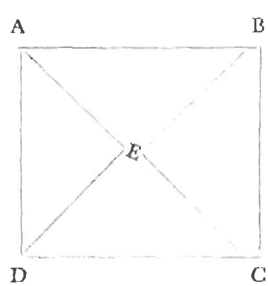


TABLE 9. TEMPERATURE CORRECTIONS FOR CHANGING PERCENTAGES OF SUCROSE BY DENSITY OF AQUEOUS SOLUTIONS TO TRUE VALUES AT 20°C.

Temperature °C.	Observed percentages of sugar													
	0	5	10	15	20	25	30	35	40	45	50	55	60	70
	Substract from observed percentage													
0	0.30	0.49	0.65	0.77	0.89	0.99	1.08	1.16	1.24	1.31	1.37	1.41	1.44	1.49
5	.36	.47	.56	.65	.73	.80	.86	.91	.97	1.01	1.05	1.08	1.10	1.14
10	.32	.38	.43	.48	.52	.57	.60	.64	.67	.70	.72	.74	.75	.77
11	.31	.35	.40	.44	.48	.51	.55	.58	.60	.63	.65	.66	.68	.70
12	29	.32	.36	.40	.43	.46	.50	.52	.54	.56	.58	.59	.60	.62
13	.26	.29	.32	.35	.38	.41	.44	.46	.48	.49	.51	.52	.53	.55
14	.24	.26	.29	.31	.34	.36	.38	.40	.41	.42	.44	.45	.46	.47
15	.20	.22	.24	.26	.28	.30	.32	.33	.34	.36	.36	.37	.38	.39
16	.17	.18	.20	.22	.23	.25	.26	.27	.28	.28	.29	.30	.31	.32
17	.13	.14	.15	.16	.18	.19	.20	.20	.21	.21	.22	.23	.23	.24
17.5	.11	.12	.12	.14	.15	.16	.16	.17	.17	.18	.18	.19	.19	.20
18	.09	10	.10	.11	.12	.13	13	.14	.14	.14	.15	.15	.15	.16
19	.05	.05	.05	.06	.06	.06	.07	.07	.07	.07	.08	.08	.08	.08
	Add to observed percentage in above table													
21	0.04	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.09
22	.10	.10	.11	.12	.12	.13	.14	.14	.15	.15	.16	.16	.16	.16
23	.16	.16	.17	.17	.19	.20	.21	.21	.22	.23	.24	.24	.24	.24
24	.21	.22	.23	.24	.26	.27	.28	.29	.30	.31	.32	.32	.32	.32
25	.27	.28	.30	.31	.32	.34	.35	.36	.38	.38	.39	.39	.40	.39
26	.33	.34	.36	.37	.40	.40	.42	.44	.46	.47	.47	.48	.48	.48
27	.40	.41	.42	.44	.46	.48	.50	.52	.54	.54	.55	.56	.56	.56
28	.46	.47	.49	.51	.54	.56	.58	.60	.61	.62	.63	.64	.64	.64
29	.54	.55	.56	.59	.61	.63	.66	.68	.70	.70	.71	.72	.72	.72
30	.61	.62	.63	.66	.68	.71	.73	.76	.78	.78	.79	.80	.80	.81

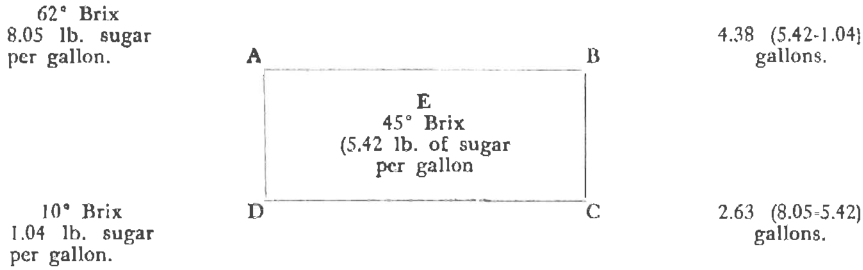
TABLE 9. *Continued*

Temperature °C.	Observed Percentages of Sugar													
	0	5	10	15	20	25	30	35	40	45	50	55	60	70
	Add to observed percentage													
35	.99	1.01	1.02	1.06	1.10	1.13	1.16	1.18	1.20	1.21	1.22	1.22	1.23	1.22
40	1.42	1.45	1.47	1.51	1.54	1.57	1.60	1.62	1.64	1.65	1.65	1.65	1.66	1.65
45	1.91	1.94	1.96	2.00	2.03	2.05	2.07	2.09	2.10	2.10	2.10	2.10	2.10	2.08
50	2.46	2.48	2.50	2.53	2.56	2.57	2.58	2.59	2.59	2.58	2.58	2.57	2.56	2.52
55	3.05	3.07	3.09	3.12	3.12	3.12	3.12	3.11	3.10	3.08	3.07	3.05	3.03	2.97
60	3.69	3.72	3.73	3.73	3.72	3.70	3.67	3.65	3.62	3.60	3.57	3.54	3.50	3.43
65	4.4	4.4	4.4	4.4	4.4	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9
70	5.1	5.1	5.1	5.0	5.0	5.0	4.9	4.8	4.8	4.7	4.7	4.6	4.6	4.4
75	6.1	6.0	6.0	5.9	5.8	5.8	5.7	5.6	5.5	5.4	5.4	5.3	5.2	5.0
80	7.1	7.0	7.0	6.9	6.8	6.7	6.6	6.4	6.3	6.2	6.1	6.0	5.9	5.6

TABLE 10. RELATION BETWEEN DENSITY, SALT PER CENT. AND SALOMETER READING

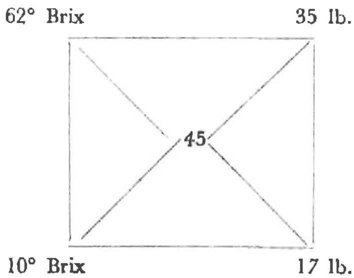
Density	Per cent. Salt wt./wt.	Salometer	Salt to 1 gallon water
1.017	2½	9.5	4½ oz.
1.034	5	18.9	8½ oz.
1.052	7½	28.3	13 oz.
1.071	10	37.7	1 lb. 2 oz.
1.090	12½	47.1	1 lb. 7 oz.
1.109	15	56.6	1 lb. 12 oz.
1.128	17½	66.0	2 lb. 2 oz.
1.148	20	75.5	2 lb. 8 oz.
1.169	22½	84.9	2 lb. 15 oz.
1.190	25	94.5	3 lb. 5 oz.
1.204	26½	100.0	3 lb. 10 oz.

Example: *To prepare a syrup of 45°F. Brix from syrups of 62° Brix and 10° Brix:*



Thus to prepare a syrup of 45° Brix, mix syrups of 62° Brix and 10° Brix in the ratio of 4.38: 2.63 by volume.

Syrups can be mixed by weight also as illustrated in the following example. Thus, to prepare a syrup of 45° Brix starting with syrups of 62° Brix and 10° Brix, mix 45-10=35 lb. of syrup of 62° Brix with 62-45=17 lb. of syrup of 10° Brix to obtain 52 lb. of syrup of 45° Brix. This is shown in the diagram below.



By following this procedure, different types of problems in preparing syrups can be easily solved.

BRINES

Brines are used in canning vegetables. Brines containing 1-2 per cent. of common salt are generally used. Only salt of good quality should be used. It should be free from iron, alkaline impurities, such as sodium sulphate, calcium chloride, magnesium sulphate, and their bicarbonates. The maximum solubility of common salt in water is about 26.5 per cent.

Strength of the brine is measured by a Salometer (also called Salinometer) or a Baumé hydrometer. The Salometer is calibrated from 0 to 100 degrees at 60°F. A brine testing 100 degrees Salometer contains 26.5 per cent. of salt. In other words, each degree corresponds approximately to 0.25 per cent. of salt. The Baumé scale directly represents the percentage of salt in the brine. One Baumé scale reading is equal to approximately four Salometer scale divisions. Relationships between the percentage of salt in the brine and Salometer readings are shown in Table 10. Colours and flavours are sometimes added to the brine used for canning some of the vegetables.

CHAPTER V

CANNING FRUITS

General methods of canning various kinds of fruits are discussed in the following pages. Specific requirements regarding the types of cans, syrup strengths, exhaust and process temperatures, the time factor, etc., are given separately in Table 11.

Apples

Apples are not canned to any great extent. Canned apples, which are usually available in large packings, are generally used in pies. The varieties commonly canned are: Yellow Newton Pippin, Spitzenberg, Winesap, Baldwin, Russet, Jonathan, Delicious, and Rome Beauty.

The fruits are first washed in warm dilute hydrochloric acid to remove any lead or arsenic spray residue and then rinsed in cold water. Next, they are peeled with hand or by machine and cut into slices, 1/8″ to 1/4″ thick. The slices are placed in 2-3 per cent. common salt solution to prevent their darkening due to enzyme action. They are then blanched at 160°-180°F. for 3-4 minutes in plain boiling water or 3 per cent. boiling brine. Blanching is essential to remove oxygen from the tissues and thus prevent pinholing in the cans during storage. The blanched slices are filled into cans, covered with hot water or thin syrup, exhausted, sealed and processed.

Apricots

Apricots are canned largely in the U.S.A. In India these grow mostly in Kashmir, Simla Hills and Uttar Pradesh, where considerable scope exists for their canning.

Apricots are of two kinds: white and yellow. In other countries, the Blenheim variety, which is of moderate size, deep yellow in colour, has good flavour, and can stand processing well, is popular for canning. The Tilton and Hemskirk varieties also are canned.

Apricots are not peeled for canning. They are merely cut into halves and the stones removed. Sometimes they are canned whole. According to Cruess, on an average, a ton of apricots yields about 55 cases of 24 No. 2½ cans. Siddappa has reported an average yield of 58 cases per ton of apricots.

Bananas

Banana is one of the most important fruit crops of India. More than 200 commercial varieties are grown over an area of about 4,04,550 acres.

Recently, Das, Jain and Girdhari Lal worked out a method for canning

TABLE 11. CANNING TIME TABLE FOR FRUITS AND TOMATOES*

Fruit	Type of can	Strength of syrup Degrees Brix	Exhaust	Processing time (min.) in boiling water 212°F.				
				No. 2 can	No. 2½ can	No. 10 can	Pint Jar	Quart Jar
Apple	Plain	Water or light syrup	Exhaust the cans at 180-212°F. for 7-10 minutes or until the temperature in the centre of the can reaches at least 165°F.	10	12	25	15	15
Apricot	Plain	55	,,	25	35	50	25	35
Banana	do	30+0.2% citric acid	,,	—	20	—	—	—
Blackberry	Fruit lacquered	55	,,	15	20	30	20	20
Cherry, sweet	do	40	,,	15	20	25	20	30
Cherry, sour	do	45	,,	15	20	25	20	30
Fig	Plain	55	,,	10	15	35	15	20
Grape, coloured	Fruit lacquered	40	,,	12	12	15	15	20
Grape, white	Plain	40	,,	10	12	15	15	20
Grapefruit	do	60	,,	See recipe	See recipe	See recipe	See recipe	See recipe
Greengage	do	40	,,	15	20	—	15	15
Guava	do	40	,,	20	20	—	25	30
Jackfruit	do	50	,,	25	30	—	—	—
Litchies	do	40	,,	25	30	—	—	—
Loganberry	Fruit lacquered	45	,,	10	12	25	—	—
Loquat	Plain	40	,,	25	30	—	—	—
Mango	do	40	,,	25	30	—	—	—
Mulberry, coloured	Fruit lacquered	40	,,	10	12	—	—	—

TABLE 11. *Continued*

Fruit	Type of can	Strength of syrup Degrees Brix	Exhaust	Processing time (min.) in boiling water 212°F.				
				No. 2 can	No. 2½ can	No. 10 can	Pint Jar	Quart Jar
Orange	Plain	50	Exhaust the cans at 180-212°F. for 7-10 minutes or until the temperature in the centre of the can reaches at least 165°F.	See recipe	See recipe	See recipe	See recipe	See recipe
Papaya	Plain	40	,,	25	30	—	—	—
Peach	Plain	55	,,	25	35	50	25	35
Pear	Plain	40	,,	25	35	60	25	30
Pineapple	Plain	40	,,	20	30	60	25	30
Plums, red	Fruit lacquered	40	,,	15	20	30	15	15
Raspberry	do	45	,,	10	12	25	—	—
Strawberry	do	50	,,	10	15	20	15	15
Tomato	Plain	Only tomato juice in case of standard pack	,,	25	30	70 (air-cooled) 90 (water cooled)	—	—

**Note*: These data have been taken from (i) The All American Way of Canning & Cooking. Wisconsin Aluminium Foundry Co., Inc., Manitowoc, Wisconsin. (ii) The Burpee Way of Home Canning & Cooking. The Burpee Can Sealer Company, 2635 North Kildare, Avenue, Cragin Station, Chicago, Illinois. (iii) Lal Singh & Girdhari Lal (1943), Final Report on the work done under the Fruit & Vegetable Preservation Scheme, Punjab (1934-1942), pp. 1-104 and (iv) author's data.

the fruit, alone as well as in combination with other fruits in the form of salads. According to them, only some varieties are suitable for canning. Out of the 20 South Indian varieties which they tried, *Pachabale, Chandrabale, Nendran, Chenganapurikodan, Poovan,* and *Vannan* yielded satisfactory results.

Fully ripe fruit is peeled with hand and cut laterally into slices of ½" to ¾" thickness. Sugar syrup of 25-30° Brix, containing 0.2 per cent. citric acid is used. The *p*H value of banana has been found to vary from 4.5 to 5.3. Butter size cans (1 lb. squat) are processed for 15 minutes in (i) boiling water (212°F.), if the *p*H of the fresh fruit is 4.8 or lower, and (ii) in a pressure cooker at 5 lb. steam pressure (sea level) if the *p*H is higher than 4.8. Cooling after processing should be quick and thorough.

Blackberries

Blackberries are canned to some extent in the U.S.A. and in the U.K. They are not available in any large quantity in India for commercial canning. Evergreen, Mammoth, and Himalaya are the important canning varieties.

The berries should be handled quickly after harvesting since they do not keep well for long.

Cherries

Cherries are grown mostly in the Kashmir Valley. There are three kinds of cherries—sweet varieties, sub-acid varieties, and acid varieties. The sweet varieties are light coloured with pinkish flesh, or deep red, or black. According to Siddappa and Mustafa, the White Heart Cherry, which is fairly big in size and has a creamy white flesh, and the Red Cherry, which is rather small and has a creamy white flesh, are good for canning. The Royal Anne, the Napoleon Bigarreau, and the Kentish Bigarreau are good foreign varieties for canning. Of the sub-acid varieties, the Mary Duke, the Kentish Red, and the Flemish Red are important for canning. These are bright red in colour and taste good. Morello, which is a large cherry of bright reddish purple colour, is important among the acid varieties. It is canned in heavy syrup. Maraschino cherries are canned for mixing with other fruits, fruit cocktails, ice creams, etc. For this, Royal Anne cherries, when slightly under-ripe, are used.

They are packed in barrels of brine containing calcium hydroxide, sulphur dioxide, and (occasionally) alum. According to Cruess, in California, brine for this purpose is made up of about 0.75-1.0 per cent. SO_2 and about 0.4-0.6 per cent. of unslaked lime. In Oregon, approximately 1.5 per cent. of SO_2 and about 0.90 per cent. of lime are used. The brined cherries are stored for 4-6 weeks for curing when their colour changes to white or pale yellow. These are then washed well and dyed with a red dye, like erythrosin, and the colour fixed with citric acid. These coloured cherries are used for canning or candying.

Figs

Figs are usually canned as a preserve. They should be allowed to ripen on trees to ensure good results. Kadota, Celeste, Magnolia and Smyrna are important canning varieties. After grading, the figs are wilted by placing them in hot water for 2-3 minutes at 180°F. They are sometimes lye-peeled and washed with water to remove the waxy coating and the adhering lye. These are then blanched in boiling water for 10-20 minutes, depending on their size and degree of ripeness, and packed in syrup of 45-55° Brix. Addition of about 0.5 per cent. citric acid to the syrup improves the blend and the keeping quality.

Grapes

Muscat and Thompson Seedless are good canning varieties. Only large sized berries are used for canning. Syrups of 20-40° Brix are used. Loss in canning is nearly 16 per cent. According to Siddappa and Ishaq, the seedless Kishmish and the seeded Haitha grapes give good canned products. Coloured grapes should be canned in lacquered cans.

Grapefruit

Grapefruit should preferably be tree-ripened. Marsh Seedless, Duncan and Foster are good canning varieties. According to Lal Singh and Girdhari Lal, Marsh Seedless and Foster varieties are the best for canning.

To remove the thick outer peel, the fruit is immersed in water at 200-206°F for 2-5 minutes, so that the peel becomes soft and can easily be removed with hand. The peeled fruit is then either lye-peeled or hand-peeled further. After peeling, the whole fruit is immersed for 20-30 seconds in a bath of hot dilute lye containing 1.5-2.0 cent. caustic soda. It is then thoroughly washed with cold water, and the segments are separated. A clean stainless steel knife of special design is employed to lift the segments one by one from the membranes without breaking them. When all the segments are separated, the membranes will be in the form of leaves of a book. In Florida, sections of peeled fruits are carefully removed by means of a special blunt knife or a knife made of bamboo or some other hard wood. The segments are filled carefully into plain cans, and sugar is added in layers or as syrup of 60° Brix. Syrup gives a better product. If dry sugar is used, about 2 ounces would suffice for an A2 size can. Unlike several other fruits, the filled cans of grapefruit are given a long exhaust of 25-30 minutes at 180°-190°F., and processed for 30-40 minutes at the same temperature to retain the full aroma and texture of the fruit. The cans are cooled immediately after the processing. Canned grapefruit becomes slightly firmer if kept for some time after canning. The cans should, therefore, be retained for some weeks before marketing.

According to Loesecke, eighty pounds of grapefruit yield about 33 cans of A2 size when lye-peeling is adopted, and 24-27 cans when the peeling is done with hand.

Greengage

Greengages are canned in syrup containing about 0.5 per cent. citric acid. The canned product, however, has a tendency to turn brown and become soft with a bitter flavour during storage. True greengage is fairly satisfactory for canning.

Guavas

Guavas of good quality are found in abundance in Uttar Pradesh, Madhya Pradesh, and some parts of South India. Canned guavas often have a taste and aroma better than those of even the fresh fruit. Its pulp, although soft in texture, stands the processing well, and does not darken during storage. Fully ripe firm fruit, preferably with white flesh and few seeds is selected for canning. It is peeled with knife or, sometimes, with hot lye, and cut into halves. The seeds are scooped out by means of spoon-shaped knives. The peeled and cored fruit is kept immersed in 1-2 per cent. common salt solution to prevent it from browning. According to Jain, Das and Girdhari Lal, peels and cores can be used for making guava jelly or guava cheese.

Jack-fruit

Jack-fruit (*Artocarpus integrifolia*) is available in plenty in Bombay, Bihar, Orissa, Mysore, Malabar and some parts of Madras State. It is an important staple food of certain sections of the people. The tree bears annually 60-75 fruits weighing 20-40 lb. each. In exceptional cases, the fruit weighs even 70-80 lb. The unripe green and immature fruit is prized as a vegetable. Experiments have shown that green jack-fruit can be canned as a curried vegetable. The crisp bulbs of the ripe fruit are used for canning in syrup. Yield of bulbs varies from 25 to 40 per cent. of the fruit's weight.

After cutting the fruit into several large pieces, the bulbs are removed with hand. As the fruit contains a white, highly sticky latex, a little gingelly or *til* oil or hydrogenated fat (commonly known in India as *Vanaspati*) is smeared on the hands to avoid it. The latex is soluble in the oil. The seeds are removed from the bulbs which are canned whole or as halves or quarters. Syrup of 50°Brix with 0.5-0.75 per cent. citric acid should be used as the *p*H of the fruit is very high, i.e., about 5.2. The method of canning jack-fruit has been fully standardised at the Central Food Technological Research Institute, Mysore.

The canned product has an exotic flavour and is quite likeable. There is scope for developing canning of the fruit on a commercial scale. The outer skin is rich in pectin, and can be used for preparing pectin. A good jelly can also be made out of the peel, and the inner perigones. The seeds can be used as a vegetable, or ground into flour which can be blended with wheat flour for making chapaties.

Litchi

Litchies are found in Uttar Pradesh, Bihar and Orissa.

For canning, the fruit should be tree-ripened. The outer shell is first cracked ; then the inside pulp is separated, and finally the stones are removed. Plain cans and syrup of 40°Brix with 0.5 per cent. citric acid are used. Prompt and thorough cooling of the cans after processing is necessary to prevent development of pink colour in the product. Canned litchies from China are well known in foreign countries.

Loquat

Loquats can be cut into halves and canned to get an attractive product.

Mangoes

India is the home of mangoes. A large number of varieties are found in almost all parts of the country. According to statistics collected by the Fruit Development Adviser, Government of India, out of a total fruit acreage of 3.16 million, mangoes alone covered 2.2 million acres in 1948-49, i.e., nearly 70 per cent. of the total area under fruits. Uttar Pradesh, Madras, Bihar and West Bengal lead in mango growing.

Among the numerous varieties, *Safaida, Sarholi* and *Duschri of* U.P., *Alphonso* of Ratnagiri ; *Badami* of Mysore ; *Benishan* of Circars ; and *Raspuri, Neelum* and *Mulgoa* of Madras and Mysore, are more important for canning purposes. The *Bangalora* variety also gives a fairly good canned product. Juicy and fibrous varieties are not suitable for canning. They are mostly used for making squashes, chutnies and pickles.

Firm ripe mangoes are picked and ripened in straw. These are then peeled with hand, and the pulp cut into 6-8 longitudinal slices. The slices are placed in a 2 per cent. common salt solution to prevent browning. Plain cans are used. Since some of the varieties have a comparatively high *p*H value, it is necessary to add 0.3-0.5 per cent. citric acid to the syrup for safe processing of the cans. About 1½ lb. of the unprepared fruit would be required for a one lb. butter size can. The trimmings of the pulp can be made into squash or jam.

Since mango is the most important commercial fruit of India, it is essential to develop its canning and preservation.

Oranges

Oranges are canned to a limited extent only. Satsuma and Mandarin of Japan are the important canning varieties. Malta, *Sathgudi* and the loose jacket oranges of Nagpur and Coorg also have been found suitable for canning.

The outer skin is removed straight with hand or after dipping the fruit in boiling water to loosen it first. The segments are separated and the fibres removed. These are then dipped into boiling lye solution of 1-2 per cent. strength for 20-30 seconds, rinsed in warm water, dipped into dilute HCl

FIG. 21. PREPARATION OF PAPAYA FRUIT FOR CANNING

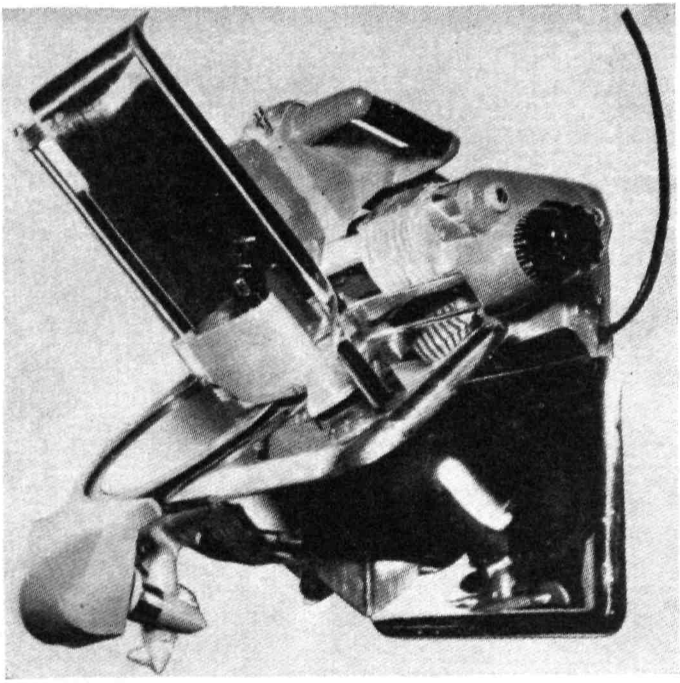


Fig. 22. A Small Power-driven Pineapple Slicing Machine

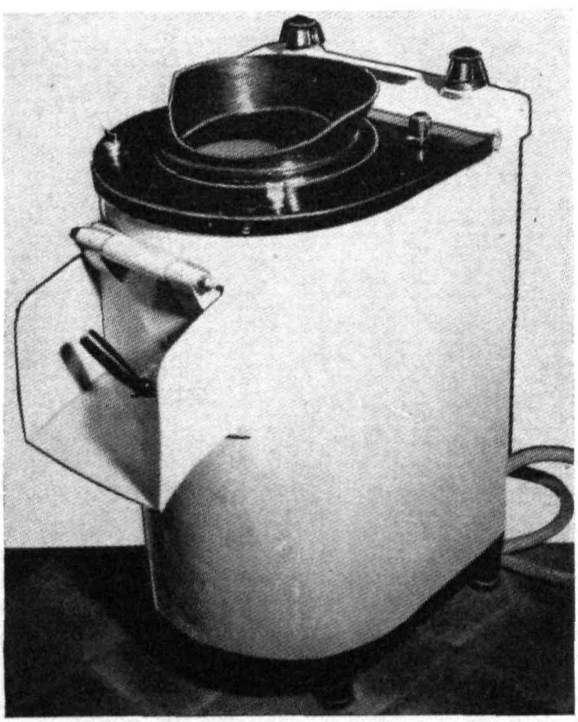


Fig. 23. Power-driven Potato Peeler

of 0.5-1.0 per cent. strength to remove traces of alkali, and finally rinsed in cold water. Any adhering membrane and seeds are removed with hand. Plain cans are used. A small amount of orange flavour may be added to the syrup. The cans are processed in the same way as grapefruit cans are processed—these are exhausted for 15-20 minutes, and then processed for 15-20 minutes, both at 180-190°F. Orange segments can also be used for canning as salad with other fruits like mango, pineapple, jack-fruit bananas, etc.

Papaya

Papaya slices or cubes can be used for canning (Fig. 21). About 0.5 per cent. citric acid should be added to the syrup.

Peaches

There are two types of peaches, the Cling-stone and the Free-stone. Among the former, the Tuscan, which is an early ripening variety, and the mid-summer varieties, Palora, Sims and Peaks, are important canning varieties. Phillips Cling is a good late variety. Elberta, Lovell, and J. H. Hale are free-stone peaches suitable for canning, while Muir is good for drying only. Crawford and Salway do not give good results. Canning of peaches is a very important industry in California and other parts of the U.S.A.

Almost all the canning varieties have a uniform yellow colour. According to Siddappa, *et al,* the white-fleshed varieties, which are soft and juicy like those of Quetta, are not suitable for canning. The Peshawari 6-A peach, which is similar to Elberta, is a good canning variety.

The fruit is cut round the suture, and the pit removed by inserting a spoon-shaped knife from the stem end and turning it until one half of the fruit separates off. The other half is freed of the stone with the same knife. In large-scale canneries, the pits are cut by a rapidly revolving buzz saw and removed by mechanically operated crescent-shaped knives. The cut halves are peeled by immersing them in boiling lye of 1-2 per cent. strength for ½ to 1 minute. Free-stone peaches are sometimes steam-peeled. They are then placed in cold water to prevent darkening. According to Cruess, a ton of Clingstone peaches will yield on an average 45 cases, and a ton of Free-stone peaches 41.2 cases of No. 2½ cans.

Pears

Pears are grown in abundance in the Kulu and Kashmir valleys, and to some extent in the hilly areas of South India. The fruit is harvested when it attains full size, but is still green. According to Lal Singh and Girdhari Lal, William pears of Kulu should be picked at a pressure of about 13-14 lb. These are subsequently ripened at 75-80°F.

The fruit is peeled with a knife from stem end to blossom end, cut into halves longitudinally, and the core removed with a coring knife. The peeled and cored fruit is placed in 1-2 per cent. common salt solution to prevent browning. Prompt and thorough cooling of the cans is necessary to prevent development of pink discolouration.

Pineapples

Pineapples are grown mostly in Assam, Bengal, Godavari district, and the west coast of South India. Giant Kew and Queen are the two important varieties.

In Hawaii and West Indies where pineapple canning is a big industry, peeling, coring and cutting are done mechanically by a Ginaca machine. In India, however, slicing machines (Fig. 22), punches, corers and eye removers worked with hand are generally employed. Rubber gloves should be worn as the fruit contains highly proteolytic enzymes which are injurious to the skin. The fruit is cut into rings, cubes or tit-bits and canned. The trimmings and cores can be used for preparing pineapple juice or squash.

Recently, Pruthi, Tandon and Girdhari Lal conducted extensive canning trials on three varieties of Indian pineapples, namely, Giant Kew, Kew, and Mauritius. They found that the percentage recovery of 'A' grade material fit for canning from these varieties ranged from 24 to 32, 13.7 to 20.8 and 9.7 to 11.4, respectively. Pruthi reports that their ascorbic acid content ranges from 14.0 to 16.6, 5.2 to 8.6, and 19.3 to 24.6 mg./100 gm., respectively ; the percentage acidity w/w (as anhydrous citric acid) from 0.6 to 0.8, 0.3 to 0.7, and 0.9 to 1.0 ; the percentage of refractometer solids, from 12.8 to 15.3, 9.3 to 15.4 and 10.4 to 13.4 ; and the *p*H from 3.3 to 3.5, 3.4 to 3.6, and 3.2 to 3.3, respectively. He also found that the retention of ascorbic acid in canned pineapples after 12 months' storage at room temperature (24-30°C.) was 72.3 per cent.

Plums

A few varieties of plums are grown in some parts of North India and in some hilly tracts in the South. Plums are canned largely in the U.K. The Red Victoria and the Yellow Pershore plums are important canning varieties. Purple Pershore, Early Laxton, Magnum Bonum, Evesham Wonder, Czar, etc., are other varieties that are moderately good for canning. The Alubukhara plum of North India gives a fairly good canned product.

Gummosis is a serious trouble in the case of plums. Plain cans are generally used in preference to lacquered ones. Plums are canned whole without removing the stones.

Berry Fruits

Strawberry, loganberry, blackberry, blueberry, raspberry and mulberry are the important berry fruits which are used for canning in different parts of the world. John Paxton, Royal Sovereign, and Oberschlesien strawberries are good for canning. Ponceau 2R colour is added to the syrup used for canning strawberries. White mulberries give a good canned product.

CHAPTER VI

CANNING VEGETABLES

Vegetables such as peas, beans, carrots, beetroots, tomatoes, asparagus, etc., are canned in large quantities in different parts of the world. In India, there is a good market for canned peas. Carrots, cabbages, potatoes, cauliflowers, tomatoes, etc. are canned in brine either in their natural form or in curried style using spices, fat, etc. Attempts are also being made to pack indigenous vegetables like brinjals, lady's fingers, green jack-fruit, etc. However, canned vegetables at present cater mostly for the requirements of armed forces, the demand from the general public being rather limited. Canning of some important vegetables is dealt with in Table 12.

Asparagus

Canned asparagus is a delicious thing. Green and white asparagus shoots of tender texture are used for canning. Immediately after removal from the field the shoots are washed to prevent subsequent discolouration. These are graded for size, and cut into lengths according to the height of the can. Blanching is done carefully for 2-3 minutes in boiling water with the bundles placed, tips up, inside a wire cage to prevent undue breakage. Sulphur resistant cans of the round or square type, and 2.0 per cent. brine are used for packing. Green asparagus is filled into cans with tips down, while the white ones are filled with tips up.

Beans

Tender stringless beans are preferred for canning. These are cut into one inch long slices. They are then blanched, filled into plain cans, covered with brine, exhausted, and sealed and processed under pressure. Lima and wax beans also are canned similarly in some parts of the world.

Beetroots

Beetroots are canned in the form of discs or cubes. The top and roots are cut off with a stainless steel knife, and the vegetable placed in 1-2 per cent. common salt solution to preserve colour before canning is done. Vegetable lacquered cans and 2.0 per cent. brine are used for canning.

Cabbage

Early season cabbage with tender yellowish leaves is used. The head is either cut into 4 to 8 pieces or shredded into pieces, about an inch thick. These are generally blanched for 5-6 minutes in boiling citric or tartaric

TABLE 12. CANNING TIME TABLE FOR NON-ACID VEGETABLES*

Vegetable	Type of can	Strength of brine	Exhaust	Processing time (min.) at 10 lb. steam pressure				
				No. 2 can	No. 2½ can	No. 10 can	Pint jar	Quart jar
Asparagus	Plain	2.25% common salt solution	Exhaust the cans at 190-212°F for 7-10 minutes or until the temperature in the centre of the can reaches at least 170°F.	20	24	40	30	35
Bean	Plain	2.5% ,,	,,	40	40	75	35	60
Beetroot	Sulphur resistant	Water or 1.5% common salt solution	,,	30	30	40	25	55
Cabbage	Plain	2% common salt solution	,,	—	40	60	—	—
Carrot	Plain	2% ,,	,,	20	25	50	35	40
Cauliflower	Plain	2% ,,	,,	20	20	..	25	30
Curried vegetable	Plain	—	,,			... See recipe ...		
Green gram	Plain	2% ,,	,,	40	45	..	40	40
Mushroom	Plain	2% ,,	,,	25	25	40	30	40
Okra	Plain	2% ,,	,,	25	35	..	25	40
Pea	Sulphur resistant	2% Common salt & 2-5% sugar solution	,,	40	45	60	40	40
Potato	Plain	2% common salt solution	,,	40	45	—	—	—
Turnip	Plain	2% ,,	,,	30	35	50	35	40

* The data have been taken from: (i) The All American Way of Canning & Cooking, Wisconsin Aluminium Foundry Co., Inc., Manitowoc, Visconsin, (ii) The Burpee way of Home Canning & Cooking. The Burpee Can Sealer Co., 2635, North Kildare Avenue, Cragin Station, Chicago, Illinois, (iii) Lal Singh & Girdhari Lal (1943), Final Report on the work done under the Fruit & Vegetable preservation Scheme, Punjab (1934-42), pp. 1-104 and (iv) author's data.

acid solution of 1.0 per cent. strength, and subsequently cooled in 2.0 per cent. brine to prevent discolouration. Plain cans and 2.0 per cent. brine are used for canning.

Carrot

There are two kinds of carrots available in this country, i.e. purple and yellow. Only the yellow variety is canned. Tender and small carrots are selected, washed well, and the skin rubbed off with coarse cloth. For large-scale work, mechanical peelers like the potato peeling machines are used. After peeling they are either used as such or are cut into discs or cubes. The pieces are blanched in boiling water for 5-13 minutes, and packed in plain cans using brine as covering liquid.

Cauliflower

Compact flower heads cut into pieces of suitable size are used for canning. The method is the same as that employed in the case of cabbage.

Gram

The white variety of gram in the fresh state is suitable for canning. Shelling is done by hand. The method of canning is the same as that employed in the case of fresh peas.

Mushroom

Edible mushrooms are canned in the U.K. and the U.S.A. Since many of the mushrooms are poisonous, great care is necessary in making selection. Sometimes, they are bleached to a pale colour in a solution of sodium sulphite and citric acid. They are then washed thoroughly and blanched for 4-5 minutes in boiling water or in steam, and dipped in cold water afterwards to avoid discolouration. Plain cans and 2.0 per cent. brine are used for packing. Sometimes, to enhance the flavour, about an ounce of citric acid is added for every 5 gallons of brine. To give a 'fried' flavour to the product (when working on a small scale) the mushrooms are cooked in an oven for a few minutes and a little water, butter and salt are added before canning.

Okra (Lady's Finger)

Tender, green okras of fairly uniform size are selected for canning as whole or as slices. These are blanched for 1-2 minutes in boiling water and then cooled in common salt solution of 1.5 per cent. strength for about 10 minutes. Plain cans and 2.0 per cent. brine are used.

Peas

In 1945, nearly 39 million cases of peas were canned in the U.S.A. alone. Alaska, Surprise, Thomas Laxton and Lincoln are the important canning varieties in the U.K. and the U.S.A. In India the peas grown are not of any definite variety.

Peas for canning should be uniformly ripe and should retain their green colour even after processing. These should have good flavour and texture. Large sized peas are generally suitable.

The peas are graded by size using sieves ranging from 9/32" to 13/32" or more. Sometimes they are graded by floating them in brine of 1.040-1.070 specific gravity. They are then blanched in boiling water for 2-5 minutes, rinsed in cold water, and filled into plain cans. Brine containing 2½ lb. of sugar and about 1½ lb. of common salt per 10 gallons of water is used as covering liquid. Sometimes an edible green colour and mint flavour are also added to the brine. The cans are exhausted, sealed and processed under pressure of 10 lb. for 40-50 minutes.

Canned fresh peas are commonly known as 'garden' or 'green peas'. Dried peas, which are soaked in water and then canned, are known as 'processed peas'. These are somewhat cheaper than fresh peas, and can be canned out of season also. For processed peas, the covering liquid should contain about 1¼ lb. of common salt, 5 lb. of sugar, and about 4-5 oz. of a 2.0 per cent. solution of a good green colour per 10 gallons of water.

Potato

Potatoes are canned whole or as slices. They should be sufficiently firm. They are peeled with hand or on a rotary vegetable peeler (Fig. 23), and placed in 2 per cent. brine to prevent discolouration. Some of the softer varieties of potatoes have to be placed, after blanching, in about 2.5 per cent. calcium chloride solution for an hour for firming of the texture. They are to be washed well before being filled into cans. Plain cans and 2.0 per cent. brine are used for canning.

Tomato

Only ripe tomatoes of medium size, regular shape and uniform red colour, free from blemishes and having plenty of pulp should be used for canning. Stone and San Jose are the two important canning varieties in the U.S.A.

Tomatoes are washed and then scalded in boiling water or steam for 2-3 minutes to crack the skin and facilitate its removal. The peeled tomatoes are placed in shallow pans to prevent crushing. Loss in peeling and trimming is about 30-35 per cent., according to Siddappa and Mustafa. The peeled tomatoes are then filled into plain cans, and common salt is added at the rate of about one per cent., i.e., a teaspoonful of salt for an A2½ size can. A little sugar is also added sometimes. Tomatoes are canned either as a solid pack, that is, without the addition of tomato juice, or as a standard pack with the addition of tomato juice. Generally, for safe processing, long cooking for 45-60 minutes in boiling water is necessary. Pressure processing, however, is not adopted as the tomatoes are fairly acidic.

Turnip

There are three types of turnips—red, white and yellow. White turnips are generally canned. They should be tender and free from fibre. They are cut into pieces of about 3/8 inch thickness, blanched for 3-4 minutes in boiling water, and then packed in plain cans using brine.

CURRIED VEGETABLES

In the West, vegetables are generally canned in brine. Spices are added to the drained vegetable before serving. In India people prefer to add fats, spices, etc., to the vegetable while it is being cooked. A suitable method has been worked out at the Central Food Technological Research Institute for preparing 'ready-to-save' canned vegetables in curried form. Potatoes and cauliflowers; cauliflowers and tomatoes; potatoes and peas; potatoes, peas and cauliflowers, are some of the suitable combinations. Green jack-fruit has also been found suitable for mixing. The vegetables are prepared for canning in the same way as for cooking. A special type of gravy is prepared as follows:

FOR ONE DOZEN A2½ CANS OF CURRIED VEGETABLE

Mustard (whole)	¾ oz.
Coriander powder	¾ oz.
Red chilli powder	½-¾ oz.
Caraway seed	¾ oz.
Turmeric powder	1½-1¾ oz.
Common salt	3¼ oz.
Vegetable fat (hydrogenated oil)	14 oz.
Water	Sufficient to make up gravy for 12 cans.

The fat is heated in a pan and the mustard fried in it for a few minutes till the seeds crack. The other spices, etc., are then added and frying is continued for a few more minutes. The required quantity of water is then added and the whole mass brought to a boil. Sixteen to twenty ounces of the vegetable are filled into an A2½ plain can, depending upon the combination of vegetables used. Hot gravy is finally added. The cans are then sealed and processed at 10 lb. pressure for 60-75 minutes.

CHAPTER VII

SPOILAGE IN CANNED FOODS

In storage, canned foods are liable to spoilage for various reasons. Fruit products often lose their normal and attractive appearance and become unsaleable although they may remain quite fit for consumption. The two important kinds of spoilage are: (i) spoilage by micro-organisms; and (ii) spoilage due to physical or chemical changes. Of these, the former is more important. The appearance, taste and smell of a spoilt can of food are different from those of a good one. Various indications of spoilage are as follows.

Swell

In a swelled can the ends are tightly bulged. The bulge is due to the formation of carbon-dioxide or other gases inside the can as a result of decomposition caused by micro-organisms. If the bulged ends are pressed hard, they may go inward, but when the pressure is released they will get back to their original position and would remain convex. The decomposed food in the can has an offensive and sour odour, and is generally discoloured. It is not fit for consumption, and may even contain toxins produced by bacilli like *Clostridium botulinum*.

Hydrogen Swell

Hydrogen, formed by the action of acids present in the fruit on the tin-plate, causes the can to bulge at the ends. In such cases, the food remains generally free from harmful micro-organisms and is fit for consumption.

Springer

A mild swell at one end or both the ends of a can is called a 'springer'. It may be an initial stage of hydrogen swell, or may be caused by insufficient exhausting or overfilling of the can. The bulged ends (or at least one end) can be pushed back to the original position by pressing, but will again become convex after some time. Food in such cans generally remains fit for consumption.

Flipper

A can with a mild positive pressure is called a 'flipper'. It may be an initial stage of swell or hydrogen swell, but more frequently it is due to under-exhausting or over-filling.

Flat Sour

This type of spoilage is caused mostly in non-acid foods like vegetables, by micro-organisms without production of gas. It is, therefore, difficult to detect it from the outward appearance of the can. It may be caused almost entirely by under-sterilization. In that case, thermophilic bacteria would be of special significance. The product always shows the presence of greater acidity than the normal stuff does and becomes unfit for consumption.

Leaker

A very small leak may appear in the can due to (i) faulty seam, (ii) faulty lock seam, or (iii) pinholes as a result of corrosion from the inside of the can or from rusting of the can from the outside.

Breather

There may be a very small leak in the can through which air may pass in, but not the micro-organisms. Consequently, air passes back and forth into the can. In this case, the vacuum is always nil and the pressure inside the can is equal to that of the atmosphere. The food remains fit for consumption. The damage to food in such cases is usually due to rusting of the can caused by oxygen in the air passing through the small leak.

Bursting of Cans

Cans may sometimes burst. This may be due to excess of pressure caused by the gases inside, produced by decomposition of the food by micro-organisms, or by hydrogen gas formed by chemical action of acids on the tinplate. In such cases, the canned food becomes a total loss.

DISCOLOURATION OF FRUIT PRODUCTS

Discolouration of canned foods may be due to biological causes or metallic contamination, or due to both.

Biological Causes

Cut and peeled apples and pears, if kept in air, turn brown due to oxidation. This change of colour is induced by oxidase enzymes present in them, and can be avoided by placing the cut and peeled fruits in 2-3 per cent. common salt solution until used for canning. Plums, greengages, etc., sometimes turn slightly brown near the surface of the can during exhausting. This can be prevented by regulating the exhausting process.

Brown discolouration of fruit products may also be caused by reactions other than enzymatic. Any of these reactions may go on independently of the others. The colour changes may be caused by reactions between (i) nitrogenous matter and sugars; (ii) nitrogenous matter and organic acids; (iii) sugar and organic acids; and (iv) organic acids themselves. These reactions, generally known as 'Maillard reactions', are of great importance in food preservation.

Metallic Contamination

This type of discolouration is caused by iron and copper salts. The following are important among these:

1. **Ferric tannate.** Some fruits and vegetables originally contain tannins. Sometimes tannins may also enter through the spices used for seasoning. These tannins, on coming into contact with the iron of the tinplate, form black compounds which spoil the appearance of the canned product.

2. **Iron sulphide.** Sulphur dioxide may enter the can through sugar or it may be formed inside the can itself due to the decomposition of the proteins in the product. The gas may react with the hydrogen formed by fruit acid acting on tinplate, and get itself reduced to hydrogen sulphide, which, in turn, will react with the iron of the can and form iron sulphide which is black in colour.

3. **Copper sulphide.** When the plant is shut down for some time (even for a few days), a thin film of copper oxide is formed on the surface of the equipment made of copper or brass. Although the equipment may be thoroughly cleaned before use, small traces of copper oxide or copper salts may still remain sticking to the surface of the metal. When the plant is started again, the first lot of the product will react with the copper compounds and dissolve the copper. The product coming into contact with hydrogen sulphide, formed inside the can due to several causes, will form a black copper sulphide which will discolour the product.

4. **Hydrogen.** Fruit acids reacting on the body of the can form hydrogen. Even in lacquered cans these acids may react through any scratches in the lacquer coating. The hydrogen thus formed will react with the red or purple colour of fruits like strawberries, loganberries, red plums, damsons, etc., and bleach it. The best remedy against this is to use perfectly lacquered cans. This will be possible if cans are lacquered after they are manufactured. In the case of cans made from lacquered tinplate, defects like scratches would generally develop during the fabrication process on high speed machines.

COLOURING MATTER IN FRUITS AND VEGETABLES

The colouring matter in fruits and vegetables considerably influences the discolouration of the canned products. There are two kinds of colouring matter: one which is soluble in the cell sap, and the other which is insoluble. The soluble colouring agents are called anthocyanins, and include blues, purples, violets, mauves, magentas and nearly all reds. They are mostly found in the epidermal tissues of the fruit, but are sometimes present in the flesh of the fruit also. Flavones are also formed in the plant. Both these groups of colours generate oxygen which corrodes tin in the presence of organic acids.

Nascent hydrogen bleaches the colours of anthocyanins, but the colours reappear on sufficient exposure to air. Sulphur dioxide also bleaches these colours, but they reappear on the removal of sulphur dioxide or on the addition of a stronger acid. Anthocyanins undergo certain changes in association with metals. These are precipitated by lead acetate. They are insoluble in ether and chloroform. Raspberries, cherries, red, purple and blue plums, damsons, and strawberries contain anthocyanin pigments. In the case of apples and peaches, however, the anthocyanins are present in the skin only, and do not, therefore, get into the canned product, since the skin is peeled off before canning these fruits.

The insoluble colours are bound up in portions of protoplasm, known as chloroplasts or chromoplasts, and include substances like chlorophylls. The scarlet, orange, red, brown and even black colours may be due to a mixture of soluble and insoluble colours present in the same tissues. Fruits like greengages, yellow plums, apricots, tomatoes and green gooseberries contain insoluble colours. Among these, the yellow colour does not suffer any change in the presence of metals or when the product is heated. Chlorophyll, in the presence of acid and oxygen, however, turns brown on heating. It reacts with zinc and copper, forming a deep colour which is not affected by heat.

DISCOLOURATION IN VARIOUS CANNED FOOD PRODUCTS

Typical examples of discolouration in canned products are given below:

Black deposit in canned pumpkin. The amino compounds present in the pumpkin react on the iron of the can forming black deposits in the canned product.

Discolouration in canned corn. Canned corn sometimes turns grey in colour. This is due to the formation of sulphides of iron and copper on account of corrosion of the tinplate and tarnishing of the metal of the equipment respectively. To prevent it, only 'C-enamel' or 'Corn-enamel' cans should be used. Zinc oxide forms one of the constituents of the enamel with which these cans are coated. Hydrogen sulphide formed during the processing of corn reacts with zinc oxide, forming white zinc sulphide. Since corn contains practically no acid, the zinc sulphide formed does not go into solution.

Black deposit in canned peas. A black flaky deposit is sometimes formed in canned peas due to the formation of iron sulphide. This is particularly marked when peas get heated or sweated before being canned. Thorough washing and blanching of the peas would help to overcome this trouble. There is also likelihood of a black deposit occurring on account of the formation of copper sulphide through copper contamination from unclean equipment. Formation of black deposit can, however, be prevented by using C-enamel cans.

Black deposit in canned fruits. In the case of fruits canned in syrups prepared from sugar, which sometimes contains sulphur dioxide, there is often serious blackening of the tinplate due to the formation of iron sulphide.

Pink colouration in canned pears and peaches. Pears and peaches turn pink if the cans are not cooled properly after sterilization. Pears grown in hot climate mostly develop this kind of discolouration. There is reason to believe that over-heating or sweating of fresh pears before canning also results in pink discolouration in the canned product.

Browning of canned apples. Peeled apples, when exposed to air, turn brown. As already pointed out this can be avoided by keeping the peeled or cut apples in 2-3 per cent. common salt solution. Pinholes also appear in the can if it is not thoroughly exhausted before sealing. The dissolved iron may also react on the tannins of the fruit and cause darkening.

CORROSION AND PERFORATION OF TINPLATES

Large quantities of canned fruit products are lost because of corrosion and perforation of tin containers. Great loss generally occurs in the case of acid fruits like apples, plums and berries. Corrosion, however, also takes place even in the case of less acid foods like pumpkin.

Corrosion due to Oxygen

It is well-known that oxygen rapidly decreases in the cans after they are sealed and sterilized. This is because it combines with the nascent hydrogen, formed by the action of acid on the tin container, or with the food. The larger the quantity of oxygen in the can, the greater is the corrosion. In the absence of air, the rate of corrosion of tinplate slows down. Oxygen can be excluded from the can by filling it properly and exhausting it thoroughly.

Effect of fill. When cans are filled properly, the head-space and the volume of air left inside will be small. Corrosion due to oxygen of the air in the head-space, will, therefore, be negligible. Slack filling of cans should, therefore, be avoided. In the case of products likely to produce hydrogen swell, sufficient head-space should, however, be left in the can to provide space for any hydrogen gas that may be produced.

Effect of exhaust. Heating of fruits before canning greatly reduces the amount of air in them. The filled cans, are, therefore, exhausted for a definite time to get rid of most of the air. A long exhaust at low temperature (5-6 minutes at 180-190°F.) gives better results than an exhaust at higher temperatures for shorter periods does.

Effect of temperature. Corrosion of tinplate is more brisk at higher temperatures than at lower. Fruit products, should, therefore, be stored at low temperatures to slow down the rate of corrosion and prolong their shelf-life.

Effect of cooling after processing. If hot cans are stacked together in a pile they do not cool down for a fairly long time. This results in stack burning. It is, therefore, necessary to cool the cans to about 100°F. before stacking them.

SPOILAGE BY MICRO-ORGANISMS

In some cases, due to the action of micro-organisms, gases are generated inside the can. Where there is no gas production, as in flat sour spoilage, the cans keep their original shape. Microbial spoilage of canned foods is generally of two kinds: non-poisonous and poisonous.

Non-poisonous Spoilage

This is usually due to understerilization. It is most commonly caused by a variety of yeasts present in the product. Bacteria are very seldom present in canned fruits of fancy, choice and standard grades which are carefully packed. They, however, appear sometimes in pie grade fruits. Spoiled cans are easily detected by the bulged appearance of their ends which is due to the pressure of carbon dioxide generated inside.

Poisonous Spoilage

This is caused by thermophilic bacteria. In this case, gas formation is very rare, and the cans retain their shape. However, the taste and flavour of the product inside suffer. Almost all non-acid foods are liable to flat-souring. It usually occurs in pasty materials or solid packs which are difficult to sterilize, e.g., spinach, sweet potato, etc.

Thermophilic bacteria are heat-resistant, and persist even at 212°F. If the canned food is stacked in a pile without proper cooling, the cans remain at a favourable incubation temperature for a long time so that these bacteria multiply and spoil the product. It is, therefore, quite essential that the cans should be cooled to about 100°F. before being stacked.

Thermophilic bacteria grow by forming spores. Some species, which are facultative, grow at 110°F., while some other species, which are obligative, grow at 110-170°F. Obligative bacteria are more difficult to kill than the facultative ones. Some thermophiles produce hydrogen, and some hydrogen-sulphide gas. The only way to get rid of them is to clean and wash the material thoroughly before canning.

STORAGE LIFE OF CANNED FRUITS AND VEGETABLES

As already pointed out, spoilage of canned products during storage may be due to two causes, i.e., (i) chemical action on the can producing hydrogen swells or perforations, and (ii) chemical action on the fruit or vegetable producing discolouration, loss of flavour, etc.

Hydrogen Swells and Perforations

Lal Singh, Girdhari Lal, Sadasivan and Jain have studied the formation of hydrogen swells in the case of canned plums, peaches, apricots and tomatoes. The higher the storage temperature, the more rapid will be the formation of hydrogen or of localised corrosion, producing finally perforation.

Several factors influence the formation of hydrogen. These, in the order of their importance are: (i) quality of tinplate; (ii) type of fruit; (iii) type of can used (i.e., plain or lacquered); (iv) quality of sugar; (v) addition of acid; (vi) exhaust, clinch, vacuum and headspace; and (vii) cooling.

Quality of tinplate: In the case of hydrogen swell, it is the can rather than the fruit which is affected. The quality of the can depends on the porosity of the tin surface of the plate used. The more this porosity, the greater is the corrosion of the can. This porosity can, however, be minimised by increasing and putting uniformly the tin coating on the plate. It is on this account that charcoal plate, which has about 2½ lb. of tin per base box, is preferred to coke plate which has only 1½-1¾ lb. of tin per base box.

Type of fruit. The marketable life of canned fruits varies according to their type. The storage life of some important canned fruits and vegetables is as follows:

(i) Canned fruits and vegetables that can be stored for about 2 years. Pineapple, peaches, peas, beans, celery, spinach, grapefruit.

(ii) Canned fruits and vegetables which can be stored for a brief period only. Soft and stone fruits, apricots, pears, prunes, fruit salad, tomatoes, vegetable soups, beetroot, carrot.

Type of can used. Plain cans are less susceptible to hydrogen swell formation than lacquered ones. Further, the green colour of fruits and vegetables is retained better in plain cans than in the lacquered ones, although more tin goes into solution in their case. Probably, the natural green colour of chlorophyll is stabilised by tin. White cherry, gooseberry, golden plum, greengage, mango, orange, grapefruit, jack-fruit, peach, apricot, etc., give good results when packed in plain cans.

Quality of sugar. Cane sugar tends to promote formation of hydrogen swell, while beet sugar retards it. This shows that some sugars contain accelerators, while some others contain inhibitors of corrosion. Beet sugar is a good inhibitor of corrosion in the case of fruits of low acidity such as greengages and cherries, but in the case of fruits of high acidity it does not give good results. This aspect of the problem has been studied in detail by Hirst and Adam at the Fruit and Vegetable Preservation Research Station, Campden, England.

Addition of acid. Addition of citric acid up to a strength of about 0.5 per cent. in the syrup used for canning fruits like sweet cherries, greengages, etc., checks the rate of formation of hydrogen swells to a considerable extent.

Other acids like tartaric, adipic, phosphoric etc. are not, however, as effective as citric acid.

Exhaust, clinch, vacuum and head-space. All these factors, which are inter-related, are controllable in the canning factory. Exhausting is done to drive out most of the air from the cans. It not only helps in proper filling of fruits and vegetables into cans, but also ensures a good vacuum, which is necessary to accommodate any pressure that might develop inside the can as a result of production of hydrogen gas due to corrosion.

Sometimes, the cans are clinched before exhausting. In that case, they can be exhausted at a higher temperature without any risk of damaging the contents at the top of the can. Chilling of the surface is also avoided during the transfer of the can from the exhaust box to the seaming machine.

A long exhaust at a lower temperature, that is at about 165°F., gives better results than a short one at about 180°F. provided the cans are closed at the same temperature. The advantage of exhausting the cans is, however, quickly lost if they are allowed to cool down appreciably before closing. Any undue cooling of the cans after exhaust and before sealing should, therefore, be avoided.

Head-space. This should be ¼"-⅜" before placing the lid on the can.

Cooling. The processed cans should be cooled to about 100°F. before stacking to avoid stack-burning.

The following precautions are required to be taken to prevent formation of hydrogen swells and perforations:

1. Cans made of tinplate of good quality should be used.
2. Citric acid up to 0.5 per cent. should be added to the syrup used for canning fruits of low acidity such as cherry, greengage, mango, jack-fruit etc.
3. The closing temperature should not be below 165°F.
4. Exhausting should be done for a sufficiently long time, but without unduly affecting the quality of the product.
5. The lids may be clinched before exhausting to get better results as regards vacuum and storage life of the product.
6. The headspace in the can should be ¼"-⅜" before fixing the lid.
7. The cans should be stored under cool and dry conditions.

CHAPTER VIII

FRUIT JUICES, SQUASHES AND CORDIALS

In India cold drinks are in demand for a greater part of the year. Among these, fruit juices have an eminent place. They are rich in essential minerals, vitamins and other nutritive factors, and are becoming popular on that account. Besides, they are delicious and have a universal appeal.

The dietetic value of real fruit beverages is far greater than that of synthetic products which are being produced in large quantities by aerated water bottlers in this country. The annual production of carbonated waters like lemonade, orangeade, strawberry, lime juice, etc. as well as of various kinds of *sherbets* and other artificially flavoured beverages runs into several million bottles. If real fruit juices could be substituted for these synthetic preparations, that would prove a boon to the consumer as well as to the fruit grower. There is, therefore, a great scope in this country for the manufacture of fruit juices and other beverages.

With the rapid progress in fruit farming that has taken place during the last two decades, fresh juices are being increasingly sold by vendors in some of the large towns in India. The demand for fresh juices is increasing but these cannot be had when the fruits are out of season. Fruit juices have, therefore, to be preserved in a form in which they can be used in off-season also.

The preparation of fruit beverages on commercial scale was practically unknown in India till about 1930. However, now products like squashes and cordials are being manufactured in the country to the extent of over 3 million bottles annually. If aerated water factories begin to use pure fruit juices instead of synthetic flavours and colours, that alone will create a demand for several thousand tons of fruit every year.

In the U.S.A., the annual production of juices is about ten crore gallons. Till about 15 years ago, only grape and apple juices were produced there in any considerable quantity. In those days, these juices were used almost exclusively for medicinal purposes and were recommended by physicians generally for infants and invalids. However, now on account of the common use of pure fruit juices as breakfast foods, a large variety is produced on a big scale from fruits such as orange, pineapple, tomato, grapefruit, apple and grape. Small quantities of juices from sour lime, lemon, tangerine, loganberry, cherry, blackberry, youngberry, apricot, peach, prune, plum, pomegranate, papaya, currant, and pear are also manufactured. Most of these tart juices are largely used for preparing mixed drinks and in bakery

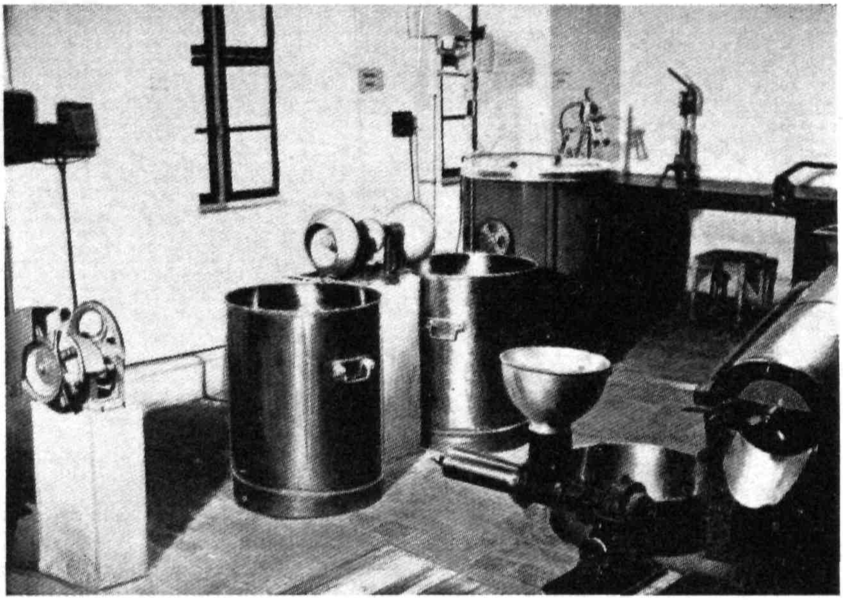


FIG. 24. HALVING AND BURRING MACHINES

FIG. 25. BURRING MACHINE FOR EXTRACTION OF JUICE FROM ORANGES

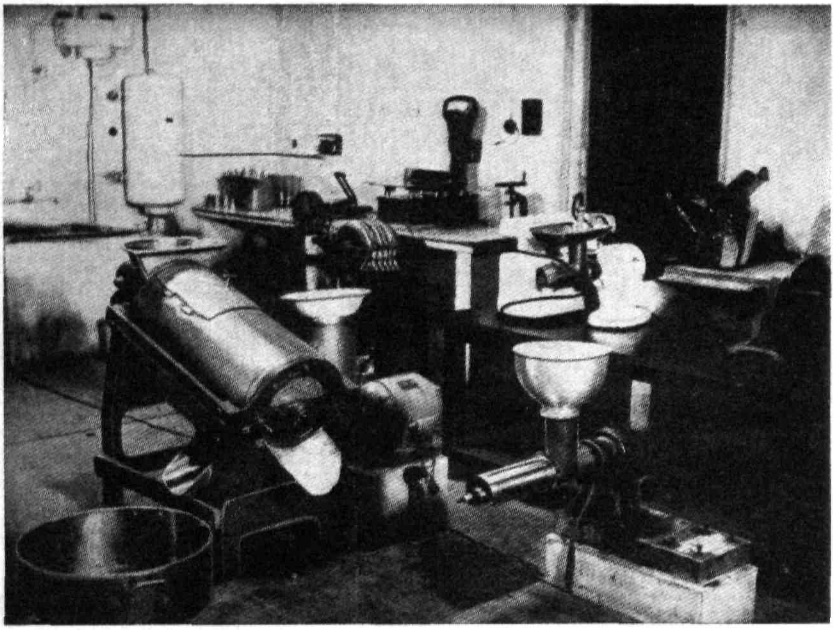


Fig. 26. Juice Extraction Room in Central Food Technological Research Institute, Mysore

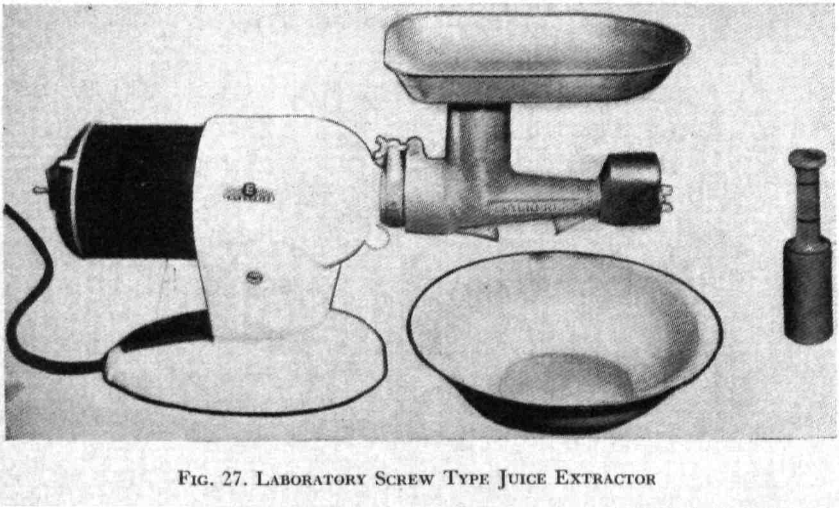


Fig. 27. Laboratory Screw Type Juice Extractor

products. These are now becoming more popular than the carbonated fruit juice beverages from apples and grapes.

In India, the pure fruit juice industry is still in its infancy. Preparation of these juices is limited mostly to home-scale production. The fruits generally used are grape, apple, pomegranate, mulberry, *jamun* (*Eugenia jambolana*), *phalsa* (*Grewia asiatica*) and mango. The scope for commercial production of fruit juices is, however, limited at present, as these are not yet included in the normal dietary of people. Tomato juice, however, has considerable commercial possibilities as it is already in fair demand.

Sherbets, which consist of sugar syrups flavoured with artificial essences of fruits and herbs, have been manufactured in India from times immemorial.

Of late, manufacture of orange squash, lemon squash, lime juice cordial, pineapple squash, and mango squash on a commercial scale has also made good progress in different parts of the country. Methods for preparing other beverages like passion-fruit squash, pomegranate syrup, mulberry syrup, plum squash, etc., were worked out at Lyallpur and Quetta in West Pakistan before partition. There appears to be good scope for these beverages also. However, proper publicity of the dietetic value of fruit beverages is necessary to stimulate demand for them.

EQUIPMENT FOR FRUIT JUICES

Until recently, the equipment used for extracting fruit juices was similar to that used in the manufacture of wine, vinegar, etc. In recent times there has been a rapid advance in the fruit juice industry in the U.S.A., the U.K. etc. Consequently, now one can get equipment ranging from the simple household juice extractor or press to the fully automatic juice lines capable of handling a few lakh bottles daily. Development of the citrus juice industry particularly, has been the most important factor in revolutionising the entire fruit juice industry. It is obviously essential that suitable equipment should be selected for successfully operating this industry.

Washing Equipment. For washing apples, citrus fruits, tomatoes, berries, etc., various types of washing equipment are available. Tender fruits, like berries, tomatoes, etc., are usually washed with overhead fine sprays of water while the fruits travel on a continuous woven wire belt. On a small scale, cement or galvanised iron tanks are quite suitable. A battery of these will be adequate for a factory of a moderate size.

Sorting Equipment. In large factories, a continuous broad belt made of woven metal is employed for sorting the fruits. Batch sorting will, however, suffice for small factories.

Extraction Equipment. There are two types of extractions. In one case, fruits are crushed and pressed simultaneously in one operation, while in the other, the fruits are crushed or cut into small pieces which are then pressed.

In citrus fruits, the juice is enclosed in small natural sacs. Besides these, there are other adhering tissues also. The peel consists of an inner white spongy portion, called the *albedo,* and an outer yellow coloured portion, called the *flavedo*. The oil glands are embedded in the *flavedo* and are easily broken with a slight pressure. Substances which are responsible for the bitterness of the juice are chiefly located in (i) the fruit tissues in which the juice sacs are embedded, (ii) the inner portion of the *flavedo,* (iii) the *albedo,* and (iv) the seeds. The presence of these bitter substances offers much difficulty in the extraction of the juice free from bitterness. An ideal equipment would be that in which juice is extracted from the juice sacs only without its coming into contact with the other tissues of the fruit. No mechanical device has been produced so far for doing this. With the present equipments, the bitter substances get extracted with the juice in varying dgrees. In general, the following four different types of equipment are used.

1. Halving and Burring Machines. *Malta* (*Citrus sinensis* Osbeck), grapefruit (*Citrus paradisi* var. maximan), lemon (*Citrus medica* var. Limonum) and galgal (*Citrus limonia* Osbeck) are cut by a special machine in which the fruit is placed in a cup on a wheel which brings the fruit against a stationary or revolving knife (Figs. 24 & 25). The fruit is cut into two halves which drop into a receptacle below. The cut halves are held against a revolving rose or burr which is conical in shape and is ribbed. The reamed juice is collected in a vessel placed below. The burrs are generally made of stainless steel, monel metal, aluminium, nickel, or non-odorous hard wood. By regulating the speed of the burr and the pressure on the fruit any undue tearing of the tissues can be avoided. In the U.S.A. several types of automatic rosing machines are in use (Fig. 25).

2. Continuous Screw Expeller Press. These presses are similar in principle to the household meat mincer (Figs. 27 & 28). The segments of the fruit are fed through a hopper at one end of a feeding screw revolving inside a conical jacket which has perforations below. The juice flows out through the perforations, and the pomace comes out at the end of the conical jacket. Power-driven extractors of this type are, however, not in general use in India. The juice from the extractors is cloudy and contains much macerated pulp. These extractors are generally employed in the case of tomato and pineapple juices.

3. Plunger-type Press. The halved citrus fruit is held on an inverted cup which is pressed along with the fruit by an automatic adjustment against a metallic cone fitting into the cup. The clearance between the cup and the cone is slightly more than the usual thickness of the peel of the fruit so that oil in the peel is not pressed out. This type of press is used only in one factory in India at present.

FIG. 28. SCREW TYPE JUICE EXTRACTOR

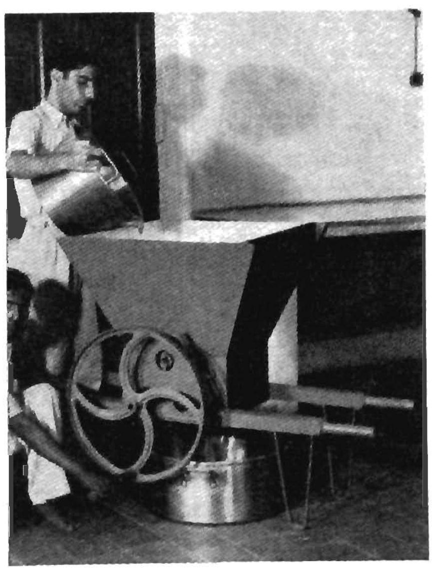


FIG. 29. GRAPE CRUSHER

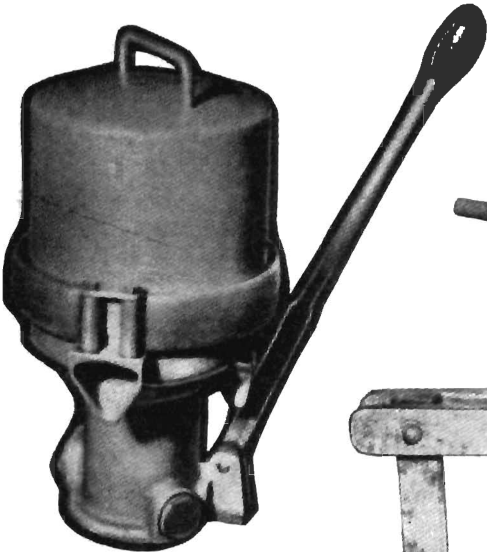


Fig. 30. A Small Hydraulic Press

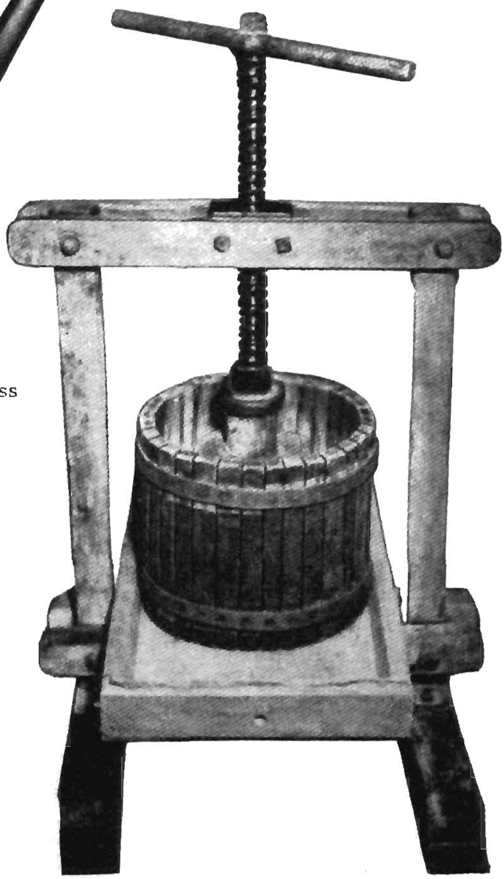


Fig. 31. A Basket Press

4. Roller-type Press. Roller presses made of hard granite or wood are specially designed to extract juice from sour limes (*Citrus medica* var. acida) which are popularly known as *Kagzi* or *Kagdi nimboo* or *limboo*. The whole lime is fed through the press. These presses are in extensive use in West Indies and Jamaica. They are in use in some of the factories in India also.

DOUBLE OPERATION

Fruits like apples, grapes, berries, etc., are first crushed in a grater or a crusher, and the juice then extracted in a hydraulic press. In large-scale production, the crushing device forms an integral part of the press itself.

Crushing

Apple Grater. The skin and other tissues in apples do not have any undesirable constituents which spoil the flavour of the juice as in the case of citrus fruits. The entire fruit is, therefore, crushed and pressed. The machine is commonly known as an apple grater. A battery of such graters can be used for large-scale production. The grater consists of a heavy steel cylinder, on the surface of which are fixed short knives which work against a corrugated plate attached to the frame of the press by the side of the steel cylinder with a series of steel springs. These springs give a certain amount of flexibility to the mechanism so that the grater is not damaged in case pieces of wood or stone get into the press along with the fruit. Gear arrangements are provided for running the rollers at high speed. Whole apples are fed into the hopper. They are grated or crushed between the cylinder and the corrugated plate, and fall into a container below. The grater can be set to crush the fruit to any desired degree of fineness. Pieces of $\frac{1}{8}''$ to $\frac{1}{2}''$ thickness are best for extraction of juice. In recent years a different type of crusher known as 'Hammer type Pulper' has come into use in the U.S.A.

Crusher for Grapes, Berries, etc. A grape crusher (Fig. 29) consists of two fluted or grooved rollers made of wood or metal. These are fixed horizontally, and revolve close together and towards each other. The fruit which is fed into the hopper at the top gets crushed between these rollers. Berries like strawberries, which contain gums, are first heated and then crushed. These crushers are good for crushing tomatoes also.

Pressing

Basket Press. Two types of presses are used in the industry for pressing juice from crushed fruit. They are (i) the basket press (Fig. 31), and (ii) the rack and cloth press. Basket presses which are of various designs and capacities, are worked by hand or by hydraulic pressure (Fig. 30). The hand-

It rests on a wooden or metallic base. There is a screw at the top of the frame. The crushed fruit is folded in a piece of strong cloth and placed inside the basket. By working the screw by hand or by a hydraulic pump, juice is pressed out and collected in a vessel placed below. The basket press has been found useful in the case of apple, grape, pomegranate, *phalsa* (*Grewia asiatica*), etc.

Rack and Cloth Press. In this type of press, the crushed fruit is placed on coarse woven cloth which is arranged in alternate layers between racks made of wooden slats and subjected to hydraulic pressure. The pressed juice is collected at the base of the pile. Various types of these presses are in use in foreign countries, and are claimed to give higher yield of clear juice than the basket type presses. In California, however, basket presses are preferred for extraction of juice from grapes. Rack and Cloth presses are not in use in India.

Other Types of Extractors. Special juice extracting devices have been designed in the U.S.A. for fruits like pomegranate, passion-fruit, etc. Chace, *et al*, have described a press for pomegranate juice in which the entire fruit is pressed. At the Quetta Fruit Preservation Laboratory, a hand worked basket press has been successfully used for the extraction of juice from whole pomegranates. Poore has described a special pulper for passion fruit in which the juice is extracted by reaming the halved fruit.

Pulping Equipment

Fruit juices extracted or pressed by any of the methods described above contain suspended matter like coarse fruit tissues, pieces of skin and seeds, and finely divided fruit pulp. These are removed in various ways, depending on the nature of the product required, e.g., cloudy, sparkling, clear, etc. Three important methods in common use are: (i) straining or screening; (ii) settling or sedimentation; and (iii) filtration.

Straining or Screening Equipment. Several types of equipment, varying in design and capacity are in use for straining juices. A pulper (Fig. 33) made of stainless steel, with a perforated cylindrical sieve enclosed in a jacket and with power-driven wooden, metallic or brush paddles revolving inside it, has been found highly useful in the case of citrus, tomato and mango juices. The fruit, which is fed through a hopper, is crushed and pressed by the paddles against the sieve. The juice flows out through the sieve into the jacket, and is collected at the outlet below, while the coarse residue passes out at the lower end of the sieve.

Equipment for Settling and Sedimentation. For sedimentation and settling only a few tall wooden barrels are required.

Filtration Equipment. Finely suspended particles in the juice are removed by special equipment known as 'filter press' (Fig. 34). Filter presses are of various designs and capacities. The filtering media may be finely woven cloth, canvas, fibre, asbestos pads, cotton or wood-plup discs, porous porcelain-ware, etc. The frame and filter press, which is similar to that used in sugar factories, but is made of wood, has been found highly effective for the clarification of lime juice for preparing cordial in some Indian factories. Seitz filters of various designs and sizes are useful for filtering wines, spirits, fruit juices, cordials, sugar syrups, etc.

A simple filtering mechanism, however, is a large conical bag of heavy drill cloth or felt, similar to the ordinary jelly bag. The juice is heated with filter aids, and placed inside the bag. Filtration is rather slow, but the output can be increased by having a battery of such filter bags.

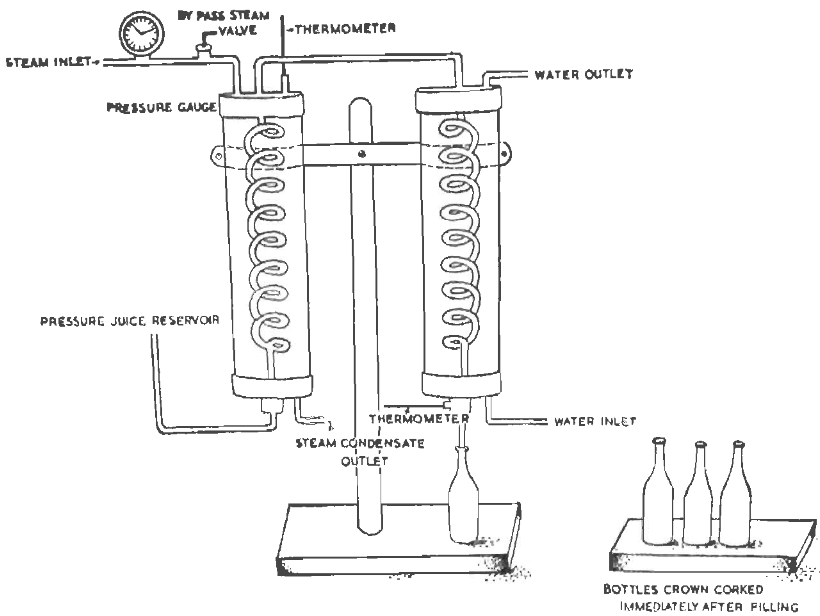


FIG. 32. DIAGRAM OF A LABORATORY FLASH PASTEURIZER

Deaerator and Flash Pasteurizer

Freshly extracted and screened juices contain appreciable quantity of oxygen which should be removed before packing. The special equipment used for this purpose is called a deaerator. The deaerated juice is then heated in a flash pasteurisation equipment (Figs. 32, 36 & 37).

Commercial deaerator and flash pasteurisers vary greatly in design, construction and capacity. Deaeration and flash pasteurisation units have been developed very much in the U.S.A. Special mention must be made of Stero-Vac process developed by Ayers in 1937. This process is a combination of deaeration and flash pasteurisation, and has been used with success in the case of citrus, tomato and pineapple juices. Such advanced processes and machines are not yet in use in India. They are, however, recommended for improving the quality of the natural juice products.

FRUIT BEVERAGES

Fruit juices are preserved in different forms such as pure juices, squashes, cordials, fermented juices, etc. These are broadly defined as follows:

1. **Unfermented Juice or Pure Fruit Juice.** This is a natural juice pressed out of a fruit, and remains practically unaltered in its composition during its preparation and preservation.

2. **Fruit Juice Beverage.** This is a fruit juice which is considerably altered in composition before consumption. It may be diluted before being served.

3. **Fermented Fruit Beverage.** This is a juice which has undergone alcoholic fermentation by yeast. The product contains varying quantities of alcohol, e.g., grape wines and apple ciders.

4. **Fruit Juice Squash.** This consists essentially of strained juice containing moderate quantities of fruit pulp to which cane sugar is added for sweetening, e.g., orange squash, lemon squash and mango squash.

5. **Fruit Juice Cordial.** This is a sparkling, clear, sweetened fruit juice from which all the pulp and other suspended materials have been completely eliminated, e.g., lime juice cordial.

6. **Sherbet or Syrup.** This is a clear sugar syrup which has been artificially flavoured, e.g., sherbets of *sandal, sangtra,* almond, etc.

7. **Fruit Juice Concentrate.** This is a fruit juice which has been concentrated by the removal of water either by heat or by freezing. Carbonated beverages and other products are made from this.

Preparation and Preservation

Fruit juices are best in taste, aroma and colour when freshly expressed. All subsequent efforts to preserve them injure their quality to varying degrees depending on the method of preservation employed. The most important problem, therefore, is to use such methods as would help retain these properties to the maximum extent.

The most important steps involved in processing juices are: (i) Selection and preparation of fruit; (ii) extraction of juice; (iii) deaeration; (iv) straining, filtration and clarification; and (v) preservation. The quality of the juice will depend on the manner in which the above processes are carried out.

Selection and Preparation of Fruit. All fruits are not suitable for making juice, either because of difficulties in extracting juice from them or because they yield juice of poor quality. Even some of the juicy fruits are not desirable as they do not yield juice of good quality. The variety of fruit,

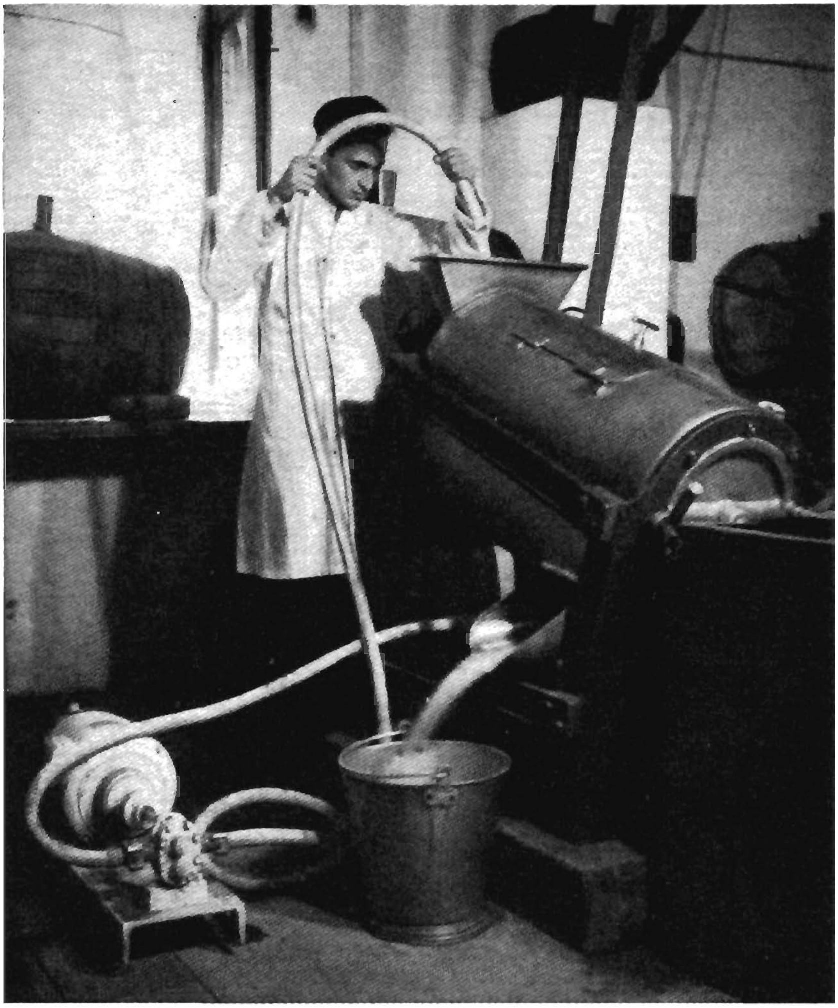


FIG. 33. A.P.V. PULPING MACHINE

FIG. 34. A HAND OPERATED JUICE FILTER PRESS

its maturity, and the locality in which it is grown, have a marked effect on its flavour, and keeping quality. The best juice is, therefore, extrated from freshly picked, sound and suitable varieties when these are of optimum maturity. Fully ripe, mid-season fruits, particularly citrus fruits, generally yield juice superior to that of early or late picked fruit. Decayed or damaged fruits do not yield good juice. Some cull fruits, i.e., under-sized, over-sized, malformed or blemished, which are not readily saleable as fresh friut, also can be used for the production of juices.

The fruits should be thoroughly washed with water, and in some cases thoroughly scrubbed while washing to remove dust and other extraneous matter. Residues of sprays of arsenic and lead should be removed with dilute HCl. Five gallons of HCl in 100 gallons of water is adequate for this purpose. All mouldy and decayed parts should be removed as in the case of fruits prepared for canning.

Juice Extraction. The method of juice extraction will differ with the structure and composition of the fruit. Generally juice from fresh fruits is extracted by crushing and pressing them. While extracting juice from a fruit in which it is enclosed in juice sacs or in cells, various other tissues in which these sacs or cells are embedded are also broken or crushed, resulting in the incorporation of some undesirable constituents. The methods of extraction employed should, therefore, aim at eliminating this contamination as far as possible. Further, the juice during extraction should not be unduly exposed to air as it will spoil its colour, taste and aroma and also reduce its vitamin content. Citrus juices, tomato juice, and even the more stable juices such as those of apples and grapes, deteriorate in quality rapidly when they are extracted by methods which expose them to air for unnecessarily long periods. For products like tomato juice, special extraction equipment has been designed recently to reduce incorporation of air to the minimum. The entire process of manufacture of tomato juice should be conducted in an atmosphere of steam to protect the juice from oxidation by air.

Deaeration. In spite of all improvements made so far in the extraction equipment, fruit juices retain some air. This is due to the difficulty of extracting juices without some aeration, as also to the presence of air in intracellular spaces of the fruits. Most of the air is present on the surface of the fruit particles, and some is found dissolved in the juice. In advanced countries, the juice (particularly pure orange juice, which is extremely susceptible to the adverse action of the residual air) is subjected, immediately after extraction, to a high vacuum whereby most of the air as well as other gases are removed. This process is called 'deaeration'. The equipment employed is very expensive and is not used at present in any factory in India.

Straining, Filtration and Clarification. Fruit juices after extraction always contain varying amounts of suspended matter which consists of broken fruit tissue, seed and skin, and also various gums, peptic substances and proteins in colloidal suspension. Usually coarse particles of fruit pulp, seeds and pieces of skin are removed by the use of screens, practically in all kinds of juices. The presence of these generally causes deterioration in quality. In the early years of the fruit juice industry in foreign countries, it was a common practice to remove completely all suspended matter, including colloidal suspensions, while packing pure fruit juices. This, no doubt, improved the appearance, but often resulted in lack of fruit character and flavour. The present trend is to let fruit juices and their beverages be reasonably cloudy or pulpy in appearance. Some juices and juice beverages like grape juice, apple juice and lime juice cordial are, however, still packed brilliantly clear.

Coarse particles of suspensions in juices are either removed by straining through non-corrodible metallic screens or by sedimentation. Sedimentation is a process of storing the juices in barrels or carboys after adding preservatives, to allow the coarse particles to settle down gradually. The supernatant juice, which contains mostly fine suspended particles and colloidal suspensions, is syphoned off for subsequent treatment. Straining machines used in commerce differ with the kind of juice. These machines are fitted with screens having holes of varying dimensions through which the juice is passed immediately after extraction. Coarse particles of tissues, skins and seeds are thrown out, and the juice with the desired amount of fine pulp and juice sacs is collected.

Where clear juices are required, complete removal of all suspensions is effected either by filtration or by clarification. This is done by employing fining agents and enzymes. These methods of clarification which have been used for a long time by wine makers, brewers and sugar manufacturers, are also being used in the fruit juice industry now.

Filtration is necessary for removing completely all fine and colloidal suspensions. It is a mechanical process in which the juice is forced through a filtering medium after it has been strained and separated from coarse particles. The filtering medium usually consists of woven fibre cloth, asbestos pads, cotton pulp, porous porcelain, or wood pulp. The colloidal suspension tends to clog the filters in the press. In order to minimise this, earthy filter-aids, like diatomaceous or infusorial earth also known as Kieselguhr, Kaolin, Spanish clay, etc., are added to the juice so that the filtering medium is coated with these and filtration is facilitated. The use of these filter-aids, however, imparts an unpleasant earthy taste to the juice. These should, therefore, be used with caution and in small quantities only. Besides, these should be kept in uniform suspension by constant agitation when the juice is forced through the press. They can be ignited and re-used several times. Joslyn and Marsh recommend boiling of filter-aid with 1.0 per cent. of citric or tartaric acid before use as this minimises their adverse effect on the taste and aroma of the juice. For the clarification of unfermented apple juice, Lal Singh and Girdhari Lal recommend the use of ignited Kaolin as filter-

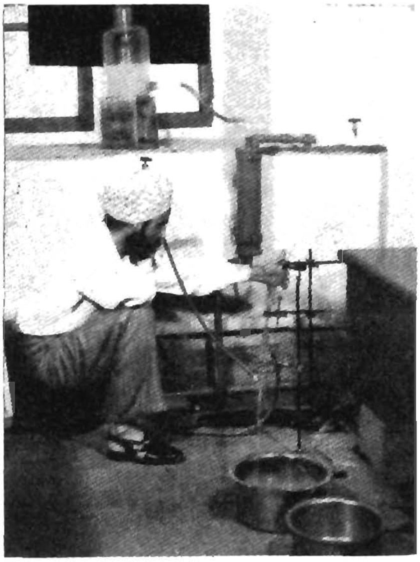


FIG. 35. LABORATORY JUICE DEAERATION UNIT

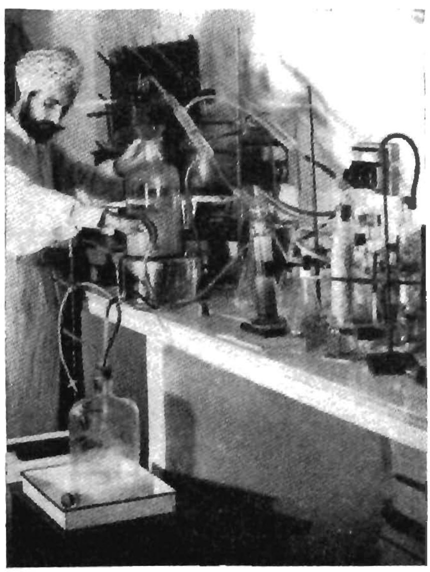


FIG. 36. LABORATORY FLASH PASTEURIZER

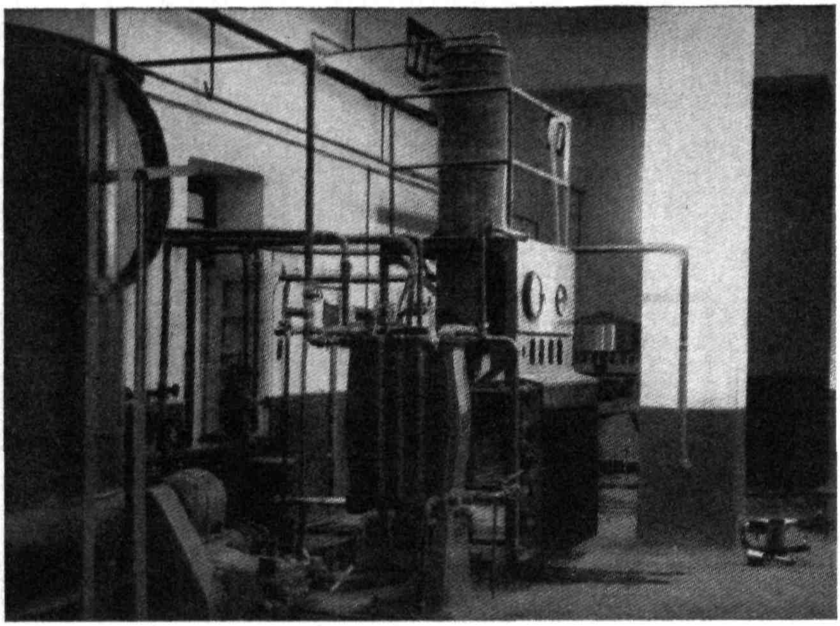


FIG. 37. DEAERATING AND PASTEURIZING PLANT

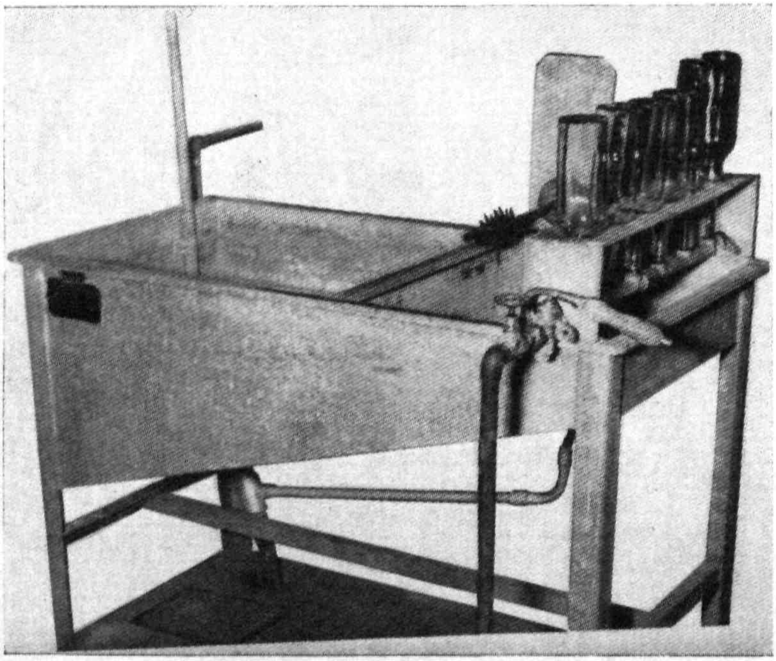


FIG. 38. BOTTLE WASHING MACHINE

aid at the rate of 1 lb. to 100 lb. of juice, for getting a sparkling clear juice. A variety of equipment like multiple disc filters, frame and plate filters, etc. is available in which the different types of filter-aids mentioned above can be used.

Use of Fining Agents. This method aims at producing a voluminous flocculent precipitate which gradually settles, carrying down with it finely divided particles and colloidal suspensions that cause cloudiness or 'haze' in clarified juices. A number of substances like gelatin, mixture of tannin and gelatin, milk, white of egg, casein, etc., have been used by wine makers and brewers for clarification. The tannin-gelatin method is most widely used for clarifying fruit juices. Clarification of apple juice by this method has been worked out by Carpenter and Walsh, Poore, Marshal, Cruess and Celmer, Joslyn and Marsh, Charley, and Lal Singh and Girdhari Lal.

Finings are of three kinds: (i) enzymes which destroy the colloids present in the juice, (ii) finings which are purely mechanical in their action, e.g., infusorial earths, and (iii) chemical finings which act on the gummy and colloidal substances present in the juice to form insoluble coagulates that settle down easily, e.g., gelatin, albumen and casein.

Enzymes. Various kinds of enzymes, such as proteolytic, pectin-decomposing, hydrolytic, starch-liquefying enzymes, etc., are sometimes used to remove pectin, proteins, and starch from fruit juices. In the trade, these enzymes preparations are sold under different names such as Pectinol Filtragol, Ido, Pectasine, etc. Each class of enzyme has a different type of action on the colloids present in the juices. The process of clarification differs according to the particular enzyme used.

Pectinol. The natural enzymes being not quite satisfactory, in 1930, Kertesz prepared an effective enzyme which he called Pectinol 'A'. Later on Pectinol 'B' and 'E' were also produced. Pectinol enzymes are prepared from the mould *Penicillium glaucum* which is found growing on grapes. Pectinol decomposes the pectin into soluble form, thus freeing the suspended particles which settle down speedily leaving the solution clear. Pectinol is widely used for clarification of fruit juices, and is sold in the market in different forms in foreign countries. There are three grades, namely (i) W. Grade for grape juice and wine, (ii) A. Grade for apple juice, and (iii) M. Grade for juices of other fruits like cherries, raspberries and prunes. The effectiveness of pectinol in coagulating colloidal material depends on the following factors:

1. Quantity of pectinol used. The amount of pectinol required for giving satisfactory results depends on the quantity of the suspended matter present in the juice. Usually, 0.1 per cent. of pectinol is sufficient to clarify apple juice.
2. Composition of the juice, particularly its *p*H value. Pectinol gives better results in acid juice.

3. Temperature at which the juice is treated. Apple juice can be clarified in about 20 hours at 66°F. At a lower temperature, however, it requires a much longer time. At 100°-110°F., only a few hours are required. Charley has compared the relative efficiency of pectinol, filtragol and maltolysin (a proteolytic enzyme for clarification of unfermented apple juices).

Filtragol. This is another pectin-decomposing enzyme which has been developed by Messrs Bayer, Leverkusen-Germany, for the clarification of juices of kernel-fruit, stone-fruit and grapes.

In the usual method of clarification by filtration, involving considerable quantities of precipitate in addition to the coarse matter from the juice, a large part of the colour and aromatic substances similar to the colloidal matter also get removed with the result that the juice suffers in quality in regard to its colour, taste, and aroma. But when Filtragol is used, it transforms into soluble compounds the pectin matter that holds the precipitate in suspension so that the suspended matter settles down. The juice is thus freed from slimy matter and is easily filtered. The colour, taste and aroma are not affected much. It has been reported that in the case of unfermented apple juice, clarification by Filtragol is far better than when other methods are employed.

The advantages of using Filtragol are as follows:

1. To facilitate filtration, fresh juices have to be pasteurised in order to coagulate pectin and other gummy substances in suspension. With Filtragol, however, heating becomes unnecessary.
2. As Filtragol reduces the quantity of the sediment, filtration takes less time.
3. Filtragol makes the colouring matter of the fruit go into solution without any heating. This avoids the usual heating process which is otherwise necessary to extract colour.
4. Efficiency of Filtragol is not impaired by the addition of sulphur dioxide in concentrations of 30-60 p.p.m. to the juice. Thus, the juice does not ferment while enzymes are at work.

The quantity of Filtragol to be added would vary with different juices. For the juices of kernel and stone fruits, and for grape juice, ¾-1½ grammes of it per litre are enough ; for juices of berries like raspberries, currants, gooseberries and blackberries, 1½-2 grammes per litre are required. When the juice is to be filtered soon after the addition of the enzyme, a slightly larger quantity should be added.

It is difficult to determine the stage of complete decomposition of the pectic substances in the juice, because the juice does not always become crystal clear after the pectic substances have been decomposed. Further, estimation of pectin as calcium pectate takes a fairly long time. The viscosity method, however, is quite rapid. With the progressive decomposition of pectin in the juice, viscosity goes on decreasing till it reaches a minimum indicating completion of the process.

After filtration, the juice should be heated to 170°F. for about 30 minutes or flash pasteurized at 190°F. to stop further action of the enzymes ; otherwise, the juice may become cloudy again.

Finings Having Purely Mechanical Action

Generally, infusorial earths like Spanish clay, Kaolin, Bentonite, etc. which are known as Filter-cels in commerce, are also used for the clarification of fruit juices. Work at the Central Food Technological Research Institute, Mysore, has shown that a local China clay also is suitable.

Roasted Filter-cels are called Super-cels. Filter cels should be immune to the action of acids present in fruit juices. They should not impart any undesirable flavour to the juice, and should not form any colloidal suspension. To ensure this, the earths are heated to dull redness to burn off all the organic matter likely to cause undesirable changes in flavour, and then treated with 1-1.5 per cent. citric or tartaric acid to remove all those constituents which are likely to be attacked by juice acids. They are subsequently washed thoroughly with water to remove all soluble salts, dried and ground to about 80-200 mesh size.

Usually, 0.5-0.6 per cent. of the earth is mixed with the juice, and the mixture then passed through the filter press. It has been found that in the case of unfermented apple juice ignited Kaolin added at the rate of 1 lb. to 100 lb. of the juice gives a sparkling clear juice.

Absorbing Carbons. Absorbing carbons are not suitable for clarification of fruit juices because they absorb not only the colouring matter of the juices, but also tannins and flavouring materials, thus rendering the juice insipid. Further, they also go into colloidal form in the juices and are, consequently, difficult to filter.

Chemical Finings

The bulk of suspended matter, particularly in apple juice, consists of proteins and pectin-like substances. The colloidal substances carry on them electrical charge, generally negative, and are precipitated when the charge is reduced to zero by the addition of positively charged colloids. Gelatin and casein act partly in this manner and partly by forming insoluble precipitates with the constituents of the juice. For instance, casein combines with the acids and gelatin with tannins. On settling, these carry down with them other suspended particles also.

Gelatin. It is an excellent fining material and is widely used for clarification of juices. The chemical reaction involved should be adjusted accurately for each juice and each type of gelatin used. This requires considerable time and experience. Further, there is also the danger of the juice becoming cloudy on account of excessive quantities of gelatin, because it forms a stable colloidal suspension.

The quantity of gelatin to be added to the juice is always determined by carrying out a series of small scale laboratory tests. Sufficient tannin is added to the juice to minimise the bleaching action of gelatin.

In the case of juice from Baldwin and Yellow Newtown Pippin, it has been found that addition of 1.25 ounces of tannin and 2.5 ounces of gelatin per 100 gallons of juice gives maximum clarity. About 0.5-1.5 ounces of tannin and 1.5-6.0 ounces of gelatin are generally required per every 100 gallons of the juice, depending on the condition of the juice. The juice is well stirred to make it homogeneous, and then the tannin solution is added. The treated juice is allowed to stand undisturbed for 18-24 hours to let the precipitated matter clot together and settle down. The clarified juice is then syphoned off, care being taken not to disturb the sediment. In the case of lime juice, it has been found that a dose of 7.5 ounces of tannin and 10 ounces of gelatin per 550 gallons of juice, preserved by the addition of about 350 p.p.m. of sulphur dioxide immediately after extraction, gives a brilliantly clear juice. The precipitate formed settles down completely in 4-6 days, and the clear supernatant juice can be syphoned off and used for the preparation of lime juice cordial.

Albumen. The white of egg contains albumen which can be liberated by heating it in a small quantity of water. It is sometimes used for clarifying fruit juices. Albumen is also available in the market in solid form which can be dissolved in water by soaking and agitation. Care should, however, be taken not to use very warm water as, otherwise, the albumen will coagulate. The albumen solution is mixed well with the juice, and the mixture heated to a temperature of about 10°F. higher than the pasteurization temperature to ensure complete coagulation of the albumen. If this care is not taken, there would be risk of further coagulation of albumen during the process of pasteurization, which would spoil the appearance of the juice. Usually, 2.0 per cent. solution of albumen gives good results, but it is advisable to find out by preliminary tests the exact quantity of the albumen solution required for any particular juice.

Casein. It is prepared from skimmed milk by precipitating it with hydrochloric acid. The precipitated casein is thoroughly washed with water to remove all traces of acid, and then dried and powdered. It is dissolved in liquor ammonia, diluted with 10-20 parts of water, and then boiled to remove all traces of excessive ammonia. Finally it is diluted with water to get a 2.0 per cent. solution. This dilute solution is mixed well with the juice which is to be clarified. In about 24 hours the acids in the juice precipitate the casein, which settles down along with the other colloidal particles. It is, however, advisable to find out by small scale trials the exact quantity of the solution of casein required for any particular lot of juice.

Clarification by Freezing

Colloidal suspensions, when subjected to freezing, are readily precipitated on thawing. Apple juice, particularly, responds very well to this treatment. Freshly extracted grape juice, besides containing the usual suspension of pulp, skin, etc., also carries varying quantities of cream of tartar or potassium hydrogen tartrate. When the juice is bottled in the usual manner, the cream of tartar goes on precipitating gradually in the form of fine crystals. The presence of these crystals in the juice is rather objectionable. In order to stop this slow precipitation, the bulk of the juice is subjected to refrigeration for several months to complete the precipitation. The clear juice is then bottled. Grape wines also behave like grape juice and are, therefore, treated similarly.

Clarification by Heating

It is a well-known fact that colloidal material in fruit juices usually coagulates when heated and settles down readily. To get good results, the juice is heated to about 180°F. for one minute or less, and then cooled down immediately. The heating is done in flash-heaters to avoid oxidation by air and to minimise the loss of volatile flavouring materials. After flash-heating and cooling, the juice is mixed with the filtering material and passed through the filter press. One great advantage of this method is that it also removes those substances from the juice which would otherwise be precipitated during pasteurization of the juice. Clarification of pomegranate juice is a typical example of this process.

PRESERVATION OF FRUIT JUICES

Freshly extracted juices are very attractive and have good taste and aroma, but they deteriorate rapidly if kept for sometime. This is due to several causes which are given below:

1. Fermentation may be caused by mould, yeast and bacteria.
2. Enzymes present in the juice may spoil its colour and flavour. For example, apple juice turns brown due to the activity of oxidative enzymes present in it.
3. Chemicals present in the juice may react with one another and spoil the taste and aroma.
4. Air on coming in contact with the juice may react with the glucosidal material in it and render the juice bitter. Thus the juices from Navel orange and sweet lime often turn bitter when they are exposed to air even for a short time.
5. Metals may enter into the juice from the equipment and spoil its taste and aroma.

To retain the natural taste and aroma of a juice, it is necessary to preserve it immediately after extraction. Various methods of preservation are employed, and each has its own merits. The methods generally used are: (i) Pasteurization ; (ii) addition of chemicals ; (iii) addition of sugar ; (iv) freezing ; (v) drying ; and (vi) filtration. Other methods such as preservation by pressure, by gases, by electric current, etc., are not generally used at present.

Pasteurization

Preservation of fruit juices by heat is the most popular method. The process of heating the juice to 212°F. or below for a sufficient time to kill micro-organisms which cause spoilage is called pasteurization. The juice is hermeticalled sealed in containers before being pasteurized. It would not spoil as long as the containers remain sealed against outside micro-organisms. Pasteurization temperatures do not kill all micro-organisms present in the juice. Some spore and spore-bearing bacteria like *B. subtilis* and *B. mesentericus* can survive the process and multiply later on. These survivals are, however, generally too weak to cause any spoilage. Further, these organisms are highly sensitive to acids and cannot grow in acid fruit and acid vegetable juices.

Mould spores are destroyed by heating at 175°F. for 5-10 minutes. Moulds require oxygen for their growth. Removal of air from the juice by filling the containers completely or by deaerating the juice under vacuum, or by replacing the air by carbon dioxide, therefore, facilitates their destruction even at lower temperatures. Yeast and acid-tolerant bacteria are readily killed if the juice is heated at about 150°F. for some minutes, but the spore-forming bacteria found in tomato juice require processing for several minutes at a higher temperature, i.e., at 190°F. Enzymes also require air for their action, and if air is removed from the juice they can be destroyed at a moderate temperature. Pectic enzymes, which cause changes in flavour and also bring about the clotting of particles in the juice, can be destroyed by heating the juice for about 4 minutes at 185°F. or for 1 minute at 190°F.

Fruit juices are pasteurized at such temperatures and for such periods as would render them sterile without impairing their flavour. Usually, the juices are pasteurized at about 185°F. for 25-30 minutes according to the nature of the juice and the size of the container. Acid fruit juices require lower temperature and less time for pasteurization than the less acid ones. To get good results, it is essential to keep all equipment perfectly clean and to carry out the work under hygienic conditions.

Pasteurization of juices can be done in two ways: (i) heating the juice at a low temperature for a long period, and (ii) heating the juice at a high temperature for a short time only.

In-the-Bottle Method or 'Holding' Pasteurization. This method is commonly used for the preservation of fruit juices at home. The juice, after extraction, is strained, filtered or clarified as the case may be, and filled into bottles leaving proper head for the expansion of the juice during heating. The bottles are then sealed air-tight and pasteurized.

Pasteurization by Over-flow Method. In this method, the juice is heated to a temperature about 5 degrees higher than the pasteurization temperature, and filled into hot sterilized bottles up to the brim, taking care that during filling and sealing the temperature does not fall below the pasteurization temperature. Only hot bottles should be used for filling to safeguard against fall of temperature of the juice and breakage of bottles. The sealed bottles are pasteurized at a temperature about 5 degrees lower than the filling and sealing temperature. After pasteurization, these are cooled. On cooling, the juice contracts leaving a small headspace which does not contain any air. This method is highly suited for grape juice because it minimises the adverse effect of air on the quality of the juice.

Flash Pasteurization. This is a process of heating fruit juices for only a short time at a temperature higher than the pasteurization temperature of the juice. In this method, the juice is heated rapidly for about a minute to a temperature about 10 degrees higher than the pasteurization temperature and filled into containers which are sealed air-tight under cover of steam to sterilize the seal and then cooled. It has especially been developed for the canning of natural orange juice which with ordinary pasteurization methods suffers in quality. It can also be adopted for pasteurization of other juices, like apple juice, grape juice, etc.

Different fruit juices require different amounts of heating. In order to get the desired effect, the flow of the juice through the pasteurizer is regulated so that it will be heated to the desired temperature and for the given time before passing out of the pasteurizer. The rate of heat transfer in these pasteurizers depends on the following factors which must be controlled carefully to get a product of good quality:

1. Viscosity and agitation of the juice.
2. Material and thickness of the juice.
3. Circulation of steam and removal of condensate.
4. Specific heat of juice and steam.
5. Temperature differences—initial, final and average.

Flash pasteurization has the following advantages:

1. It minimises losses in flavour.
2. It aids in the retention of vitamins.
3. It effects economy in time and space.
4. It helps to keep the juices uniformly cloudy.
5. It heats the juice uniformly reducing the cooked taste to a minimum.

Preservation with Chemicals

Pasteurized squashes and cordials have a cooked flavour and spoil within a short period after they are opened, particularly in tropical climate. To avoid this, it is desirable to use chemical preservatives. Chemically preserved squashes can be kept for a fairly long time even after opening the seal. It is, however, important that the use of chemicals should be properly controlled, since their indiscriminate use is likely to lead to harmful results. The preservative used should not be injurious to health and should be non-irritant. It should also be easy to detect and estimate.

According to the British Food and Drug Act of 1928 a 'Preservative' is any substance which is capable of inhibiting, retarding, or arresting the process of fermentation, acidification or other decomposition of food or of masking any of the evidences of any such process or of neutralizing the acid generated by any such process; but does not include common salt (sodium chloride), saltpeter (sodium or potassium nitrate), sugar, acetic acid, or vinegar, alcohol or potable spirits, spices, essential oil or any other substance added to the food by the process of curing known as smoking.

The two important preservatives permitted in different parts of the world are (i) Benzoic acid (including benzoates), and (ii) sulphur dioxide (including sulphites). These are allowed in India also according to the Fruit Products Order of 1955.

Sodium Benzoate. It is a salt of Benzoic acid and is used in the preservation of fruit juices and squashes. Benzoic acid is the effective agent; but since it is sparingly soluble in water, its sodium salt, which is water-soluble, is used. One part of sodium benzoate is soluble in 1.8 parts of water at ordinary temperature, while only 0.34 parts of benzoic acid will dissolve in 100 parts of water. Sodium benzoate is, therefore, 180 times more soluble than benzoic acid. Chemically pure sodium benzoate is practically tasteless and odourless.

The quantity of sodium benzoate required would depend on the extent and type of infection to be overcome and the nature of the juice, particularly its acidity. It has been found that in the case of juices having *p*H 3.5-4.0, which is the range of most fruit juices, 0.06-0.10 per cent. sodium benzoate is sufficient, but in less acid juices, such as those from ripe grapes, at least 0.3 per cent. is necessary. The acidity of the medium in which sodium benzoate is effective is very important.

The preservative action of benzoic acid increases in the presence of carbon dioxide. A typical example is that of *bacillus subtilis* which cannot survive in benzoic acid solution in the presence of carbon dioxide. Benzoic acid is more effective against yeasts than against moulds. It does not stop lactic acid and vinegar fermentations.

Introduction of substituted groups in the ortho, meta and para-positions of the benzoic acid molecule increases its germicidal properties, that is to say, as the side chain increases, the effectiveness of the compound also increases. In Germany, esters of para-hydroxy benzoic acid like methyl, ethyl and propyl esters, are generally used. They are, however, not used in India.

Sulphur Dioxide. Potassium meta-bisulphite (K_2O, $2SO_2$ or $K_2S_2O_5$) is used as a source of sulphur dioxide. The dry chemical is easier to use than liquid or gaseous sulphur dioxide. Potassium meta-bisulphite is a crystalline salt and is fairly stable in neutral or alkaline media. It is, however, decomposed by weak acids like carbonic, citric, tartaric and malic acids. When it is added to the fruit juice or squash, the potassium radicle reacts with the acid of the juice forming the corresponding potassium salt, and the sulphur dioxide, which is liberated, forms sulphurous acid with the water of the juice. The reactions are as follows:

	$CH_2.COOH$	$CH_2.COOK$		
	:	:		
(i) $3K_2O, 2\ SO_2 +$	$2C(OH).COOH =$	$2C(OH).COOK$	$+6SO_2$	$+3H_2O$
	:	:		
	$CH_2.COOH$	$CH_2.COOK$		
Potassium meta-bisulphite	Citric acid	Potassium Citrate	Sulphur dioxide	Water

(ii)	SO_2	$+H_2O$	$=$	H_2SO_3
	Sulphur dioxide	Water		Sulphurous acid

The preservative effect of sulphurous acid depends not on its total quantity but on the available amount of sulphur dioxide. According to Cruess, combined sulphurous acid has very little antiseptic value against micro-organisms, 6,000 p.p.m. of the combined form having less toxic action on yeast than 50 p.p.m. of free sulphurous acid. It has been shown that it is the undissociated H_2SO_3 molecule which prevents the multiplication of yeast, and the HSO_3 ion which inhibits the growth of bacteria *E. Coli* in concentration of 10 mg. per 100 ml. The growth of yeast is not inhibited by HSO_2 ion. The difference in the efficiency of the undissociated molecule and the ion of the same acid is explained as being due to the difficulty for the ions to permeate living cell membranes.

Pure sucrose does not combine with H_2SO_3, but many other substances like glucose, unidentified acetaldehydes or ketones, pectin, perhaps also break-down products of pectin, like arabinose, etc., which are found in fruit juices, have the property of combining with sulphur dioxide with the result that the effectiveness of sulphur dioxide is reduced. This is especially important in the case of syrups and concentrated juices where the sugar content is high. It has been shown that such a reaction is reversible and reaches equilibrium according to the following equation:

Sugar (or aldehyde) + bisulphite $\rightleftarrows$ Sugar (or aldehyde) sulphite

Although sulphur dioxide can retard the development of yeast in the juices, it cannot arrest their multiplication, once their number has reached a high value. It is, therefore, necessary to carry out a yeast count before adding sulphur dioxide to the juice.

According to the Indian Fruit Products Order, the maximum amount of sulphur dioxide allowed in squashes and cordials, is 350 p.p.m. This corresponds to about one ounce of potassium metabisulphite per 100 lb. of the squash or cordial.

For preserving raw citrus juices which are to be stored for some months for the manufacture of squashes in the off-season, generally 700 p.p.m. of sulphur dioxide is used. In the final squash containing about 25-30% of juice, this concentration will be considerably reduced.

It is well-known that juices with a high percentage of acidity do not ferment readily. The preservative action of the acid may be due to the hydrogen ion concentration or to the toxicity of the undissociated molecule or the anion. The toxic effect of a mineral acid is due to its hydrogen ion concentration, but the toxicity of an organic acid is mainly due to the undissociated molecule or the anion. Moulds grow in the *p*H range of 1.5-8.5; yeasts in the *p*H range of 2.5-8.0, and bacteria in the range of *p*H 4.0-7.5. As fruit beverages like citrus squashes and cordials have generally a *p*H value of 2.5-3.5, the growth of moulds and yeast in them cannot be prevented or checked by acidity alone. Bacteria, however, cannot grow in this *p*H range.

The *p*H value is thus of great importance in the preservation of food products. By regulating the *p*H of the product, one or more kinds of micro-organisms in the beverage can be eliminated, and the preserving quality of the beverage increased. Cruess found that the preservative action of sulphur dioxide increases with decrease in the natural *p*H of the fruit juice. It has also been noticed that the real antiseptic power of sulphur dioxide in musts and wines is proportional to their acidity. Rahn and Conn have shown that the undissociated sulphurous acid is nearly one hundred times more efficient as a preservative in strongly acid solutions than in neutral solutions. The marked influence of the *p*H of the medium on the effectiveness of the preservative can be seen from the following Table:

TABLE 13. CONCENTRATION OF SULPHUR DIOXIDE (IN PARTS PER MILLION) REQUIRED TO PREVENT GROWTH OF ORGANISM AT DIFFERENT *p*H LEVELS

(*After Salton, Annear and Ohye, 1946*)

*p*H Value	Saccharomyces ellipsoideus	Mucor Mould	Penicillium Mould	Mixed Bacteria
	p.p.m. of SO_2	p.p.m. of SO_2	p.p.m. of SO_2	p.p.m. of SO_2
2.5	200	200	300	100
3.5	800	600	600	300
7.0	above 5,000	above 5,000	above 5,000	above 1,000

The toxicity of sulphur dioxide is markedly increased at higher temperatures.

One great advantage of preserving fruit juices and squashes with sulphur dioxide is that its strong effect in retarding oxidation prevents discolouration and loss of flavour in the product. It cannot, however, be used in the case of naturally coloured juices, like *phalsa*, *jamun*, and pomegranate juices, strawberry pulp, etc., on account of its bleaching action. It cannot also be used in the case of those juices which are to be stored in tin containers, because not only does it act upon the tin of the can causing pinholes, but also forms hydrogen sulphide which has a disagreeable smell and forms a black compound with tinplate. Both are highly objectionable defects.

The following are some of the important considerations to be kept in view while using chemical preservatives:

1. As natural juices contain only small quantities of substances that combine with sulphurous acid, they can be preserved with normal doses of sulphur dioxide, i.e. about 350 p.p.m.
2. In the case of fruit juices of low acidity, extra acid should be added to lower their *p*H value and thereby increase the preservative action of sulphur dioxide.
3. In concentrated juices the sulphurous acid-fixing substances are high, and higher percentages of sulphur dioxide are, therefore, required for their preservation. Downer suggests that in the case of concentrated juices the total sulphurous acid to be used should be equivalent to that needed for a normal juice multiplied by the degree of concentration of the juice. Commercially concentrated juices are, however, generally preserved with about 1,500 p.p.m. of sulphur dioxide.
4. Since sulphur dioxide has got selective action and is more toxic to moulds, mould spores and vinegar bacteria, than to yeast, its use in conjunction with sodium benzoate, which is more toxic to yeast than to vinegar bacteria, is desirable. The use of these preservatives in combination has been advocated by Joslyn and Marsh, particularly because the use of sodium benzoate alone results in the darkening of the product. For effective preservation, the amount of these preservatives to be used singly or in combination depends on the character of the juice, particularly its acidity and sugar content. For instance, according to Lal Singh and Girdhari Lal the maximum permitted concentration of 350 p.p.m. of sulphur dioxide can be diminished to 100-200 p.p.m. in citrus squashes having an acidity of 2.0-2.5 per cent. as citric acid and sugar content ranging from 45° to 65° Brix.
5. Sulphur dioxide imparts a slight taste and odour to a freshly prepared beverage, but these are not discernible when the beverage is diluted for drinking. Further, these adverse effects on taste and odour disappear during subsequent storage of the product. This is particularly true of citrus fruit squashes.

In spite of its shortcomings, the use of sulphur dioxide for preservation of juices and squashes is preferred for the following reasons:

1. It has a better preserving action against bacterial fermentation than sodium benzoate.
2. It helps to retain the colour of the beverage for a longer time than Sodium benzoate.
3. Being a gas, it helps in preserving the surface layers of the juice also.
4. Being highly soluble in juices and squashes, it ensures better mixing and hence preservation.
5. Any excess of sulphur dioxide present in the juice can be removed either by heating the juice to about 160°F. on passing air through it, or by subjecting the juice to vacuum. This causes some loss of the flavouring materials due to volatilization, but can be compensated for by adding flavours.

The chemical preservatives should never be added in the solid form to fruit juices and squashes. They should be dissolved in a small amount of juice or water and the solution then added to the bulk of juice. If this care is not taken, the solid preservative may settle at the bottom of the container with the result that fermentaion may start before the preservative dissolves.

PRESERVATION BY ADDITION OF SUGAR

Fruit juices containing 66.0 per cent. or more of sugar do not ordinarily ferment. Sugar absorbs water with the result that the latter is not available for the growth of micro-organisms. Thus, dry sugar does not ferment, and it is very difficult to induce fermentation in very highly concentrated sugar solutions. Sugar syrups containing 66.0 per cent. (Sp. Gr. 1.330) have so little moisture available for micro-organisms that their propagation is inhibited, and also those already present die gradually. Thus sugar acts as a preservative by osmosis and not as a true poison for micro-organisms.

PRESERVATION BY FREEZING

According to Joslyn and Marsh, the best way of preserving pure juices is by 'freezing'. The properly frozen juice retains its freshness, colour and aroma for a long time. This method is particularly useful in the case of juices whose flavours are injured by heating. The juice is first de-aerated and the vacuum released with nitrogen gas. The juice is then transferred into containers which are hermetically sealed and frozen. This prevents not only the volatilization of aromatic elements of the juice but also absorption of any disagreeable odours and flavours. Cruess, Overholser and Bjarndson were able to store apple and berry juices in sealed containers for two years at a temperature of 10-15°F. without any noticeable loss of flavour, aroma and colour. The dehydration and concentration processes, which mechanically separate water as ice at low temperatures, destroy a fair percentage of micro-organisms in the juice though moulds are not affected sometimes.

In filling cans or bottles, an allowance of 10 per cent. should be made for the expansion of the juice on freezing. A juice can be kept in good condition for a long time at 1-10°F. in frozen form by avoiding contact with air. The juice is defrosted before consumption.

PRESERVATION BY DRYING

This is analogous to concentration. It is done in the same way as milk drying. The juice is sprayed in the form of a very fine mist into an evaporating chamber. Hot air is next passed through the chamber. The temperature of the chamber and the blast of the air are so regulated that only dry juice falls on the floor. The juice powder is then collected and packed in dry and closely stoppered containers. The juice powder, when dissolved in water, makes a nice drink almost similar to the original juice. But fruit juice powders are highly hygroscopic, and require special care in packing. All juices, however, do not dry readily without special treatment. Siddappa and Girdhari Lal have recently developed a process for the preparation of fruit juice powders.

PRESERVATION BY CARBONATION

Carbonation

Moulds and yeasts require oxygen for their growth. As they are aerobes, they become inactive in the presence of carbon dioxide. If the yeast cells are filtered off, as in Ruef's process, by passing the juice through a porcelain filter, and then carbonation is done under aseptic conditions, the juice will not ferment. In the ordinary carbonated drinks, the oxygen of the air, which is normally present in solution in water and is sufficient to bring about fermentation, is displaced by carbon dioxide. Although carbonated beverages contain sugar far below 66.0 per cent., the absence of air and the presence of carbon dioxide in them prevent the growth of mould and yeast.

High carbonation should, however, be avoided as it usually destroys the delicate flavours of the juice. The keeping quality of carbonated bottled fruit beverages is enhanced by adding about 0.05 per cent. of sodium benzoate.

PRESERVATION BY FILTRATION

Germ-proof Filtration or Sterilization of Cold Juices. In this method, the juice, clarified by 'settling' or by using ordinary filters, is passed through special filters which are capable of retaining yeast and bacteria. Various types of Seitz E.K. 'germ-proof' filters are used for this purpose. Recently, this method has come into use in the U.S.A., South Africa and Germany for preserving apple and grape juices. It requires elaborate precautions to ensure complete sterility in the bottled product. Equipment for such an elaborate process is yet lacking in this country.

OTHER METHODS OF PRESERVATION

In recent years, new methods of sterilization, such as use of electric current, ultra-violet rays, Oligodynamic properties of silver, etc., have been used. Various patents have been taken out for these, e.g., the Schoop, Katadyn and Matzka processes. The Schoop process is based on the catalytic activity of a certain plant substance in the presence of sodium chloride. The Oligodynamic properties of silver are made use of in the Katadyn and Matzka processes. These processes are, however, not in use in this country, nor are they used to any large extent in other foreign countries.

Glass-lined equipment or equipment made of metals like stainless steel, monel metal, nickel, aluminium or bronze should be used, because such equipment is not readily acted upon by the fruit and vegetable juices. A unit of machinery made of different metals should also be avoided because dissimilar metals in the system or unit will lead to the setting up of small electrical couples, and corrosion will result. Use of rubber in the equipment should also be avoided as far as possible.

CHAPTER IX

FRUIT BEVERAGES

Fruits most commonly used for preparing beverages are sweet orange, mandarin (sangtra), sour lime (*Kagzi* nimboo or limboo), lemon, grapefruit, grape, apple, mango, pomegranate, *phalsa* (*Grewia asiatica*), *Jamun* (*Eugenia jambolana*), mulberry, passion fruit etc. Tomato juice has also become quite popular. Among the squashes, sweetened orange juice, popularly known as orange squash is the most popular.

SQUASHES AND CORDIALS

Fruit juices in this country are most commonly packed as squashes or cordials. Methods of preparing some of the more important of these are given below.

Orange Squash

Extraction of Juice. Orange squash can be prepared from tight-skinned oranges such as *Malta, Sathgudi,* and *Musambi* as well as from loose-skinned oranges like *Nagpur* and *Coorg* varieties. Tight-skinned oranges are cut into halves either by hand or with a halving machine. The halves are pressed by hand against a revolving burr or rose fitted to a rosing machine. These machines are of various sizes and capacities. The reamed juice is collected in a vessel. It contains plenty of coarse tissues, seeds, etc. To remove these, it is filtered through a net cloth or passed through a sieving machine, known as pulper, in which the juice gets brushed through a stationary cylindrical sieve by revolving stainless steel, wooden, or brush paddles. The sieved juice is utilized for making squash.

Loose-skinned oranges are peeled, and the rag sticking to the segments is removed as it creates some bitterness in the juice if allowed to remain. According to Siddappa, lye dipping of the segments removes bitterness from the juice. The segments are passed through a screw-type juice extractor. Alternatively the segments may be crushed in a tomato crusher and then passed through a pulper.

Preparation of Squash. Sugar, citric acid, flavouring materials, colour and preservative are added to the juice. The method of preparation has been standardised by Lal Singh, Girdhari Lal, and other workers, who have given simple recipes for small-scale production.

RECIPE

Ingredients	25% juice, 45° Brix, 1.5% acidity	33⅓% juice, 45° Brix, 1.5% acidity	25% juice, 65° Brix, 2.0% acidity	33⅓% juice, 65° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Orange juice 10° Brix, 0.8% acidity	100 0	100 0	100 0	100 0
Sugar	164 9	121 2	242 9	179 10
Citric acid	5 3	3 11	7 3	5 3
Essence of orange	2 8	1 14	3 5	2 9
Water	127 8	73 2	46 11	12 7
Orange colour	q.s.	q.s.	q.s.	q.s.
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Sugar, citric acid and water are mixed together, heated (if necessary), cooled, and filtered through cloth. The clean syrup is mixed with the juice. To improve flavour, peel emulsion of 2 to 4 oranges for every 100 oranges used, or an appropriate quantity of an essential oil or orange essence is added. Its colour can be improved by adding an edible colour like Sunset yellow, Edicol orange A.G., etc. This must be resistant to the action of sulphur dioxide. After mixing all the ingredients, a chemical preservative like potassium metabisulphite dissolved previously in a small quantity of juice or water is added at the rate of about an ounce for every 100 lb. of squash. This corresponds to approximately 350 p.p.m. of SO_2 in the squash, which is permitted by law. By careful attention to hygienic conditions the concentration of SO_2 can be reduced to about 250 p.p.m. This will help in minimising the taste of SO_2 in the beverage. The squash is then filled into washed (Fig. 38) and sterilized bottles, leaving about one inch head space. The bottles are closed with crown or ordinary corks, capsuled, and labelled (Figs. 39, 41, 42, 43, 44). They are then stored in a cool and dry place. The squash keeps well for 1 to 1½ years without much change in colour or taste.

Grapefruit Squash

The method of preparing juice for grapefruit squash is the same as that employed in the case of orange squash.

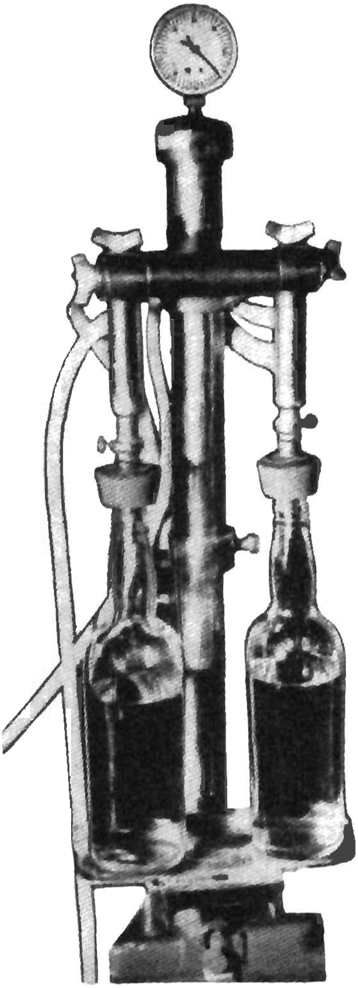


FIG. 39. VACUUM OPERATED BOTTLE FILLING MACHINE

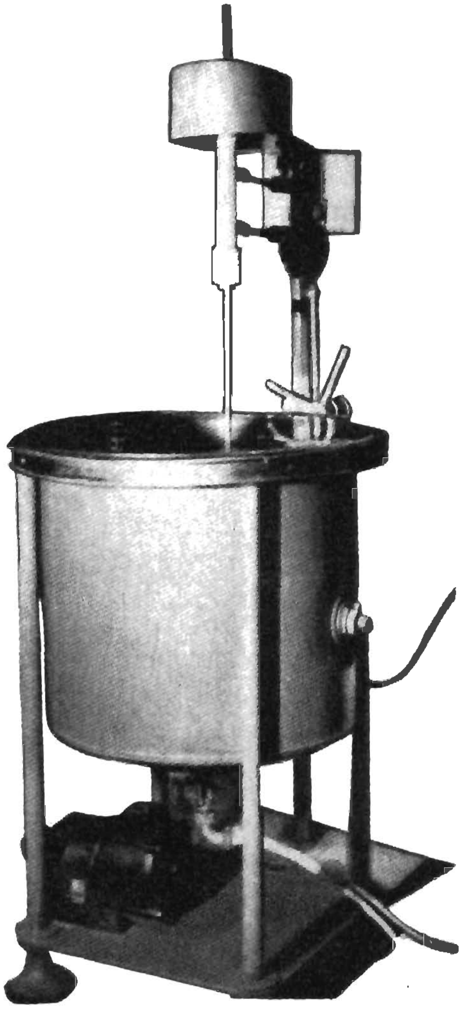


FIG. 40. SYRUP MIXING TANK

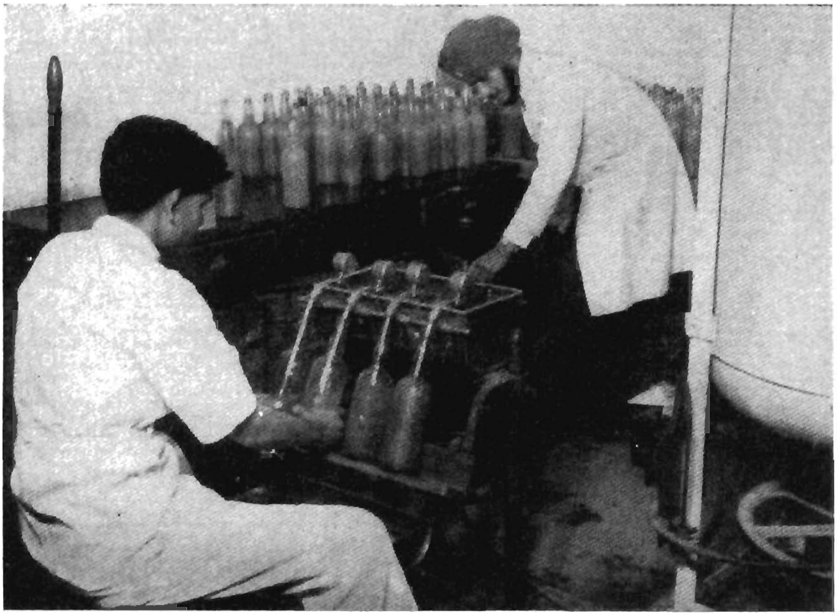


FIG. 41. BOTTLE FILLING MACHINE (Syphon pipe filler)

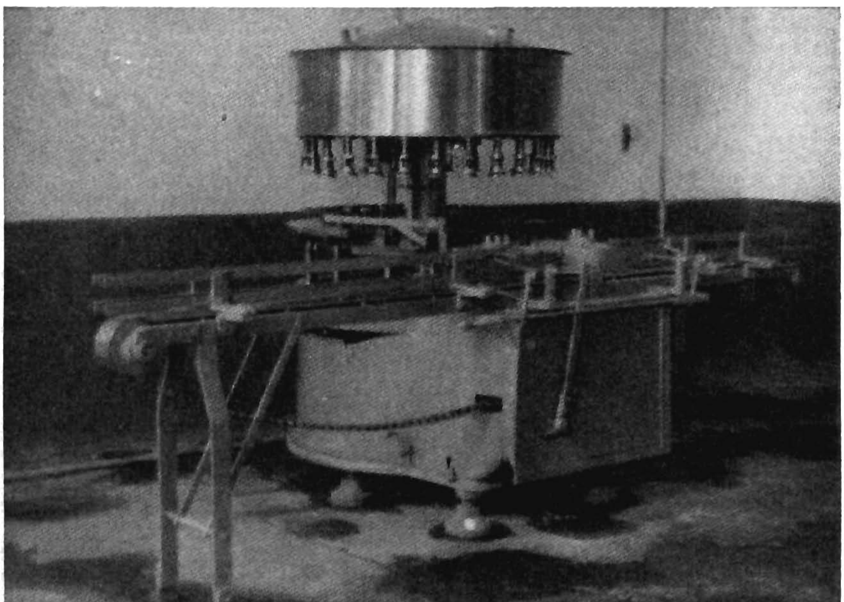


FIG. 42. AN AUTOMATIC FILLER (ASCO FILLER)

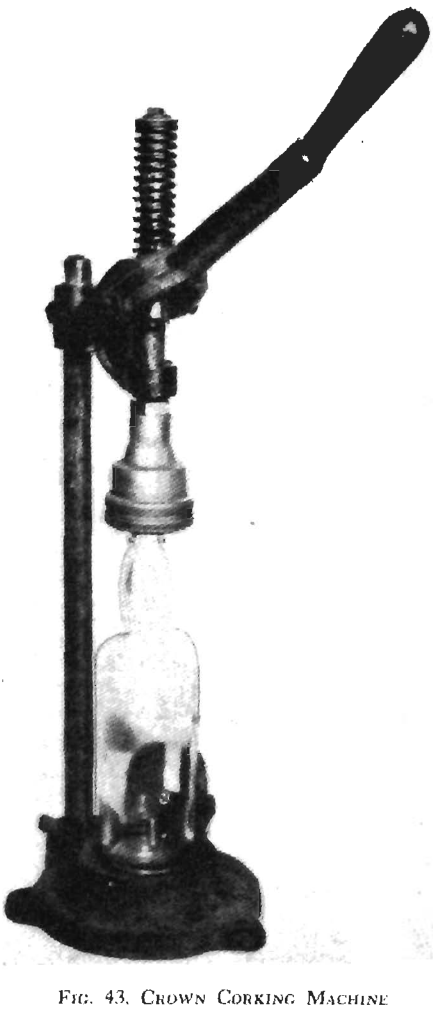


FIG. 43. CROWN CORKING MACHINE

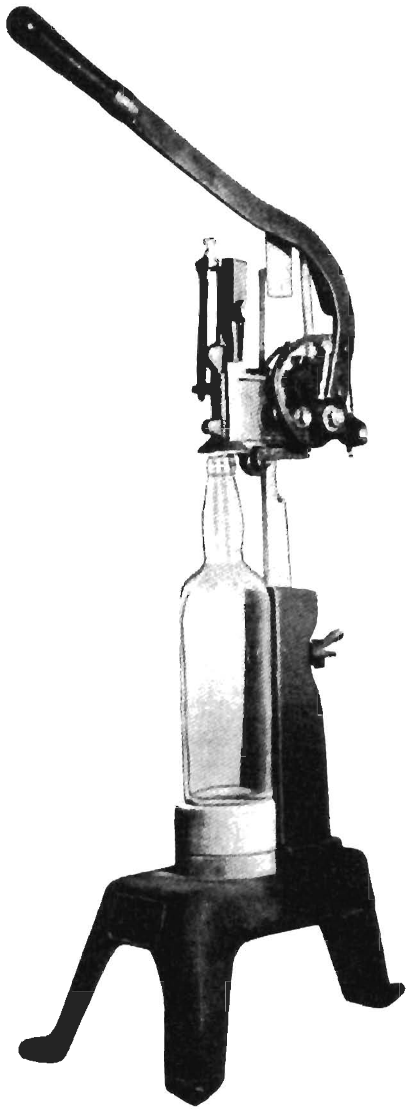


FIG. 44. BOTTLE CORKING MACHINE

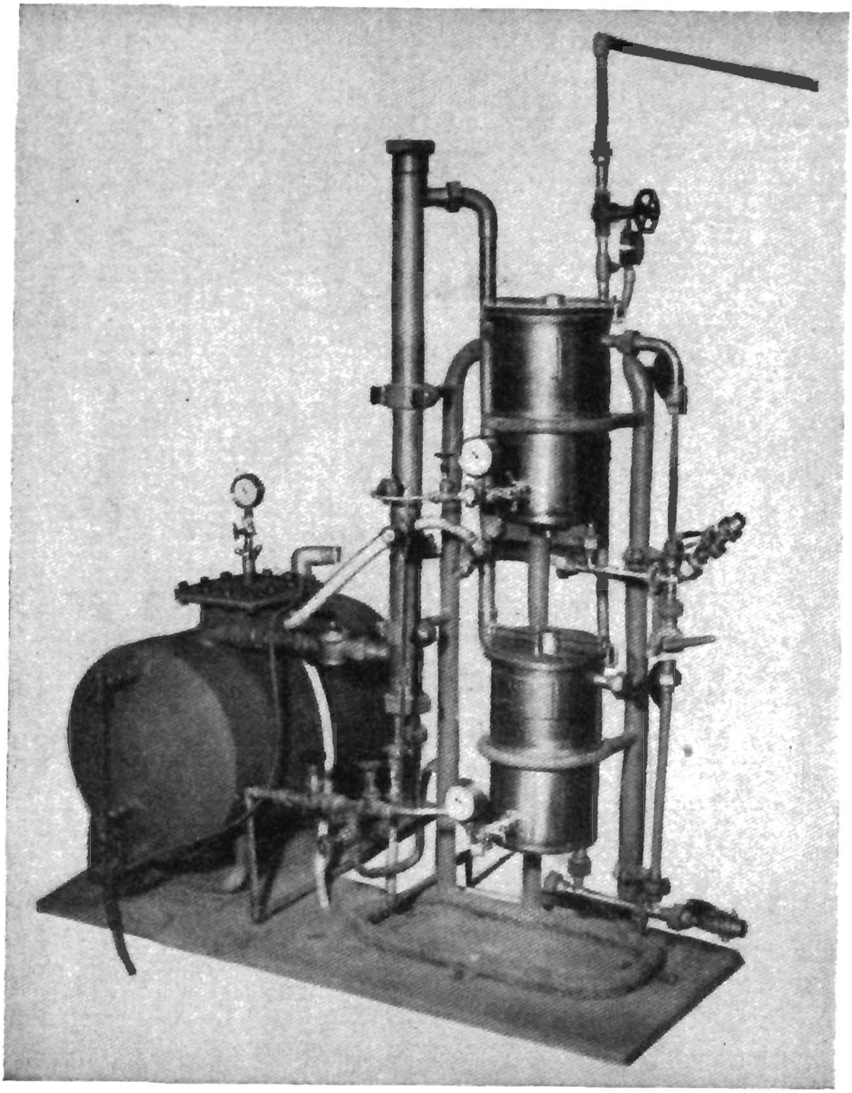


FIG. 45. A.P.V. LABORATORY TWO-STAGE FRUIT JUICE CONCENTRATION UNIT

RECIPE

Ingredients	25% juice, 45° Brix, 1.5% acidity	33⅓% juice, 45° Brix, 1.5% acidity	25% juice, 65° Brix, 2.0% acidity	33⅓% juice, 65° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Grapefruit Juice 10° Brix, 1.25% acidity	100 0	100 0	100 0	100 0
Sugar	165 0	121 9	243 0	180 1
Citric acid	4 12	3 4	6 12	4 12
Water	127 8	73 2	46 11	12 7
Essence of grapefruit	2 8	1 14	3 5	2 9
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Lemon Squash

European lemon, Eureka lemon, and *Galgal* (*Citrus limonia*) are generally used. True lemons are not, however, available in large quantities in India.

Lemon squash requires addition of flavour to improve its taste. The method of preparing juice for the squash is practically the same as that employed in the manufacture of orange squash.

RECIPE

Ingredients	25% juice, 45° Brix, 1.5% acidity	33⅓% juice, 45° Brix, 1.66% acidity	25% juice, 65° Brix, 2.0% acidity	33⅓% juice, 65° Brix, 1.66% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Juice 10° Brix, 5% acidity	100 0	100 0	100 0	100 0
Sugar	168 12	124 13	246 12	184 13
Citric acid	1 0	—	3 0	—
Water	127 8	73 2	47 8	13 2
Essence of Lemon	2 8	1 14	2 8	1 14
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Lime Squash

Kagzi nimboo is widely used for making lime squash. It is available in plenty in India.

The fruit is cut into halves with a knife, and its juice pressed out in a basket press, or by means of small wooden squeezers or by using stone-roller type presses. The juice is filtered through cloth to remove seeds.

RECIPE

Ingredients	25% juice, 45° Brix, 1.5% acidity	33⅓% juice, 45° Brix, 2.0% acidity	25% juice, 65° Brix, 1.5% acidity	33⅓% juice, 65° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Lime juice 10° Brix, 6.0% acidity	100 0	100 0	100 0	100 0
Sugar	169 12	124 13	249 12	184 13
Water	130 0	75 0	50 0	15 0
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Sugar is made into syrup and added to the juice. The preserved juice is bottled as usual.

Lime Juice Cordial

Lime juice is stored in large glass carboys or in upright wooden barrels lined with micro-crystalline wax, after adding 2 ounces of potassium metabisulphite per every 100 lb. of it. The sediment settles down after 2 to 3 months, leaving the juice clear at the top. It is then syphoned off. This method is rather slow. Clarification can also be achieved quickly by adding gelatin and tannin in proper proportions based on preliminary trials. Sugar, water, colour (if necessary) and preservative are added to the clear juice, and the mixture is then filtered using a filter press. Filter aids are added in this process to facilitate the operation. The clear cordial is bottled as usual.

RECIPE

Ingredients	25% juice, 35° Brix, 1.5% acidity	33-1/3% juice, 35° Brix, 2.0% acidity	25% juice, 50° Brix, 1.5% acidity	33-1/3% juice, 50° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Clarified Lime juice 10° Brix, 6% acidity	100 0	100 0	100 0	100 0
Sugar	129 12	94 13	189 12	139 13
Water	170 0	105 0	110 0	60 0
Colour	q.s.	q.s.	q.s.	q.s.
Preservative, (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Sugar is added in syrup form. The quantity of preservative added to the original juice is taken into account while adding the preservative to the cordial. Colour should be mixed in very small quantities.

Citrus-Fruit Barley Waters

The juice from citrus fruits is extracted and filtered. A small quantity of barley flour (according to the recipe) is made into a paste with a little water. More water is then added to thin the paste. It is then heated to gelatinise the starch, cooled, filtered and made up to volume.

RECIPES

1—Grapefruit Barley Water

Ingredients	25% juice, 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 1.5% acidity
	lb. oz.	lb. oz.
Grapefruit juice 10° Brix, 1.25% acidity	100 0	100 0
Sugar	165 0	121 9
Citric acid	4 12	3 4
Essence of grapefruit	2 8	1 14
Barley Water	127 8 of 21 oz. barley flour	73 2 of 16 oz. barley flour
Preservative (Potassium metabisulphite)	0 4	0 3

2—Lemon Barley Water

Ingredients	25% juice, 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 1.66% acidity
	lb. oz.	lb. oz.
Juice 10° Brix, 5% acidity	100 0	100 0
Sugar	168 12	124 13
Citric acid	1 0	—
Barley water	127 8 of 21 oz. barley flour	73 2 of 16 oz. barley flour
Essence of Lemon	2 8	1 4
Preservative (Potassium metabisulphite)	0 4	0 3

3—Lime Barley Water

Ingredients	25% juice, 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 2.0% acidity
	lb. oz.	lb. oz.
Lime juice 10° Brix, 6% acidity	100 0	100 0
Sugar	169 12	124 13
Barley water	130 0 of 21 oz. barley flour	75 0 of 16 oz. barley flour
Preservative (Potassium metabisulphite)	0 4	0 3

4—Orange Barley Water

Ingredients	25% juice, 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 1.5% acidity
	lb. oz.	lb. oz.
Orange juice 10° Brix, 0.8% acidity	100 0	100 0
Sugar	164 9	121 2
Citric acid	5 3	3 11
Essence of orange	2 8	1 14
Barley water	127 8 of 21 oz. barley flour	73 2 of 16 oz. barley flour
Orange colour	q.s.	q.s.
Preservative (Potassium metabisulphite)	0 4	0 3

Jack Fruit Nectar

The bulbs are removed from ripe jack fruit and passed through a mincing machine. They are then mixed with about 10 per cent. water and passed through a pulper using a fine sieve of 1 mm. hole. The pulp is used for preparing the nectar.

RECIPE

Ingredients	17% pulp, 50% Brix, 1.2% acidity		20% pulp, 50° Brix, 1.2% acidity	
	lb.	oz.	lb.	oz.
Pulp of jack fruit bulbs 20° Brix, 0.3% acidity	102	0	100	0
Sugar	272	5	224	0
Citric acid	6	14	5	11
Water	218	6	170	0
Preservative (Potassium metabisulphite)	0	6	0	5

More than 20 per cent. of the pulp should not be added to the nectar because with higher concentrations, the nectar becomes very viscous.

Jamun Squash or Syrup

The fruit is crushed and heated for about 5-10 minutes at 140°F. to extract the colour. The crushed material is then pressed in a basket press to get the juice for squash.

RECIPE

Ingredients	50% juice, 45° Brix, 1.5% acidity	
	lb.	oz.
Juice 14° Brix, 0.75% acidity	100	0
Sugar	73	9
Citric acid	2	4
Water	24	0
Preservative (Sodium benzoate)	0	3

Mango Squash

Juicy varieties are preferred for making squash. Fully ripe fruits are taken, the stem portion cut off and four slits given to each fruit. They are then passed through a pulping machine to separate the skin and the stones. The pulp is used for making squash.

RECIPE

Ingredients	25% juice, 45° Brix, 0.8% acidity	33-1/3% juice, 40° Brix, 0.8% acidity	25% juice, 50° Brix, 1.0% acidity	33-1/3% juice, 50° Brix, 1.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Mango pulp 18° Brix, 0.5% acidity	100 0	100 0	100 0	100 0
Sugar	139 1	99 15	178 4	129 5
Citric acid	2 11	1 14	3 8	2 8
Water	158 0	98 0	118 0	68 0
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Sugar is added in syrup form. The squash may be strained through cloth before bottling.

Passion Fruit Squash

With its exotic flavour, passion fruit squash is becoming quite popular. It is prepared mostly in Australia. The fruit is grown in the Nilgiris and Coorg.

Ripe purple coloured fruits are picked. These are cut into halves and the yellow mucilaginous pulp along with the seeds is scooped out. The pulp is then passed through the pulper to remove seeds. On a small scale, the pulp can be passed through ordinary sieves of 20-30 meshes per inch.

RECIPE

Ingredients	25% juice 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 1.5% acidity	25% juice, 65° Brix, 2.0% acidity	33-1/3% juice, 65° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Passion fruit juice, 18° Brix, 3% acidity	100 0	100 0	100 0	100 0
Sugar	158 12	115 5	236 12	173 13
Citric acid	3 0	1 8	5 0	3 0
Water	138 0	83 0	58 0	23 0
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Peach Squash

Juicy white peaches are good for making squash. The pulp is heated with half its weight of water for about 15 minutes at 180°F. and the juice pressed in a basket press. The pulpy juice is then converted into a good squash. Potassium metabisulphite is added as a preservative.

Phalsa Squash

The method of preparing *phalsa* squash is similar to that described for making *jamun* squash. Citric acid is, however, not needed since the juice itself is sufficiently acidic.

Pineapple Squash

The fruits are peeled and cut into slices which are then passed through a screw-type juice extractor. The pulp left over in canning may also be utilized for extracting juice. The juice thus obtained is converted into squash.

RECIPE

Ingredients	25% juice, 45° Brix, 1.5% acidity	33-1/3% juice, 45° Brix, 1.5% acidity	25% juice, 65° Brix, 2.0% acidity	33-1/3% juice, 65° Brix, 2.0% acidity
	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Pineapple Juice, 8° Brix, 0.5% acidity	100 0	100 0	100 0	100 0
Sugar	166 4	122 13	244 4	181 5
Citric acid	5 8	4 0	7 8	5 8
Pineapple flavour	2 8	1 14	3 5	2 9
Water	125 8	71 2	44 11	10 7
Yellow colour	q.s.	q.s.	q.s.	q.s.
Preservative (Potassium metabisulphite)	0 4	0 3	0 4	0 3

Plum Squash

Juicy plums like the *alucha* are to be preferred. To extract colour, the plums are heated for about 30 minutes at 180°F. in half their weight of water. These are then passed through a pulper to extract juice. This juice can then be made into a squash of 45 or 55 degrees Brix. Sodium benzoate is added as a preservative.

Water Melon Squash

Water melon is cut into suitable pieces and the flesh scraped off from the rind. The juice is extracted by means of a basket press. The pinkish juice, which is of 6-7 degrees Brix, is converted into squash. Sodium benzoate is used as preservative.

RECIPE

Ingredients	45° Brix Squash, 1.0% acidity
Juice 6° Brix, 0.1% acidity	75 lb.
Sugar	52 lb. 8 oz.
Citric acid	1 lb. 4 oz.
Sodium benzoate	2.04 oz.

Squashes and syrups can also be made from several other fruits like mulberry, raspberry, strawberry, pear, apricot, pumelo, guava, musk melon, etc. The methods of preparation are broadly the same as those explained above.

JUICES

Apple Juice

Unfermented apple juice is highly popular in Europe. In India too, it is gaining in popularity. A method has now been standardised for preparing it from Kulu apples like the Yellow Newton and Baldwin. The apples are washed with a weak hydrochloric acid solution (5 gallons of acid in 100 gallons of water) to remove arsenic and lead spray residues and are then crushed in an apple grater to pieces of ⅛" to ½". The juice is pressed out in a basket press and collected in a non-corrodible vessel. Aluminium vessels can be used for small scale work. The juice is then strained through coarse cloth to remove fruit tissues, etc., heated to 180°-185°F. temperature, filled into clean bottles, and pasteurized by the 'overflow method' (see Chapter VIII) for 30 minutes at 175°F.

Cashew Apple Juice

Cashew apples are available in plenty on the West Coast. Experiments have shown that by suitable preliminary treatment of the fruit to remove astringency in the fruit, a juice of fairly good quality can be prepared. Siddappa has described a simple method for its preparation and preservation by blending it with a small quantity of lime juice. Jain, Bhatia, Anand and Girdhari Lal have recommended steaming of the fruit for 5 minutes at 5 lb. pressure prior to extraction of the juice by pressing. The juice is mixed with 0.045 per cent. gelatin by stirring, is set aside for 15 minutes and then strained through cloth, and 5-6 per cent. sugar added to it. The resulting product has a delicious taste and the characteristic aroma and flavour of Cashew apple.

Citrus Juices

Tight-skinned oranges like *malta* and *sathgudi* give a fairly good bottled or canned juice free from bitterness. The juice from loose-jacket oranges like the Coorg and Nagpur varieties, however, often develops a characteristic bitter taste in the bottle or can. The bitterness can be considerably reduced by lye dipping the segments or by adding 5-6 per cent. sugar to the juice (Siddappa). To improve its quality, the juice is generally deaerated and flash-pasteurized. However, preservation of orange juice with its natural flavour is still a problem. It develops a characteristic stale or off-flavour during storage.

Pruthi conducted extensive studies on the effect of different factors such as head-space in the container, sweetening, deaeration, type of container used and the method of preservation employed (i.e. sulphitation, benzoation, holding pasteurization, over-flow pasteurization, flash-pasteurization, etc.) on the ascorbic acid content, colour, flavour and keeping quality of the seven types of citrus fruit juices, viz., lime, *mosambi,* orange, *Nagpuri* mandarin, grape-fruit, sweet lime, *khatta* (*C. aurantium*) and *galgal* (*C. limonia*). Deaeration combined with flash-pasteurization gave the best overall results. Losses in ascorbic acid during processing have been reported to be about 7 per cent. in comparatively less acidic juices (i.e. *mosambi, Nagpuri sangtra,* and sweet lime) and about 3 per cent. in more acidic juices (i.e. lime, *khatta,* and *galgal*). During 7 months' storage at room temperature under different treatments, the losses in ascorbic acid varied from 27.2 to 36.2% in *galgal* juice, 24.5 to 32.3% in *Nagpuri sangtra* juice, 16.8 to 23.4% in *khatta* juice, 24.3 to 28.8% in lime juice, 17.0 to 25.9% in grapefruit juice, and from 19.8 to 21.5% in *mosambi* orange juice. The flavour and keeping quality of citrus juices, and the role of pectic enzymes in sedimentation and ascorbic acid in discolouration of citrus juices have been discussed by him in detail. Colour deterioration in processed *Nagpuri* orange juice, grapefruit juice, and other citrus juices, as affected by different factors, has been reported. Addition of cane sugar to the extent of 5 per cent. is reported to have accelerated the rate of discolouration of juices. Statistical analysis also revealed that addition of sugar did not help in the retention of ascorbic acid. In most citrus juices, discolouration was visible within 1½ to 3 months' storage at room temperature (24-30°C.) and at 37°C. Low temperature of 0-2°C. during storage helped in better retention of ascorbic acid. It also retarded darkening. Better retention of ascorbic acid and colour was secured by packing the product in plain tin cans instead of in bottles. Methods were standardised for estimating ascorbic acid in unsulphited and sulphited citrus juices, as well as for photo-electric colorimeter analysis.

By a suitable modification of the methods of extraction and preliminary treatment of the juice, it has been found possible to minimise the development of bitter taste.

During the fruit season, orange juice can be extracted, acidified and preserved with potassium metabisulphite in barrels for conversion later into orange squash. This enables the manufacturer to do packing according to the market demand.

Grape Juice

Coloured as well as white grapes can be used for making grape juice. In the case of coloured varieties, preliminary heating of the crushed mass for 10-15 minutes at 140-145°F. is necessary for extracting the colouring matter. White grapes are not heated. The juice is extracted from the crushed grapes by means of a basket press. It is filtered through cloth and bottled by the 'overflow method'. In the bottled juice, cream of tartar (or argol) gradually settles down during storage. This can be avoided by preliminary storage of the juice for 3-4 months, preferably at low temperature to secure complete settling of the cream of tartar. The clear juice can then be bottled and preserved by pasteurization or by adding sodium benzoate. Addition of sulphur dioxide is not recommended as it imparts a bitter taste to the juice.

Pineapple Juice

Pineapples are cultivated on a fairly extensive scale in Assam, West Bengal, Kerala and Madras. The yield in these four States amounts to about 95 per cent. of the total production in India. Several varieties of pineapples are grown, namely, Kew, Giant Kew, Mauritius, Jaldhoop, Singapore, etc. Kew and Giant Kew are usually employed for canning, while the rest are used for preparing juice, etc. In India, pineapple juice is generally manufactured as a by-product from the cannery wastes, such as cores, trimmings, and cull or under-sized or slightly over-ripe or soft fruit.

The whole fruit is peeled, sliced and minced or grated. The cores, trimmings, etc., are also minced. The minced material is passed through a screw-type juice extractor or pulper or hydraulic press, the juice screened through mull cloth, heated to about 180-185°F., packed hot in plain cans, double seamed and processed at 175-180°F. for 25-30 minutes (1 lb. milk-size cans), and cooled in running cold water. In foreign countries, the juice is processed by the H.T.S.T. Process—the juice is quickly heated to 190°F., held at this temperature for 2-3 minutes, and then immediately packed and sealed.

Pruthi has conducted storage studies on ascorbic acid retention, and colour and general keeping quality of pasteurized (canned as well as bottled) and sulphited juice and squash stored at room temperature (24-30°C.) and at 37°C. He reports about 80-85 per cent. retention of ascorbic acid in samples stored at room temperature, and only 38-47 per cent. at 37°C. He further found that colour deterioration, as determined by photo-electric colorimeter analysis and expressed in terms of optical density at 6 different wave lengths ranging from 420μ to 640μ in juices stored at 37°C. was about 3 times of that observed in similar samples stored at room temperature. He also reports that canned pineapple juice could be stored over a period of 12-15 months without any serious loss in quality or nutritive value.

Pomegranate Juice

Pomegranates, like the *Kandhari* variety, which contain richly coloured grains, give a delicious juice. The fruit is cut into quarters, and the grains are removed and pressed in a basket press. The juice can also be extracted from the quarters as such by gentle pressing in a basket press. It is filtered through a thick cloth and bottled. It can be preserved either by pasteurization or by addition of sodium benzoate. The flavour is rather delicate and gets weakened during prolonged storage. It can also be converted into syrup of 55-60 degrees Brix.

SYRUPS

Syrups of rose, sandal, almond, *Sarasaparilla, Kewra,* strawberry, pineapple, raspberry, orange, mulberry, etc., are very popular as summer drinks in different parts of India. They are generally prepared from extracts of natural material or by using artificial flavours and colours. These are added to heavy sugar syrups of 70-75° Brix. The syrup is prepared by heating sugar in water to which a little acid is added to invert the sugar.

RECIPE

Ingredients	Orange	Lemon	Pineapple	Raspberry	Strawberry
Syrup 70° Brix	1 gallon	1 gallon	1 gallon	1 gallon	1 gallon
Citric acid	2.9 oz.	4.35 oz.	2.9 oz.	1.45 oz.	0.8 oz.
Colour	Orange yellow q.s.	Yellow colour q.s.	Yellow colour q.s.	Red colour q.s.	Strawberry colour q.s.
Essence	Soluble Essence Sweet Orange 2.9 oz.	Lemon Essence cloudy 3.6 oz.	Soluble Essence Pipeapple 1.5 oz.	Essence of Raspberry 2.9 oz.	Essence of Strawberry 2.9 oz.

A large proportion of the synthetic syrups can, however, be replaced by real fruit syrups which are more nutritious.

CARBONATED BEVERAGES

Use of fruit juices in the preparation of carbonated beverages is practically unknown in India, although large quantities of aerated waters, iced *sherbets*, and synthetic drinks containing saccharin are consumed all over the country. These commercial products have practically no nutritive value. If real fruit juices are used, the nutritive value of these beverages would be increased considerably.

The juices can be carbonated directly, or they can be stored as such or in the form of concentrates for carbonation, whenever necessary. Carbonated beverages keep well for about a week without any preservative. But it is necessary to add 0.05 per cent. of sodium benzoate to the finished product if these are to be kept longer.

To prepare orange syrup for carbonation, a heavy syrup is made by mixing 10 lb. of orange juice, 15½ lb. of sugar and 7 oz. of citric acid. Of this, about 1½ to 2 oz. are filled into 10-12 oz. bottles for carbonation. Other syrups like those of pineapple, lemon, lime, etc., also can be prepared in a similar manner.

JUICE CONCENTRATES

At present, in India several fruit juices are made into squashes or syrups by merely adding sugar to them. In other countries, however, concentrates of pure juices are highly popular. These are sometimes frozen also. Citrus juice concentrates are in great demand in the U.K., Europe, and the U.S.A., for feeding children (as sources of vitamin C), for carbonation, and for use in ice-creams, etc. Apple and grape juice concentrates of 68-72° Brix are also prepared and used for making beverages.

Juices are concentrated either by freezing or by evaporation under reduced pressure at low temperature so that their original flavours are not lost completely (Fig. 45). Very elaborate equipment is necessary in the case of citrus juices. Concentration is carried out at temperatures as low as 35-40°F., using multiple effect systems and refrigeration for the condenser. The flavours lost during evaporation are recovered and put back into the concentrates. In the freezing process, known as Gore's process, the juice is frozen either into a mushy mixture of ice crystals and juice or into a solid cake which is broken up later. On centrifuging the broken mass in a basket-type centrifuge, ice crystals remain in the basket, while the concentrated juice passes through. Centrifuged and partially concentrated juice is again frozen and re-centrifuged to raise the Brix to about 50 degrees. The concentrate should either be held in cold storage or pasteurized to prevent spoilage. The juice concentrated by this process possesses the flavour of fresh fruit which is richer than that of the concentrate prepared by other processes This process is not, however, in general use in any part of the world.

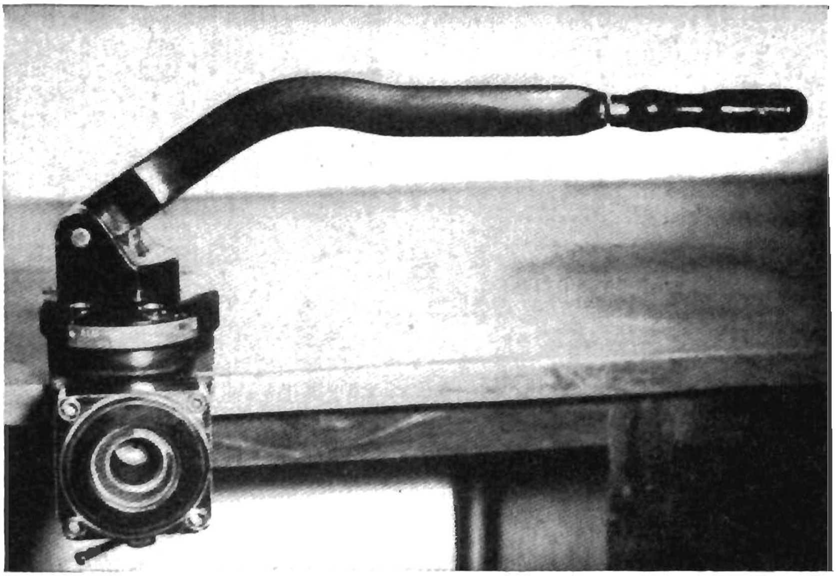


FIG. 46. CAPSULING MACHINE

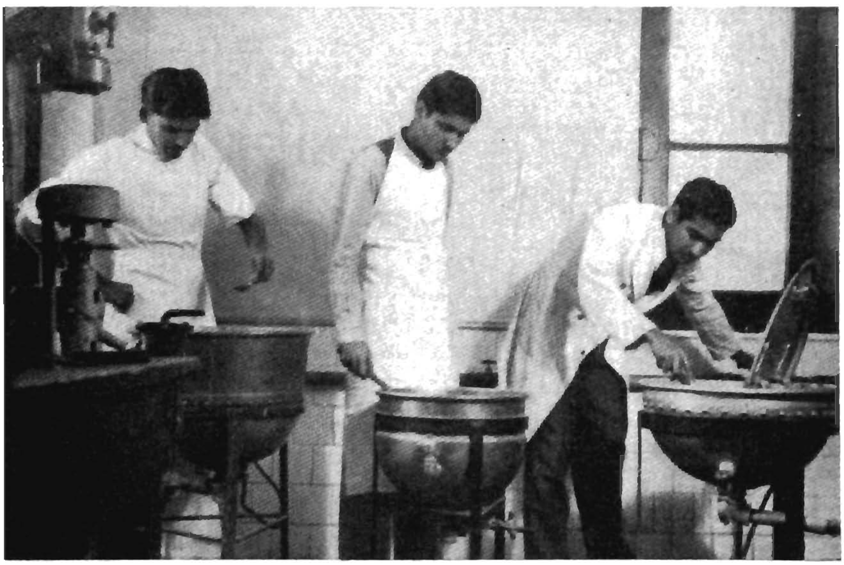


FIG. 47. STEAM JACKETED JAM BOILING PANS

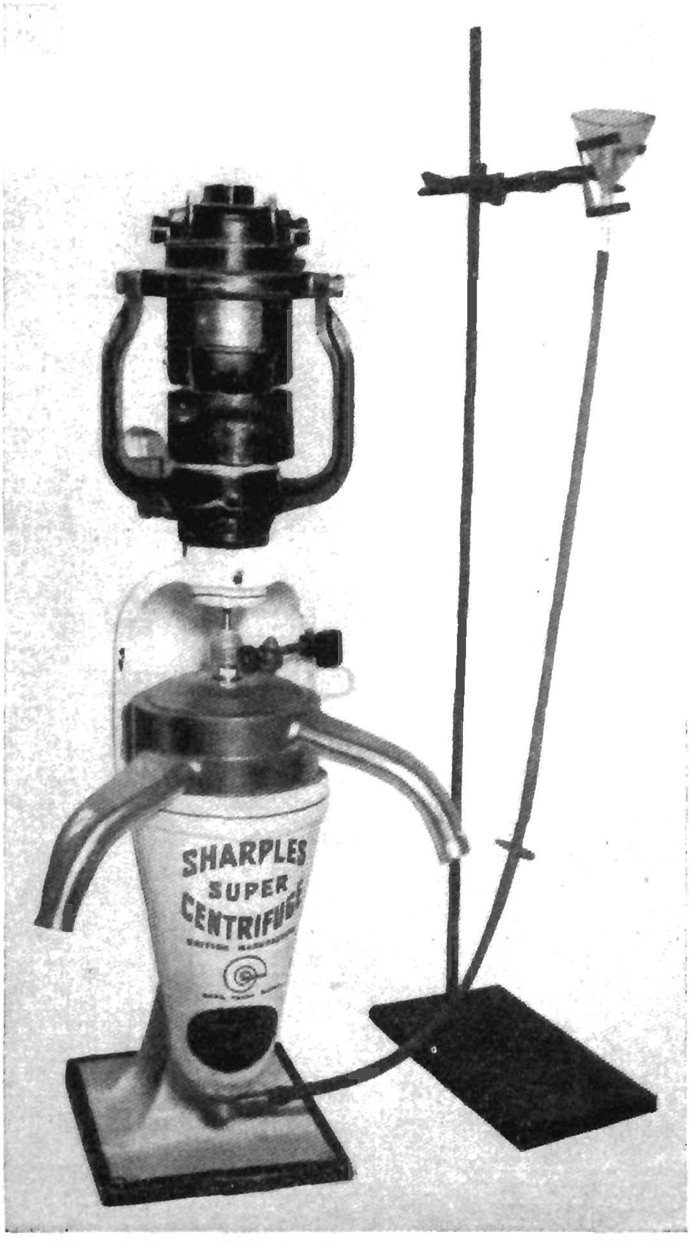


FIG. 48. SHARPLES SUPER CENTRIFUGE

Linde-Kraus Process. In this process, the juice is frozen on the outside of a refrigerated drum which revolves slowly. The lower part of the drum dips into the juice in a trough placed below. Ice is removed from the drum by a scraper. Due to constant removal of water as ice, the juice in the trough gets concentrated.

According to Cruess, a method has recently been developed for recovering apple flavour during concentration. The juice is heated under pressure in a continuous stream to 320°F., allowing the hot juice to flash-vaporise into another part of the apparatus. About 10 per cent. of the juice, (by volume) is vaporised. The vapours are condensed at 70°F. Practically all the apple esters are found in this distillate which can be used for giving natural fresh apple flavour to the concentrate. It may be possible to extend this technique to other fruit concentrates also.

Recently, in connection with a systematic investigation on the concentration of fruit juices, Siddappa and Bhatia studied the factors responsible for bitterness and gelation in orange juice concentrates. By modifying the method of extraction of juices, especially from loose-jacket oranges like the Coorg and Nagpur varieties, and by centrifuging the juice (Fig. 48) after flash-pasteurization, they were able to prepare orange concentrate free from bitterness and gelation during storage. They also studied the changes in the ascorbic acid content, natural as well as added, during preparation and storage of the concentrate under different conditions. While there is a considerable loss of ascorbic acid during storage at ordinary temperatures, it is very little at 2-5°C.

FRUIT JUICE POWDER

Spray-dried fruit juice powders are highly hygroscopic and lose much of their original fresh flavour in drying. Sweetened citrus juice powder is being developed in the U.S.A. A method for preparing fruit juice powders from *Coorg* and *Sathgudi* oranges, mango, jack fruit, guava, tomato, etc. has been evolved at the Central Food Technological Research Institute, Mysore as a result of three years of work. This method has been patented. The powders can be packed, transported and dispensed cheaply in a highly hygienic manner. There is much scope for developing these products. Further research is in progress.

CHAPTER X

FERMENTED BEVERAGES

Fermented beverages have been known to mankind from times immemorial. Grape wine is the most important of these. Wines made from fruits are often named after the fruits. Thus we have apple cider from apples, perry from pears, and orange wine from oranges. Starch and sugar are also fermented to get special types of liquors. In India such liquors are known as *Nira* (juice from palm tree), *Sake* from rice, 'country' liquors, from molasses, etc.

Grape Wine

Raw Material. Grapes for wine-making are sorted to remove mouldy bunches and then crushed between fluted rolls. In the case of white grapes, the crushed mass is pressed directly in basket type presses, but in the case of coloured grapes, it is fermented slightly before pressing the juice. The yield of juice is about 60-70 per cent.

Grape wines are of two kinds, i.e., dry and sweet. In the dry wine, there is very little or no sugar. In the sweet wine, either fermentation is arrested to retain some of the original sugar, or extra sugar or fresh grape juice is added. The alcohol content of both the wines ranges from 7 to 20 per cent. Wines with 7-9 per cent. alcohol are termed 'light wines', those with 9-16 per cent. 'medium wines', and those with 16-20 per cent. 'strong wines'. Generally, wines with more than 12 per cent. alcohol are fortified with fruit brandy prepared by distilling the grape wine.

Fermentation

To ferment the juice (known as 'must' in the trade) a culture of pure wine yeast like *Saccharomyces ellipsoideus* is added as a starter. Sulphur dioxide is added to the 'must' at the rate of about 50-70 p.p.m. (about 8 ounces of potassium metabisulphite per ton of grapes) to check the action of wild yeasts and bacteria which are undesirable in alcoholic fermentation. The temperature should be controlled between 80°F. and 85°F. Fermentation ceases usually at about 100°F. It is very slow below 50°F. The stages through which the sugar in the 'must' passes before being converted finally into alcohol have been investigated by Neuberg, Harden and Young, and others. The intermediate products are methyl glyoxal ($CH_3C:OCH:O$), acetaldehyde ($CH_3.CHO$) and pyruvic acid $CH_3C:O.COOH$). The simple reaction would be

$$C_6H_{12}O_6 = 2CO_2 + 2C_2H_5OH$$

(Fermentable Sugar) (Ethyl alcohol)

A hundred grams of hexose sugar would give 51.1 grams of alcohol and 48.9 grams of carbon dioxide. Besides alcohol, a number of other compounds are also formed. The alcohol content of wine is usually expressed as volume per cent., that is, c.c. of alcohol per 100 c.c. of wine. According to Cruess, the percentage of alcohol will approximately be equal to the Brix of the 'must' multiplied by 0.57. Thus a 'must' of 22° Brix should give a dry wine of about 22×0.57 (or 12.5) volume per cent. of alcohol.

Generally the Brix of most grape varieties grown in India ranges from 12 to 16 degrees, except in the case of seedless *kishmish* grapes which have a Brix as high as 23-26 degrees. In the case of grapes of low Brix value, cane sugar is sometimes added to raise the Brix to about 23 degrees.

A pure culture of yeast is multiplied prior to putting it in the 'must' in barrels or vats, as follows: To the culture in the bottle, 4 to 5 ounces of pasteurized juice are added, and the sterilised cotton plug is replaced. In about 24 hours, the yeast multiplies rapidly. This is inoculated into similarly pasteurized juice in a larger container, by adding the starter in the proportion of 1 to 10. Further multiplication is carried out in the same way. On inoculation of the 'must' with the starter, fermentation in the barrels would proceed apace during the first 4 or 5 days. After this stage, a water seal is attached to the barrel in order to permit release of any accumulated pressure during the subsequent slow fermentation. The rate of fermentation will depend on the Brix of the fermenting 'must'. When fermentation is complete, the Brix will be zero or, in some cases, even less. In the case of dry white wine, the sugar content should be less than 0.15 grams per 100 c.c. If fermentation ceases prior to this, it may be necessary to aerate the fermenting liquid by pumping clean air through or over it.

Maturing. When fermentation is complete, the clear wine is syphoned from the yeast sediment and filled into barrels. The barrels should be filled completely and sealed air-tight to exclude all air. In course of time, the wine matures. During this aging process, which takes from 6 to 12 months, the wine loses its raw and harsh flavour and mellows down considerably, acquiring a smooth flavour and characteristic bouquet and aroma. Oak wood barrels are generally preferred as they give a finer bouquet to the wine.

Clarification in the natural way takes place during maturation. It can also be achieved by using filter aids, white of egg, etc.

Packing. The volatile acidity of the wine, which is due mainly to acetic acid, should be low. High volatile acidity of about 0.09-0.20 grams per 100 c.c., expressed in terms of acetic acid indicates the activity of acetic or lactic acid bacteria during fermentation. It is often desirable to pasteurize the wine to destroy spoilage organisms and to coagulate colloids that cause cloudiness. Wines are pasteurized for 1 to 2 minutes at 180-190°F. and then bottled. The bottles are closed with good bark corks.

The following are some of the well-known wines:

Champagne

It is a sparkling wine, produced chiefly in France from certain varieties of grapes. Champagne-type wines are made in several other countries also. The fermentation is allowed to proceed to completion in bottles specially made to withstand the gaseous pressure produced in the process.

Port

It is a fortified sweet red wine made in Portugal and some other countries.

Muscat

It is made from muscat grapes, especially in Spain, Italy, California and Australia.

Tokay

It is the famous fortified wine of Hungary.

Sherry

It is a Spanish wine, matured at high temperature by placing the barrels for 3 to 4 months in the sun where the temperature is 130-140°F.

Cider

There are two types of apple cider, i.e. dry and sweet.

In the U.K., special varieties of apples known as cider apples are employed. Apples with high tannin content (0.1 to 0.3%) are generally used. These are crushed, and the juice is pressed out. Sugar is added to the juice to raise the Brix to about 22 degrees. Next, 100 p.p.m. of SO_2 and a pure culture of wine yeast are added. About 0.02-0.05 per cent. of ammonium hydrogen phosphate is also included to supplement the food for the yeast. The method of fermentation is almost similar to that for grape wine. After fermentation, the cider is racked, filtered, and allowed to age in oak wood barrels. The matured cider is heated to 150°F., filtered, and bottled. The bottles are then pasteurized for 30 minutes at 140°F.

It has been reported that although proper cider apples are not available in India, some dessert varieties can be utilized for making cider of fairly good quality.

Perry

It is made from pears. Wastes and trimmings left over from the canning of pears can be used profitably for its preparation.

Orange Wine

Orange juice sweetened with cane sugar can be fermented to give fairly palatable wine. The method of preparation is the same as that employed for making grape-wine. Much oil should not, however, be incorporated in the juice as it slows down and, at times, stops the fermentation process.

Berry Wines

Wines are also made from several types of berries, like elderberry, loganberry, strawberry, etc. Such berries are not, however, common in India.

CHAPTER XI

JAMS, JELLIES AND MARMALADES

Among preserved fruits, jams, jellies and marmalades form an important class of products. During World War II, fairly large quantities of these were imported into India from the U.S.A., the U.K. and Australia. Considerable quantities are being imported even now, although the products are being manufactured extensively in several factories in the country. These are also being made in many homes all over the country. Their production and demand can be increased further by making better use of cull fruit that is being wasted at present.

Jam is prepared by boiling the fruit pulp with sufficient quantity of sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position. In its preparation, about 45 lb. of fruit should be used for every 55 lb. of sugar. It should contain not less than 68.5 per cent. soluble solids as determined by refractometer, when cold, and uncorrected for insoluble solids.

Jelly is prepared by boiling the fruit with or without water, straining, mixing the strained and clear juice extract with sugar, and boiling the mixture to a stage at which it will set to a clear gel. A perfect jelly should be transparent, well set, but not too stiff, and should have the original flavour of the fruit. It should be of attractive colour and should keep its shape when removed from the mould. When cut, it should retain its shape and show a clean-cut surface. It should be tender enough to quiver, but not flow.

Marmalade is a fruit jelly in which the slices of the fruit or the peel are suspended. The term 'marmalade' is generally associated with the product made from citrus fruits like oranges and lemons in which shredded peel is included as the suspended material.

The term fruit jellies covers, in a general sense, jams and marmalades also which possess the consistency of jelly (whether made from clear juice or from pulp).

JAMS

The method of preparing jams is similar to that used for jelly-making except that pulp and pieces of fruit are used. Jams may be made from a single fruit or from a combination of different fruits.

A jam differs from a preserve in that it need not contain pieces of the whole fruit as is the case of a preserve. In preparing it, the fruit is crushed, or otherwise finely cut, so that when cooked, the mass is fairly uniform throughout. A jam is more or less a concentrated fruit possessing a fairly heavy body form. It is also rich in flavour because ripe fruits are used in its preparation. Pectin in the fruit gives it a good set. High concentration of sugar facilitates preservation. A great advantage in its preparation is that it can be made completely in a single operation, unlike preserves which have to pass through several stages.

An analysis of some of the jams of foreign as well as Indian manufacture is given in the following Table:

TABLE 14. ANALYSIS OF VARIOUS TYPES OF JAMS

(After Lal Singh and Girdhari Lal)

Description of jam	Total soluble solids by refractometer	Percentage acidity as citric acid	Degree of inversion	Remarks
Gooseberry (Indian)	71.5 78.0 72.0	0.48 0.70 0.74	50.0 55.2 80.0	
Apricot (Indian)	72.0	0.74	80.0	
Peach (Indian)	75.5	0.50	54.0	
Mixed fruit (Indian)	67.5 69.5	0.52 0.68	64.0 72.7	
Gooseberry (Foreign)	73.4 71.5	0.53 0.67	81.0 85.1	
Raspberry (Foreign)	73.8 72.5	0.57 0.81	59.0 71.6	
Strawberry (Foreign)	72.7	0.52	48.6	
Greengage (Foreign)	74.0 73.0	0.50 0.62	76.75 79.8	Stones included Stones excluded
Plum Jam (stoneless Foreign)	79.6	0.71	78.6	Calculated on stone-free basis.
Plum Jam (Foreign)	78.3	0.99	75.3	Stone-less.

A jam manufacturer can choose fruits from among the following five classes:

1. Fresh fruit.
2. Frozen, chilled or cold-stored fruit.
3. Fruit or fruit pulp preserved by heat.
4. Sulphited fruit or fruit pulp, i.e., fruit preserved with sulphur dioxide.
5. Dried fruit.

Fresh Fruits

Fresh fruits generally give the best jams. There are, however, certain difficulties in using fresh fruits. Firstly, the supply of the fruit has to be regular so that it can be used in fresh sound condition. Otherwise, it is likely to spoil, especially in hot weather. This is possible only when the factory is surrounded by its own orchards or is located in an area growing the particular fruit. If the fruit has to be transported over long distances, there will be the problem of spoilage during transit. Secondly, due to the short duration of the fruit season in many cases large stocks of fruits will have to be stored they produce a pasty product. In some cases, where the fruit is deficient will have to be cold-stored, frozen or chilled, or preserved with chemicals or by heat treatment.

Since pectin is the main ingredient which gives a set to a jam, it is preferable to use some green fruits which are rich in pectin along with ripe fruits to obtain the jellying effect. Over-ripe fruits should not be used as they produce a pasty product. In some cases, where the fruit is deficient in pectin, pectin from other fruits or commercial pectin may be added.

Frozen Fruits

In a modern fruit preserving factory, a cold store is considered a necessary adjunct. Storage is done during the fruit season to ensure regular supplies in the off-season. It has been found that the flavour and aroma of the cold stored fruits are practically unimpaired, and the jams prepared from them are as good as those prepared from fresh fruit. Fruits which cannot be kept in cold-storage for long periods are kept in frozen condition. Some fruits, such as cherries and plums, discolour badly on freezing and become brown. Such fruits are frozen with sugar or sugar syrup to prevent browning. In India, however, fresh fruits are generally used for jams. During World War II dried fruits also were used to some extent.

Fruit Preserved by Heat Treatment

The fruit is prepared in the same way as for canning, and heated to a sterilizing temperature in hermetically sealed containers. Sometimes a small quantity of sugar is also added to preserve the aroma, colour and texture of the fruit. Plums, apples, apricots, pineapples and peaches are stored without addition of sugar, but strawberries and raspberries are stored with sugar. The added sugar is taken into account at the time of making jams. This method is not, however, used largely for the following reasons:

1. Difficulty of storing the fruit in barrels.
2. Loss of colour in fruits such as strawberries and raspberries during the treatment and subsequent storage.
3. A certain amount of loss of pectin while the fruit remains hot for long periods in bulk packings.

Sulphitation for Storing

For preserving fruits in bulk, sulphur dioxide is universally employed in the form of sodium or potassium metabisulphite, sulphurous acid or calcium sulphite. Calcium sulphite provides an additional advantage in that it hardens the tissues of soft fruits and prevents their disintegration.

The preservative fluid in the fruit should be an aqueous solution containing from 0.08 to 0.1 per cent. sulphur dioxide. In general practice, the total quantity of sulphur dioxide in fruit and liquor is kept at 1500 to 2000 p.p.m. to safeguard against any possible leakage of sulphur dioxide.

Sulphur dioxide temporarily destroys the red colour of fruits like red plums, strawberries, and raspberries. The colour is, however, restored when sulphur dioxide is driven off at the cooking stage.

According to Baker and Grove, although sulphur dioxide causes complete stoppage of enzymic activities of the fruits, its presence in soft fruits causes the pectic enzymes to convert pectin into pectic acid, and practically destroys all the jellying power of the pectin in the fruit.

Sulphur dioxide toughens the skins of some fruits such as gooseberries and red currants. These fruits should, therefore, be heated to boiling temperature and cooled before adding SO_2. This preliminary heating will also destroy the enzymes present in the fruit and preserve the jellying power of the pectin present in the fruit.

Preparing the Fruit for Jam-making

The fruit is washed thoroughly to remove any adhering dust and dirt. Leaves, stalks and other undesirable portions are removed. After this the fruit is subjected to preliminary treatment which varies from fruit to fruit. For example, strawberries are crushed between rollers. Raspberries are steamed, crushed and passed through sieves to remove the cores. Plums are heated with a small quantity of water until they become soft, and are then passed through a sieve to remove the stones, unless jam with stones is to be made. Cherries are treated in the same way. Gooseberries are whirled in a machine lined with carborundum to rub off the tops and tails. They are then passed through sieves to remove the stalks. Pears are peeled, cored, and cut into small pieces. Peaches are lye peeled, and their stones removed. They are then cut into small pieces. Apricots are cut and the stones removed unless jam with stones is to be made.

Addition of Sugar

Generally pure cane sugar (sucrose) is used for making jams. The proportion in which it is added depends on the kind, degree of ripeness and acidity of the fruit. Sweet fruits require less sugar than tart fruits do. Proper quantity should be added to give maximum strength to the pectin-sugar-acid gel. To get a minimum of 68.5 per cent of sugar in the jam, generally

55 lb. of sugar is added to every 45 lb. of fruit. The finished jam should contain 30 to 50 per cent. invert sugar or glucose to avoid crystallization of cane sugar in the jam during storage. If the percentage of invert sugar is less than 30, cane sugar may crystallize out; if it is higher than 50 per cent., the jam will develop into a honey-like mass due to the formation of small crystals of glucose. Alternately, corn syrup or commercial glucose may be used along with cane sugar to avoid crystallization. Sugar in excess of the requisite quantity should not be added, because if the percentage of total soluble solids becomes very high, the jam becomes gummy and sticky. In case excess sugar has been added, the remedy lies in adding pectin and acid or both to counteract the excess. If on the other hand, the percentage of soluble solids is low and there is pre-coagulation of the jam showing thereby that the material contains excess of pectin, it is advisable to add more sugar. Under exceptional circumstances, where more sugar is not added, it would be desirable to add a small quantity of sodium bicarbonate to reduce the acidity and thus prevent pre-coagulation.

Addition of Acid, Colour and Flavour

Acid. Generally citric, tartaric or malic acids are used to supplement the acidity of fruits for jam-making. Addition of acid to fruits deficient in it, is a necessity because appropriate combination of pectin, sugar and acid is essential to give a 'set' to the jam. Tarr is of the view that the *p*H of the fruit juice and pectin should be 3.1 before sugar is added. According to Hinton, however, purified pectin gives the best 'set' at *p*H 2.0. Since fruits contain natural buffering salts and other associated materials, the best results are obtained when the *p*H of the mixture is about 3.0.

Colour. Only permitted edible food colours should be used, if necessary, and these should be added towards the end of the boiling process.

Flavour. Ordinarily, jams do not require addition of flavours, but they may be added, if desired, when jam-boiling is nearing completion.

Boiling

Jams are prepared in steam-jacketed pans (Fig. 47) made of nickel, monel metal, aluminium, stainless steel or copper heavily lined with tin or silver. They are boiled at 60-80 lb. pressure, in small lots of 100-120 lb. Sugar and fruit are first weighed in separate pans. The fruit is placed in the boiling pan and, if necessary, a small quantity of water is added to facilitate pulping. It is then cooked sufficiently to liberate pectin. Sugar is added next. The fruit and sugar mixture is then boiled to concentrate the soluble solids to about 68.5 per cent. and also to bring about the necessary degree of inversion of sugar. To avoid excessive frothing during boiling, a little butter or some other tasteless edible oil may be added to the jam. If the fruit does not contain sufficient pectin, commercial pectin may be added to make good the deficiency

Boiling under Vacuum

In the vacuum pan, cooking is done under reduced pressure at low temperatures of 150-170°F. The advantage of vacuum cooking is that it minimises the undesirable changes in colour and prevents loss of vitamin C. The disadvantage, however, is that the product has to be boiled for a long time to soften the fruit pieces and there is some loss of flavour. This drawback can be overcome by recovering the esters and putting them back into the jam.

Proper control of boiling is necessary to avoid over-concentration of soluble solids, over-inversion of sugar, and hydrolysis of pectin.

End Point

In order to make a product of uniform quality, a definite quantity of fruit and sugar should always give a definite quantity of the finished jam. This can be determined by making a jelmeter test. Generally the weight of the finished jam in the case of fruits fairly rich in pectin, is one-and-a-half times the weight of sugar used. The following table would serve as a ready reckoner:

Jelmeter test figure on nearest line	Sugar to be added for each lb. of cooked fruit	Weight of cooked jam
	lb. oz.	lb. oz.
1¼	1 8	2 6
1	1 4	2 0
¾	1 0	1 10
½	0 12	1 4

Jam containing 68.5 per cent. of soluble solids boils at 222.5°F. at sea level. Correction will, however, be necessary for higher locations as the boiling point decreases with the rise in altitude. Generally, the end point for boiling jams should be about 9°F. higher than the boiling point of water at any particular place.

Packing

Soon after the end point is reached, the jam should be cooled in a cooling pan to about 200°F. and filled into jars at this temperature either mechanically or by hand. The surface of the jam in the jars should be covered with a thin disc of waxed tissue paper, and the jars should then be allowed to cool.

For packing in cans, the jam should be filled hot, and the cans sealed and pasteurized at 180-185°F. for about 30 minutes.

Storage

Storage of jam in glass jars which cannot be hermetically sealed is rather difficult, as the surface of the jam is susceptible to mould growth. It should also be remembered that unless the jars are kept in a fairly cool place, moisture will evaporate resulting in surface graining and also shrinkage of the jam. According to Tomkins, if storage conditions are such as to allow the mould to draw moisture easily from the substratum, the atmospheric humidity will have very little effect on their growth. It will, however, have a considerable effect when movement of water from below is slow, and especially when the surface of the jam is covered with a closely adhering waxed tissue paper. This is true in cases where available water is very low due to the presence of a high concentration of sugar. He further states that most fungi are completely destroyed if they are exposed to a humidity less than 90 per cent. Therefore, as a safeguard, jams should be stored preferably at a place having a relative humidity not exceeding about 80 per cent. Hirst and also Morris state that jams are rarely spoiled by yeast because they are of jelly consistency in which yeast cannot grow or thrive. To prevent the spoilage of jams by moulds, jars should be left unsealed after placing a waxed paper on the surface since moulds do not grow under open conditions as rapidly as in a closed space. The jars should be inspected from time to time and, if there is any sign of mould growth, the waxed tissue paper should be changed. If desired, the paper may be dipped in alcohol before placing it on the jam. These jars should be finally sealed only at the time of despatch for sale. If the jam is to be packed in jars which can be hermetically sealed, or in cans, it should be filled hot and the containers sealed and pasteurized at 180°F. for 25-30, minutes, depending on their sizes.

Controlled Manufacture

Analytical control in the manufacture of jams as well as of jellies is important to ensure standards of quality. The methods of control are as follows:

Soluble Solids

Determination of soluble solids is of great importance in the chemical control of jam manufacture. Soluble solids can be determined easily with a refractometer or a specific gravity hydrometer or even a thermometer, as the boiling point of the product depends on the soluble solids in the product.

Refractometer Method. The percentage of soluble solids can be determined easily with an Abbé or Zeiss type refractometer or with a hand refractometer, while boiling is in progress. Since jams and jellies contain other materials like acid, invert sugar, fruit salts, etc., besides sucrose, the readings are not quite accurate. For all practical purposes, however, minor corrections for other materials may be ignored and the refractometer readings fixed for each type of product. If desired, the refractometer reading may be standardised with other methods based either on trial boiling to the required output weight or on a more exact determination of the soluble solids by the specific gravity method.

A sufficient quantity of a representative lot of the sample should be taken and cooled immediately so that the percentage composition of soluble solids may not alter due to evaporation of water. The sample should be thoroughly homogenized before testing. A very convenient way to do this is to squeeze a portion of the jam through a muslin cloth directly on to the prism of the refractometer. The percentage of total soluble solids is read directly on the scale. With dark coloured jams or jellies, a projection-type refractometer may be used.

Specific Gravity Method. Fifty grams of the product are stirred with a little warm water to dissolve the jelly portion. The solution thus made is poured off from the sediment of fibre and seeds, and collected in a 250 c.c. volumetric flask. The residue is then boiled two or three times with a small quantity of water and the solution mixed with the first extract. The combined extract is then cooled to room temperature and made up to 250 c.c. It is then filtered through a coarse filter paper. The specific gravity is determined at 20°C., using a specific gravity hydrometer.

Both the refractometer and specific gravity methods are useful for the determination of soluble solids content of fruit pulps when working out recipes.

Invert Sugar

Invert sugar is determined by the method evolved by Lane and Eynon. The solution prepared for determining the specific gravity is further diluted so that it should contain about 0.2 per cent. of soluble solids. It is then titrated with Fehling's solution using methylene blue as internal indicator. The amount of sugar can be calculated from the corresponding titration using a table [10 c.c. of standard Fehling's solution=0.05 gram of invert sugar of 0.0475 gram of cane sugar (sucrose)].

Sulphur dioxide

Estimation of sulphur dioxide is very important when the jam has been made from pulp preserved with sulphur dioxide. According to the Fruit Products Order (1955) the residual sulphur dioxide should not be more than

40 p.p.m. The sulphur dioxide is generally estimated by distillation according to A.O.A.C. method.

Acidity

Ten grams of the sample are dissolved in water. The solution is brought to a boil and titrated with N/10 sodium hydroxide, using phenolphthalein as indicator. When the end point is not sharp, the solution should be diluted further and phenolphthalein paper used as external indicator.

Regulating *p*H of the Material

The *p*H of the material has great influence on the inversion of sugar and the setting of jam or marmalade. The *p*H required to produce a good firm set in pectin jelly is 3.30, but in jams it varies with the kind of fruit used. The relative *p*H ranges and optimum *p*H values of a number of jams have been worked out by Cameron who states that the setting of the jams takes place only within certain ranges of *p*H. His data regarding *p*H ranges and the optimum *p*H for the setting of jams of different kinds are given in the Table 15.

TABLE 15. *p*H RANGE AND OPTIUM *p*H FOR DIFFERENT KINDS OF JAMS
(*After Cameron, 1948*)

Type of jam	*p*H range	Optimum *p*H
Apricot, Greengage, Damson, Plum	3.2-3.5	3.35
Apple and Damson, Apple and Plum	3.2-3.5	3.35
Apple and Raspberry	3.4-3.5	3.40
Orange Marmalade	3.4-3.5	3.40
Gooseberry	3.4-3.5	3.40
Black Currant	3.4-3.6	3.50
Seedless Bramble	3.4-3.6	3.50
Raspberry	3.5-3.7	3.60
Raspberry and Red Currants	3.5-3.7	3.60
Strawberry	3.7	3.70

Use of Buffer Salts. Since the *p*H is the controlling factor in the setting of jams, it is sometimes necessary to adjust it to the optimum. This is done, generally, by adding acid salts of citric or tartaric acids, or alkalies like sodium bicarbonate or calcium carbonate. The addition of about one ounce of the buffer salt to 100 lb. of jam will generally change the *p*H by about 0.1 of a unit. The *p*H can be determined with a *p*H meter.

Insoluble Solids

The fruit content in a jam can be determined from the amount of insoluble matter present in it. To determine the insoluble matter, 20 grams of a sample are taken, minced thoroughly, and boiled with 100 c.c. of distilled water for 30-40 minutes. The boiled mixture is filtered through a dried and weighed filter paper. After filtration, the fibre is washed back into the water and again boiled with 100 c.c. of water for 15-20 minutes. It is filtered again on the same filter paper. This is repeated several times. Ultimately, the fibre is washed on the filter paper itself with plenty of water and then dried on it at 100°C. to a constant weight. Knowing the insoluble matter of the original fruit, one can roughly work out the quantity of fruit present in the jam.

Estimating Pectin

Pectin does not have a definite composition, because pectins from different sources behave differently. Even if pectin is determined quantitatively by elaborate methods, that will not be sufficient to guarantee a jam of firm set. But the alcohol test for pectin is highly useful. From the general appearance of the pectin precipitate, one can judge fairly accurately its sugar carrying capacity.

JELLIES

In jelly making, pectin is the most essential constitutent. Although there is difference of opinion about the exact nature of pectin, it is generally accepted that pectins form jellies when mixed with proper amounts of sugar, acid and water. All these constituents must be present in a particular ratio for making a good jelly.

Fruits for Jelly

Pectin is present in the cell walls of fruits. Its quantity, however, varies from fruit to fruit and even from variety to variety of the same fruit. Many fruits are rich in pectin as well as acid, and are thus well suited for jelly making. There are other fruits, however, which are either rich in pectin or in acid, or are deficient in both. In order to get a jelly from fruits rich in pectin but deficient in acid, it is necessary to add either fruits rich in acid or an acid like citric, tartaric or malic acid. In the case of fruits deficient in pectin, but rich in acid, either fruits rich in pectin or commercial pectin should be added. Both these methods have their own merits. Combining of fruits rich in acid with those rich in pectin is less expensive than using acid or commercial pectin to supplement the deficiency. But the drawback is that the flavour of the jelly is affected. Special care is, therefore, necessary to ensure that the fruits are mixed in proper proportion. On the other hand, commercial pectin has no deleterious effect on the final flavour of jelly made from any particular fruit.

A classification of some fruits according to their suitability for jelly making (based on pectin and acid contents) as worked out by Elewell and Dehn is given in the Table below.

TABLE 16. CLASSIFICATION OF FRUITS FOR JELLEY-MAKING

(*After Elwell and Dehn—1939*)

Fruits rich in pectin and acid	Fruits containing less pectin and acid	Fruits rich in pectin, but low in acid	Fruits containing acid, but low in pectin	Fruits low in pectin and acid
Apples, sour and crab	Apples, ripe	Apples, kinds low in acid	Apricots, sour	Apricots, ripe
Blackberries, sour	Blackberries			Elderberries
Cranberries	Cherries, Sour varieties	Bananas, unripe	Cherries, Sweet varieties	Peaches, ripe Pomegranates
Currants	Fejoias	Cherries sour	Peaches, sour	Prunes
Gooseberries	Grapes, California	Figs, unripe	Pineapples	Raspberries
Grapes, eastern	Plums	Pears	Strawberries	Over-ripe fruits
Guavas, sour	Loquats		Rhubarb	Strawberries
Kumquats		Grapefruit, peel		
Loganberries		Guavas, ripe		
Lemons		Orange, peel		
Oranges, sour		Quince, ripe		
Plums, sour				

Selection of Fruits

The fruits should be sufficiently ripe (but not over-ripe), and should have good flavour. Slightly underripe fruit yields more pectin than over-ripe fruit does, because as the fruit ripens the pectin present in it decomposes into pectic acid which does not form a jelly with acid and sugar. The amount of pectin extracted from a fruit depends on the degree of disintegration of proto-pectin during the heating process. In practice, a mixture of under-ripe and ripe fruits is used. Under-ripe fruits are used for their pectin content and fully ripe fruits for their flavour.

After picking, the fruits should be quickly used for jelly making because, if kept for a long time, degradation of pectin proceeds rapidly. In some cases, artificial ripening of fruits is also useful.

Preparation of Fruits

Fruits are washed thoroughly with water to remove any adhering dirt. If the fruit has been sprayed with lead or arsenical sprays, it should be washed with a warm solution of one per cent. hydrochloric acid and then rinsed in water.

Since jellies are made from aqueous fruit extracts, ordinarily it is not necessary to peel the fruit. For example, fruits like guavas and apples do not require peeling. Plugs from berries need not be removed. In the case of oranges and lemons, it is necessary to remove the outer yellow portion of the peel to get jellies free from excessive bitterness. Fruits are cut into thin slices so that the acid and pectin may be extracted easily.

Extraction of Pectin

Only a minimum quantity of water should be added to the fruit for a simple extraction of pectin. If necessary, a second or even a third extraction may also be taken and these extracts mixed with the first extract. Large quantities of water should be avoided because excessive dilution of pectin would necessitate long boiling, which in turn would reduce the jellying strength. But, if water is added in too small a quantity, the pectin extract will be viscous and cloudy and difficult to clarify. Further, there is also the danger of scalding the fruit during boiling. The amount of water to be added would depend on the kind of fruit used. Usually it is added at the rate of $1\frac{1}{4}$ lb. to a pound of apples, and $2\frac{1}{2}$ lb. to a pound of oranges or guavas. In the case of grapes no water is added, the fruit being boiled in its own juice. Highly juicy fruits, such as berries, are merely crushed and boiled.

Table 17 gives the proportions of water, sugar and fruit which would yield good jelly.

TABLE 17. PROPORTIONS OF WATER, FRUIT AND SUGAR FOR JELLEY-MAKING
(After Yeatman & Steinbarger)

Kind of fruit	Quantity of water to each pound of prepared fruit	Time of boiling fruit to extract juice	Quantity of sugar to each cup of fruit juice
	Cup	Minutes	Cup
Apple	1	20-25	$\frac{3}{4}$
Crabapples	1	20-25	1
Blackberries, firm	$\frac{1}{4}$	5-10	$\frac{3}{4}$-1
Blackberries, soft	Nil	5-10	$\frac{3}{4}$-1
Black raspberries	Nil	5-10	1
Cranberries	3	5-10	$\frac{3}{4}$
Currants	$\frac{1}{4}$ or more	5-10	1
Gooseberries	$\frac{1}{4}$	5-10	1
Grapes such as concord	$\frac{1}{4}$ or more	5-10	1
Grapes, wild	1	5-10	$\frac{3}{4}$-1
Plums, wild goose type	$\frac{1}{2}$	15-20	$\frac{3}{4}$
Quinces	2	20-25	$\frac{3}{4}$
Red raspberries	Nil	5-10	1

Successful preparation of a jelly depends largely on the extent to which pectin is separated from the cells of the fruit. Fruit juices, when extracted in cold, do not contain the required amount of pectin and, hence, do not form a jelly. To get the desired pectin requirements, the fruit should be cooked because protopectin, the precursor of pectin, is insoluble in the cold juice and thus remains in the pomace or pulp when the juice is extracted in the cold. It is, however, readily converted into pectin on heating. Further, heat treatment also destroys enzymes responsible for the destruction of pectin.

The quantity of pectin extracted from a fruit depends on the degree of disintegration of protopectin on heating. To get good results, heating should be done for a limited time only. If heating is prolonged, the fruit becomes pulpy making it difficult to get a clear pectin extract. The jelly prepared also becomes cloudy. If the heating is just sufficient to extract pectin, there will hardly be any loss of flavour. Table 18 gives an idea of the boiling time required.

TABLE 18. TIME REQUIREMENTS FOR EXTRACTION OF PECTIN
(*After Yeatman and Steinbarger*)

Name of fruit	Time of boiling of fruit to extract pectin (Minutes)
Apples	20-25
Crab Apples	20-25
Blackberries, firm	5-10
Cranberries	5-10
Gooseberries	5-10
Currants	5-10
Grapes, wild	5-10
Grapes such as concord	5-10
Plums, wild goose type	15-50
Quinces	20-25
Red Raspberries	5-10
Black Raspberries	5-10
*Oranges	45-60
* Jaman (*Eugenia Jambolana*)	20-25
* Guavas (*Psidium guava*)	30-35
* Grapefruit (*Citrus Paradisi*)	20-25
* Roselle (*Hibiscus Sabdariffa*)	20-25

* Authors' Data.

Effect of Heat on Pectin. Although it is well-known that high temperatures decrease the jellying power of pectin, the minimum temperature at which degradation may occur is not well defined. Bennison and Norris report that pectin, when extracted under pressure, loses its jelly forming properties. Hinton observes that if pectin is heated at 100°C. for 30 minutes, it loses half of its jellying strength. This loss of jellying power is independent of the *p*H in the range of 2.5-3.0. There is, however, no loss of jellying power when pectin is heated at 80°C.

According to Tarr and Baker, the addition of sugar helps in retarding the hydrolysis of pectin. Pectin and acid should not, therefore, be boiled without the addition of sugar.

According to Huelin, in commercial pectin as well as in crude pectin extract, there is practically no loss of jellying power when they are heated to 100°C. for 30 minutes. Even heating for 60 minutes at 100°C. does not seriously injure the jellying strength of pectin. The degradation of pectin, however, takes place if it is heated at 105°C. or above.

According to Baker and Goodwin, demethylation of pectin can be controlled at low temperatures of about 50°C. and at a *p*H of 1.5. By this means pectin of practically any methoxyl content can be obtained. The methoxyl content of pectin is usually about 11 per cent.

Kaufman and others have been able to prepare jellies from vegetables which contain little or no pectin by addition of demethylated pectin and calcium phosphate, i.e., tomato jelly.

Effect of Various Metals. For boiling, copper and iron kettles should not be used as these are acted upon by acids and salts of the fruit resulting in the discolouration of the extract. Aluminium equipment is satisfactory if the fruit is not too acidic. The best equipment is that made from stainless steel or monel metal or glass-lined or enamelled material.

Straining and Clarification

The pectin extract can be clarified by passing it through bags made of linen, flannel, felt or cheese cloth folded several times. Cheese cloth and linen cloth are more durable than other materials. To get good results, the bags should be scalded in boiling water, squeezed and used while still hot and wet. The bags containing fruit extract should not be squeezed, otherwise the pectin extract will not be clear on account of the particles passing through the pores of the bag. For work on a large scale, a basket or hydraulic press may be used, and the pectin solution clarified by passing it through a filter press. For work on a small scale, the pectin extract is allowed to settle over-night and the supernatant pectin liquor drawn off.

Pectin Requirement

Usually, about 0.5-1.0 per cent. of pectin of suitable quality in the extract is sufficient to produce a good jelly. If the pectin content is in excess of this, a firm and tough jelly is formed and if it is less, the jelly may fail to set. Pectin, sugar, acid and water, which are the four necessary constituents for jelly making, must be present approximately in the following proportions:

Pectin	1.0 per cent.
Sugar	60-65 per cent.
Fruit acid	1.0 per cent.
Water	33-38 per cent.

THEORY OF JELLY FORMATION

Jelly formation is due to the precipitation of pectin rather than its swelling. Only when the pectin, acid, sugar and water are in definite equilibrium range, the precipitation of pectin takes place. The rate of precipitation is influenced by the following factors:

1. Concentration of pectin in the solution.
2. Constitution of pectin.
3. Hydrogen-ion concentration (*p*H) of the pectin solution.
4. Concentration of sugar in solution.
5. Temperature of the mixture.

There are several theories to explain the formation of jellies. The following are some of the more important among them:

Fibril Theory

According to Cruess, when sugar is added to the pectin solution, it destabilizes the pectin-water equilibrium, and the pectin conglomerates forming a net-work of fibrils through the jelly. This net-work of the fibrils, holds the sugar solution in the inter-fibrillar spaces. The strength of the jelly depends on the structure of the fibrils, their continuity and rigidity. The continuity of the precipitated pectin net-work, however, depends upon the amount of pectin present in the system,—the greater the amount of pectin present, the larger the number of fibrils formed, and the denser the net-work. The firmness of the net-work depends on two factors, namely, (*i*) concentration of sugar and, (*ii*) acidity.

Effect of Sugar. If the concentration of sugar in the jelly is high, then proportionately less amount of water is present. It means that the more concentrated the sugar solution, the less is the amount of water to be supported by the pectin fibrils. Thus, by increasing the amount of sugar, a firm jelly can be made and, conversely, a soft jelly can be prepared by decreasing the amount of sugar. To be more precise, the pectin decomposition fixes the maximum amount of acid which can be added to the pectin solution without any deleterious effect on the jelly. The minimum quantity of acid required for making a well-set jelly, is, however, determined by the strength of the pectin fibrils. The crystallisation of sugar in the jelly determines the maximum quantity of sugar required to form a jelly. The best results are obtained when the network of pectin fibrils is closely interwoven and is continuous. It is for this reason that the jelly should not be disturbed during setting.

Effect of Acid. The fibrils of the pectin becomes tough in the presence of acid, and are thus able to hold sugar in solution in the interfibrillar spaces. But, if a large amount of acid is present, the fibrils lose their elasticity with the result that the jelly becomes syrupy. Further, high acidity tends to hydrolyse the pectin. If the system is very highly acidic, the entire structure breaks down. On the other hand, if a smaller amount of acid is present, it results a weak fibrillar structure which is unable to support the sugar solution adequately. The jelly becomes weak and tender in consequence.

The four principal ingredients, namely, pectin, acid, sugar and water, should be in proper proportion to get good results. By varying their proportion, however, jellies of different characters can be made. Deficiency of one ingredient can be made up by using excess of one or of all the other ingredients. Thus, deficiency of sugar can be made up by using a larger amount of pectin or acid or both. For example, if sugar is present in amounts smaller than the normal quantity of 65.0 per cent, then, to get, good jelly, pectin and acid should be added in larger quantities. If the quantity of sugar is normal and that of acid is less, the deficiency can be made up by adding more of pectin to get the same firmness. Within certain limits, the addition of acid makes the jelly firmer and thereby allows the use of less pectin.

Spencer's Theory

Pectin particles are negatively charged. A pectin solution is most stable in neutral range. Increase in acidity or alkalinity decreases its stability. In jelly formation, sugar acts as a precipitating agent, and the presence of acid helps it. The more the quantity of acid present, the less is the sugar required. Some salts also help in the precipitation of pectin, while others hinder it, according to their capacity to increase or decrease the stability of the pectin.

Olsen's Theory

If pectin is taken to be a negatively charged hydrophylic colloid, then the following may be assumed:

1. Sugar acts as a dehydrating agent which disturbs the equilibrium existing between water and pectin.

2. Sugar does not hydrate the pectin micelles instantaneously, but requires time to bring about an equilibrium.
3. If the negative charge on the pectin is reduced with the help of hydrogen-ion concentration, pectin precipitates and coalesces in the form of a fine network of insoluble fibres, provided that the sugar is present in sufficient concentration.
4. The rate of hydration and precipitation of pectin increases with the addition of acid up to an optimum of about *p*H 2.0, in direct ratio to the hydrogen-ion concentration.
5. As the system reaches equilibrium, the jelly strength becomes the maximum.
6. Salts and other components, which cause a change in the ultimate jelly strength of the system, may function either by changing the rate of gelation or by affecting the ultimate structure of the jelly or by a combination of both.

Hinton's Theory

Hinton's theory is based on the assumption that pectins are complex mixtures of variable compostion. According to it, gelation of pectin is a type of coagulation in which the coagulated particles form a continuous network. Pectin, like organic acids, dissociates in solution. It is only the non-ionised, and not the ionised pectin which enters into jelly formation. To form a jelly, therefore, the concentration of non-ionised pectin must exceed a certain saturation limit, which varies with the concentration of total solids in the mixture.

Strength of Pectin Jellies

The strength of pectin jellies depends on several factors, namely:

(i) **Quality of Pectin Present.** The larger the amount of pectin present, the higher is the jelly strength.

(ii) **Quantity of Acid Present.** The larger the amount of acid present the lower the *p*H and, hence the higher the jelly strength.

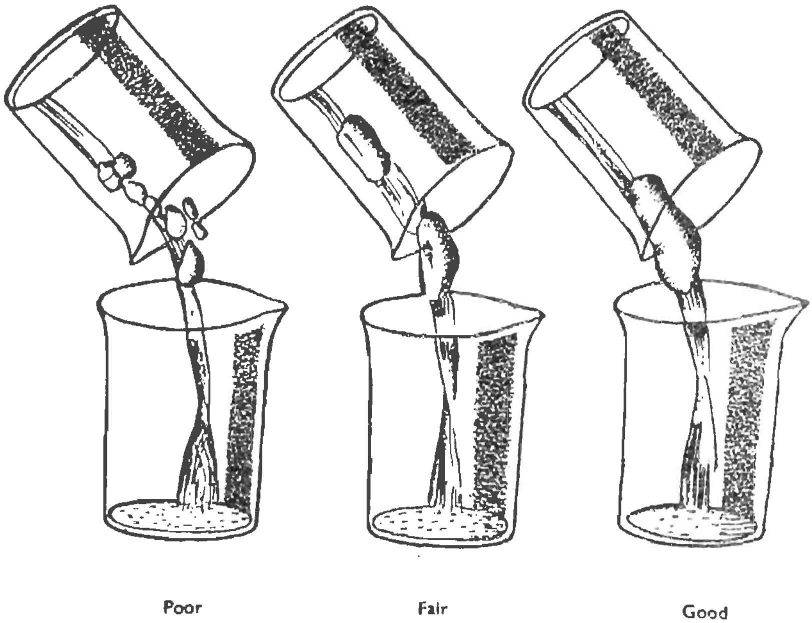
(iii) **Quantity of Salts Present.** Jelly strength is affected by the presence of salts as also by the temperature of gelation and the time elapsing between the addition of sugar and the pouring of the jelly into the containers.

(iv) ***Quantity of Sugar Present.*** The higher the sugar concentration, the greater is the jelly strength.

There are three methods of determining pectin in fruit juices.

1. Testing the amount of pectin by precipitating it with alcohol.
2. Finding the viscosity of pectin solution by using a jelmeter.
3. Making actual test jellies from the fruit extract.

Method I. While the fruit is being cooked for extraction of pectin, a teaspoonful of the juice, free from pulp, seeds and skins is taken out and poured into a glass tumbler. After cooling it, three teaspoonfuls of methylated spirit are added gently along the side of the tumbler and mixed by rotating the tumbler carefully. The mixture is then allowed to stand for a few minutes. If the extract is rich in pectin, it will form a single transparent lump of jelly-like consistency, but if the pectin is present only in a moderate



Pectin Clots

FIG. 49. TESTING FRUIT EXTRACT FOR PECTIN CONTENTS

quantity, the clot will be less firm and fragmented. The presence of insufficient pectin will result in numerous small granular clots (Fig. 49). If the solution is found poor in pectin, the fruit is boiled for a longer period to liberate the whole of the pectin present in it.

If the juice is rich in pectin, one pound of sugar per pound of juice is added. If, on the other hand, it contains only a moderate quantity of pectin, ⅔ or ¾ pound of sugar per pound of juice is added. Should the juice be poor in pectin, about half a pound of sugar is usually sufficient for each pound of juice.

Method II : The viscosity of a fruit juice can serve as an index of its jellying quality provided the *p*H is at the optimum for jelly formation. With the help of a small jelmeter (Fig. 50) or viscosimeter the sugar-carrying capacity of fruit extracts can be determined. For jellies, marmalades and jams, the jelmeter test is the same. The only precaution to be taken is that before testing the solution with the jelmeter, it must be strained through

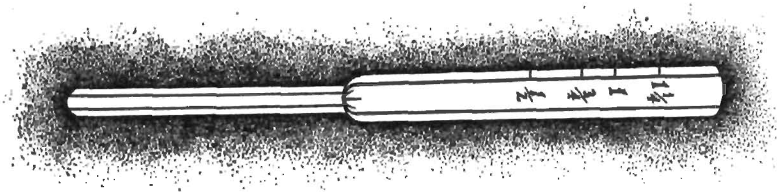


FIG. 50. SKETCH OF A JELMETER

muslin cloth to get rid of all solid particles. If this is not done, the fruit particles will choke up the bore of the jelmeter tube with the result that accurate readings of viscosity will not be obtained.

Jelmeter Test. A small quantity of pectin solution to be tested is taken and its temperature noted. If the temperature is higher than 100°F., it is cooled down, for, otherwise, it would flow too fast through the jelmeter. If the temperature is below 70°F., the solution is warmed up a little, as it will otherwise flow too slow through the jelmeter tube. To get accurate results, the temperature of the pectin solution should range between 70°F. and 100°F.

THE TEST

Step I. The jelmeter is held in the left hand (Fig. 51) with the thumb and the first finger. The bottom of the jelmeter is closed with the little finger. The strained pectin solution is then poured into the jelmeter with a spoon in the right hand, till it is filled to the brim.

Step II. While still holding the jelmeter, the little finger is removed from the bottom end of the jelmeter and the juice is allowed to run or drip exactly for one minute, at the end of which the little finger is replaced.

Step III. The figure nearest (above or below) the level of the juice in the tube of the jelmeter is noted. This figure shows cups or parts of cups of sugar to be added to each cup or part of juice extract.

If the pectin solution is too viscous to pass through the jelmeter, it indicates that it can carry 1½ cups of sugar for each cup of pectin solution. If, on the other hand, it is too thin, it requires to be supplemented with pectin. In this case, either commercial pectin or fruit extract rich in pectin is added.

Method III. In this method, several samples of jelly are made, keeping the amount of pectin solution constant but varying the amounts of sugar. The test jelly which gives the best result is taken as the basis for jelly-making.

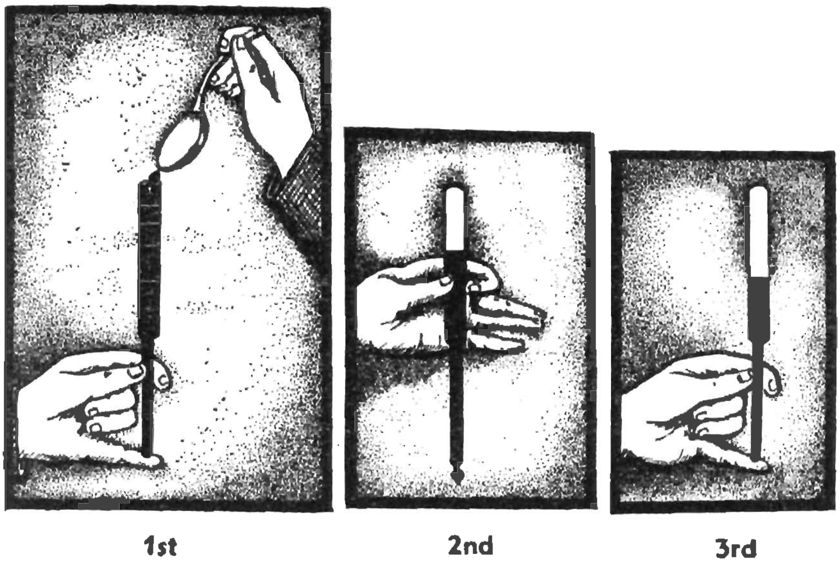


FIG. 51. JELMETER TEST FOR PECTIN CONTENT

Temperature of Gelation

Besides other factors, the strength of a jelly depends also on the temperature of gelation of the jelly. The jelly strength is more when pectin and sugar are combined at 70°F. than when they are combined at 100°C. Olsen has shown that loss of jelly strength is not due to the degradation of pectin but due to difference in gel structure when the jelly is formed at higher temperatures.

Gelation Time

If the jelly is poured into containers when gelation is premature, the gel will have weaker strength due to the mechanical disruption of the mass.

Role of Acid

According to Spencer, although acid is not essential for pectin-gel formation, yet the presence of acid in fruit extracts for making jelly is of importance, for without it jellies of good taste cannot be made.

Jelly strength increases with the increase in hydrogen-ion concentration until an optimum is reached. After this, further addition of acid decreases the jelly strength. The optimum pH in a jelly containing 1 per cent. pectin is approximately 3.0, 3.2, and 3.4, for 60, 65 and 70 per cent. of sugar, respectively. In general, with higher or lower pH, good jellies cannot be made.

The jellying point depends on the amount of acid and pectin present in the original juice. It has been found that as the percentage of acid increases from 0.05 to 1.05, the amount of sugar required to produce 100 grams of jelly decreases from 75 grams to 53.5 grams. This shows that by increasing the acid in the pectin solution it can be made to gel with a lower concentration of sugar, thus leading to saving of sugar.

Although citric, tartaric and malic acids, which are usually found in fruits, are all quite suitable for improving the acidity of the extract, tartaric acid gives the best results. The final jelly should contain at least 0.5 per cent. (preferably 0.75%) total acidity. It should not contain more than 1.0 per cent. acidity, because, with larger quantities of acid, syneresis is likely to take place. The quantity of the acid required, depends on the amounts of sugar used, as the latter forms the basis of calculations for the quantity of the jelly to be obtained.

Test for Acidity. It is necessary to test the acidity of the juice because the quantity of sugar to be added would depend on the pectin and acid content. The acidity can be found by titrating the pectin extract with N/10 NaOH solution, using phenolphthalein as indicator. In places where there are no laboratory facilities, taste is the only guide. With a little experience, one will be able to judge for oneself whether the acid present is really sufficient to give a good jelly. An easy and reliable test is as follows:

One teaspoonful of lime juice is mixed with two teaspoonfuls of sugar and three teaspoonfuls of water. The mixture is shaken until the sugar dissolves. Then the tartness of the pectin extract to be used for jelly making is compared with that of the mixture. For a good jelly, the two must agree. If the pectin extract is more acidic, it is diluted with water or with fruit extract containing a similar amount of pectin but less acid. If the acidity is less, then some lime juice or tartaric or citric acid is added to the extract.

Controlling the *p*H of Jellies

The *p*H of the jellies can be controlled in two ways, namely, (i) by adjusting the *p*H of the pectin extract with an acid or alkali and, (ii) by adding suitable buffers. Huelin studied the effect of *p*H on jelly strength by employing both these methods, and in most cases he got similar results. According to him, pectin extracts prepared under fairly acidic conditions which are probably partly demethylated, give an optimum *p*H of about 2.5 in unbuffered jellies and of 3.2 in buffered jellies. According to Clayton, although the total amount of acid required for jelly making varies considerably, the required hydrogen-ion concentration corresponds to *p*H 3.46.

It is well known that the larger the amount of acid present, the stiffer is the jelly. Tarr states that jelly can be made best when the *p*H of the pectin solution is between 3.3 and 3.1, and that with lower *p*H, syneresis takes place. Lowe, however, mentions that in gooseberry jelly, syneresis does not take place even when the *p*H is as low as 2.5. He has also been able to prepare from citrus pectins jellies which did not show any syneresis even when the *p*H was

2.0 or lower. It is, therefore, to be inferred that weak jellies can be improved by adding a little acid, but that an acid can, in no way, replace pectin.

Acid should be added near the finishing point. If external pectin is used, acid should be added just before the jellies are poured into containers. The acid to be added depends upon the acid naturally present in the fruit employed.

Role of Salts

Fruits contain salts, like sodium citrate, sodium-potassium tartrate, etc., which have buffering action and help successfully in controlling the *p*H of the pectin solution in making jellies, when added in extra amounts. In the case of highly acidic fruits, generally about 3 ounces of sodium or potassium citrate are enough per 100 pounds of sugar to prevent premature setting of jelly.

Halliday and Bailey state that a jelly can be formed with a lower concentration of pectin, acid or sugar, if a small quantity of calcium chloride is added. Hinton reports that although a calcium salt helps in jelly formation, it has its limitations. Addition of larger quantities of calcium salt would neutralize the acidity of the pectin solution and raise its *p*H, which would lower the jelly strength. According to Spencer, when acid is present, sodium chloride tends to prevent jelly formation and, to get a good jelly, one has to add larger quantities of sugar and acid.

The acid to be added depends upon the acid naturally present in the fruit employed.

Role of Sugar

Sugar is an essential constituent in jellies and marmalades. It imparts the necessary sweetness and body to the jelly.

If the concentration of sugar is high, the jelly supports relatively less amount of water. The result is a stiff jelly, probably because of increased dehydration.

Tarr found that if pectin solution is concentrated by boiling before sugar is added, pectin decomposes and loses its jelly-forming strength. The general practice of adding sugar after concentrating the juice is, therefore, not desirable. Besides, sugar added after concentrating the pectin solution does not dissolve in the very short period of boiling, and also does not get sufficient time for inversion. The result is that on cooling its crystals appear in the jelly. Further, if sugar and acid are added to the pectin solution prior to boiling, the jelly strength of the pectin is not decreased even if the jelly is boiled for an appreciable time.

The jelly should not be heated for a long time, otherwise, there may be excessive inversion of sugar resulting in a syrupy jelly. Long boiling also darkens the colour. To overcome these difficulties, the best course is to make jellies in small lots. To limit the time of boiling, the pectin solution should be brought to a boil first and sugar and acid then added to it.

Quantity of Sugar to be Added

The proper amount of sugar to be added to a fruit extract is directly proportional to the amount of pectin and acid present in the extract. As the pectin and acid contents of the fruits vary, different quantities of sugar would be needed for different fruits.

Lal Singh and Girdhari Lal have worked out the following Table which gives the amounts of sugar to be added and the final cooking weights of the jellies.

TABLE 19. COOKING WEIGHTS OF JELLIES

Jelmeter test figures on nearest line	Sugar to add for each lb. of juice extract	Cook to weight
	lb. oz.	lb. oz.
1¼	1 4	2 0
1	1 0	1 10
¾	0 12	1 4
½	0 8	0 14

Kinds of Sugar Used

Cane and Beet Sugar. Both cane and beet sugar can be used for making jellies.

Dextrose. The texture of jelly made with dextrose sugar is similar to that of jelly made with sucrose, but the main drawback is that on standing it crystallizes in the jelly spoiling its appearance. The crystallization may either start from the top and go on spreading to the substratum until the whole mass is crystallized or the crystals may appear in spots in the jelly. Crystallization starts within 24 hours after making the jelly; and if the jelly is removed from the container, the crystals appear in the whole mass within 24 hours. Lowe states that if 50 per cent. of dextrose is replaced by sucrose, the crystallization is slowed down to an appreciable extent, but cannot be prevented altogether.

Levulose. Levulose forms a syrupy jelly. To get good results with this sugar, the jelly should be boiled to 107°C., which is nearer to its saturation point.

Maltose. Maltose is less soluble than dextrose, and considerably less so than sucrose, at room temperature. Since this sugar is less sweet than sucrose, it forms tart jellies. Its other drawback is that it crystallizes readily like dextrose and thus spoils the appearance of the jelly.

How to Add Sugar

The sugar should be sprinkled on the fruit extract while it is boiling and should be thoroughly mixed by stirring to ensure complete dissolution. During boiling, the scum which rises to the top is removed from time to time. Occasional stirring is also necessary to avoid charring of the sugar sticking to the sides, and also to remove any dissolved air.

Inversion of Sugar

Sufficient inversion of sugar can be obtained by boiling the pectin extract for 10 minutes at *p*H 3.0, or for 30 minutes at *p*H 3.5. Although the cooking period required for jam or jelly making may be short, cooking is done for a long time deliberately to invert a portion of the sugar. This long boiling may, however, also cause some of the pectin to decompose with the result that the product will have a poor set. The best way to overcome this difficulty is either to use some pre-inverted sugar, which can be made by boiling the sugar with 0.05 per cent. sulphuric acid for 15 minutes, or to use commercial glucose or corn syrup.

The maximum solubility of sugar (sucrose) at 80°F. is 68.70 per cent. This means that only 68.70 per cent. of sugar (sucrose) can be held by a jelly at 86°F. and if the percentage of sugar is more than 68.70, it will normally crystallize out. Although pectin acts as a protective colloid to check crystallization, it has its limitations. It is of little avail if the percentage of sugar (sucrose) is 70 or more. When sugar is boiled with acid, sugar hydrolyses into dextrose and levulose, the degree of inversion depending on the hydrogen-ion concentration and duration of boiling. Due to partial inversion of some of the sucrose, three sugars, namely, sucrose, glucose and levulose, make their appearance in the finished jelly. Since the solubility of a mixture of these three is more than that of sucrose alone, a jelly can hold more sugar in solution without crystallization taking place.

Cooking of Jelly

Cooking promotes cohesion of jelly components and also brings them to a setting state. The mixture should be concentrated as rapidly as possible to avoid destruction of pectin. To achieve this, only that quantity of juice should be handled which can be boiled down to the desired consistency in about 20 minutes.

The cardinal point to remember in making jelly is that it is the fruit extract that requires boiling and not the sugar. If jellies are cooked for long periods, they may become gummy and sticky and may deteriorate in colour and flavour.

The end point can be found by:

i. Determining the boiling point with a thermometer (Fig. 52).
ii. Sheeting or ladle test.
iii. Weighing.

FIG. 52. JELLY THERMOMETER

Determination by Thermometer

A solution containing 65 per cent. solids boils at 220.7°F. at sea level. Heating of the jellies to this temperature would automatically bring about the concentration of solids to 65 per cent. This is the easiest way to ascertain the end point. Correction is, however, necessary for the altitude of the place. Generally, the end point of jelly should be 8-9°F. higher than the boiling point of water at that place.

Determination by Sheeting or Ladle Test

This may be the 'cold plate' test, or the 'sheet' or 'flake' test.

Cold Plate Test. A drop of the boiling liquid from the pan is placed on a plate and allowed to cool. If the jelly is about to set, it will crinkle when pushed with a finger. The main drawback in this method is that while the drop on the plate is cooling, the jelly continues to boil with the result that there is risk of over-cooking the product or of missing the setting point.

Sheet or Flake Test. This test is more reliable than the plate test. In this case, some portion of a jelly is taken in a large spoon or wooden ladle

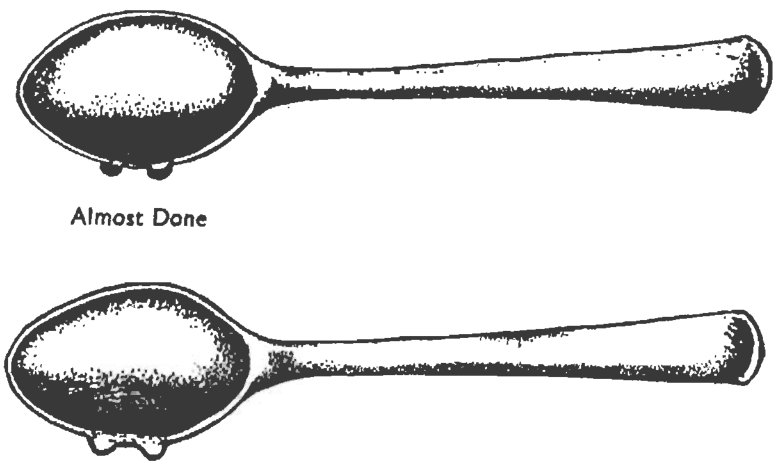


FIG. 53. FLAKE TEST: CONDITION OF JAM OR JELLY FLAKES READY FOR POURING

and cooled slightly. It is then allowed to drop. If the jelly drips like a syrup, it requires further concentration, but, if it falls in the form of flakes or a sheet (Fig. 53), the end point has been reached.

Determination by Weighing

Where there is difficulty in handling the thermometer or in understanding the sheet or flake test, the weighing method is useful. The boiling pan is weighed before and again after putting the fruit extract and sugar in it. The weight of the finished jelly should be about 1½ times the weight of sugar used.

Foaming

Foaming of jellies during cooking can be controlled by adding a little cooking oil. Generally, one teaspoonful of the oil is sufficient for a batch containing 100 lb. of sugar.

PACKING

When jellies are to be packed in large containers, it is necessary to use 5-10 per cent. more of pectin and to cook them to a temperature 1°-2°F. higher than what is normally required.

After the jelly is ready, it is skimmed to remove the foam. It is then cooled slightly and poured into hot and dry containers. If it is to be poured into glass jars, their sides should be smooth so that the jelly can be turned out without breaking. Before pouring jellies, glass containers should be warmed to prevent breakage. After filling the containers, the jelly should be cooled rapidly to 70°F. Pectin jellies set more quickly at this temperature than at lower temperatures. If the jelly fails to set or is weak, it is placed in a drier or in the sun to evaporate the excess of water in it and to promote setting. It should not be poured back into the boiling pan and heated, because this would not only cause loss of flavour, but would also result in some jelly being lost due to its sticking to the pan and the container.

Sealing and Sterilization

Jellies containing less than 65 per cent. sugar require pasteurization. In some cases, jellies containing 65 per cent. sugar or even more become mouldy if they are not properly packed. Moulding can be prevented by pouring a thin layer or hot molten paraffin wax with high melting point on top of the hot jelly. To get a good seal, the melted paraffin should be poured a second time after the first layer has solidified. A good seal can be made also by running a pointed knife around the edge of the wax layer while it is still hot. In this case, one layer of wax will suffice. The surface of the jelly can also be protected from mould growth by placing a circular disc of paper of suitable size on the top of the jelly. The paper disc should have been dipped previously in alcohol.

In commercial practice, hot jelly is packed in containers which are hermetically sealed and then pasteurized at 180°F. for 25-30 minutes.

Sometimes in fancy packs, layers of different jellies are allowed to set in the containers.

Difficulties in Jelly-Making and Their Solution

Several difficulties are experienced in making jellies. The more important of these are as follows:

I. Failure of Jellies to Set

(i) **Lack of Acid or Pectin.** A jelly may fail to set due to lack of acid or pectin, or of both, in the fruit from which it is made. It may also fail to set due to short cooking of the fruit resulting in inadequate extraction of pectin and acid.

(ii) **Addition of Too Much Sugar.** If sugar is added in excess of the right quantity, a syrupy or very soft jelly results. This can be corrected by adding some fresh clarified juice, rich in pectin.

(iii) **Cooking Below the End Point.** If cooking is stopped before the concentration of sugar reaches 65 per cent., the jelly may fail to set and remain syrupy or very soft.

(iv) **Cooking Beyond the End Point.** If heating is continued beyond the end-point, the jelly becomes tough due to over-concentration. This usually happens when the juice is rich in both acid and pectin, and enough sugar has not been added. If the acid is in excess, the pectin decomposes and a ropy syrup or a jelly with waxy consistency results.

(v) **Slow Cooking for a Long Time.** Since the coagulating properties of pectin are destroyed in the presence of acid when heated for a long time, prolonged heating should be avoided.

II. Cloudy or Foggy Jellies

(i) **Cloudy Jelly.** It is formed if the juice or extract is not clarified.

(ii) **Use of Immature Fruits.** Green fruits contain starch which is insoluble in the juice, and the jelly made from them has, therefore, a cloudy appearance.

(iii) **Over-cooking.** Over-cooked jellies get gummy and sticky, and after being poured into containers do not become clear because of excessive viscosity.

(iv) **Over-cooling.** On too much cooling, the jelly becomes viscous and sometimes lumpy. Such a jelly is almost cloudy.

(v) **Faulty Pouring into Containers.** The jelly should not be poured into containers from a great height because air gets incorporated into the mass and the bubbles formed do not clear easily, especially when the jelly is well made and sets in a short period. The spout of the pouring vessel should not be more than about an inch above the top of the container.

(vi) **Non-removal of Scum.** The jelly becomes cloudy also if the scum is not removed before pouring.

(vii) **Premature Gelation.** If there is excess of pectin in the juice, it may cause premature gelation with the result that air may get trapped and thus make the jelly opaque. There are four ways of avoiding premature gelation in jelly: (a) by heating the solution to the boiling point only and pouring it quickly into the containers so as to shorten the time of contact between pectin, acid and sugar in the jelly kettle; (b) by eliminating the acid from the cooking batch and placing it in the containers prior to pouring in the jelly batch; (c) by working at low sugar concentrations; and (d) by using relatively low setting pectin.

III. Formation of Crystals

The formation of sugar crystals in jelly is caused by adding excess of sugar. It is also an indication that the jelly has been over-concentrated.

In making jelly from fruits deficient in acid, the mixture should be boiled for a few minutes after adding sugar to hydrolyse it so that sugar crystals do not form later.

Crystals of cream of tartar sometimes separate out in grape jelly. Although they are harmless, they spoil the appearance of the jelly. The cream of tartar should be eliminated from the grape juice by cooling and settling the juice before making the jelly.

IV. Syneresis or 'Weeping'

The phenomenon of spontaneous exudation of fluid from a gel is called syneresis or 'weeping' of jelly. It is caused by several factors:

(i) **Excess of Acid.** Addition of excess of acid results in the breakdown of jelly structure due to the hydrolysis or decomposition of pectin. Syneresis is more noticeable in tender jellies. It can be prevented by mixing either some juice low in acid or more pectin so that more sugar can be added to increase the volume of the jelly and to decrease its acidity.

(ii) **Too Low Concentratiion of Sugar (Soluble Solids).** This causes the network of pectin to hold more liquid than it can possibly do under normal conditions.

(iii) **Insufficiient Pectin.** This results in the formation of a pectin network which is not sufficiently dense and rigid to hold the sugar syrup.

(iv) **Premature Gelation.** This causes the network of pectin to break during the pouring of jelly into containers so that the jelly becomes weak and remains broken.

Syneresis in jellies can be checked by adding a small proportion of buffer salts like sodium citrate, disodium hydrogen citrate or even a small quantity of common salt.

V. Fermented Jellies

Although jellies usually contain a high percentage of sugar (65 per cent.) sufficient to prevent all ordinary forms of fermentation, one often comes across fermented stuff. Fermentation usually takes place in those jellies in which syneresis has taken place. The remedy lies in storing the jelly in a cool and dry place.

Storage in a damp place favours the growth of moulds even in jellies covered with a seal of paraffin wax. Moulding may be due to various factors, such as (a) not covering the jelly properly, (b) not pouring paraffin sufficiently hot so as to kill mould and bacteria present at the surface of the jelly and (c) breakdown of the paraffin seal.

SOME TYPICAL JAMS AND JELLIES

Jams

Apricot Jam. Both white and yellow apricots can be used. The method is similar to that employed for peaches except that the quantity of acid added should be raised to 0.5 per cent. especially in the case of the sweeter white varieties. The kernels can be decuticled like almonds and added to the jam to improve its taste and appearance.

Peach Jam. White as well as yellow peaches can be used. The fruit is peeled by knife or lye, and the pulp softened by heating with about ¼th of its weight of water. An equal weight of sugar and 0.20 per cent. citric or tartaric acid should be added to get a good jam.

Pear Jam. Pears are peeled and cut into small pieces which are crushed and boiled with ¾th of their weight of sugar. To the pulp 0.25-0.5 per cent. citric acid may be added towards the end-point.

Plum Jam. It can be made with or without stones. The fruit is crushed and boiled with about one-third of its weight of water to soften the pulp. The pulp is screened through a sieve to remove the stones and skin. The *alucha* plum gives a golden brown jam with a fruit-sugar ratio of 1:1. If desired, citric or tartaric acid, 0.5 per cent. of the weight of fruit, may be added to improve the taste. Other yellow or purple varieties of plums also can be utilized.

Other Jams. Jams from cherry, mulberry, strawberry, musk melon, tomato, mango, jack fruit, cashew-apple, pineapple, etc., also can be made in the usual way. It may, however, be necessary to vary slightly the fruit-sugar ratio and the percentage of acid added.

Jellies

Guava Jelly. Ripe guavas, preferably with thick pulp, are washed, cut into thin slices, and covered with an equal weight of water containing one gram of citric acid to a pound of guavas. The mass is heated for about 30 minutes to extract pectin. A second extract can also be taken adding water equal to ¼th of the weight of pulp. The extract is strained through thick cloth and left over-night for settling. The clear supernatant liquid is syphoned off and tested for pectin. The required quantity of sugar (generally an equal quantity) is added, and the jelly boiled down to the desired consistency.

Other Jellies. Jellies can also be made in a similar manner from apple, grape, roselle, *jaman,* jack fruit, etc.

Jam-like Products

Guava Cheese. The guavas are cut into slices and boiled with an equal quantity of water or soften the pulp. The pulp is screened through a net cloth to separate seeds and skin. To one pound of pulp are added 1¼-1½ pounds of sugar, about 1 to 1½ grams of citric acid, and about 2 ounces of butter. The mixture is cooked to a thick paste. Small quantities of red colour and salt may be added towards the end to improve the appearance. The boiled cheese is allowed to set on a greased plate. After cooling, it can be cut into pieces and packed with moisture-proof paper.

Apple Butter. Apple butter is apple jam made from finely sieved pulp by adding small quantities of spices, consisting of sugar, nutmeg, cinnamon, clove, etc. The pulp-sugar ratio should be 1:¾. On account of its spicy flavour, apple butter is liked by many.

MARMALADES

In the preparation of marmalades, all the conditions necessary for jelly making are applicable. The pectin and acid contents of the marmalades should be kept slightly higher than what has been recommended for jellies.

Citrus marmalades are of two types, namely, (a) jelly marmalade and, (b) jam marmalade. The method of preparing these is similar to that used for jellies.

Jelly Marmalades

A good jelly marmalade can be made using the following combinations.

1. *Malta* or sweet orange and *khatta* (*Citrus aurantium*), 2:1 by weight (shreds of *malta* orange peel).

2. *Sangtra* (loose jacket orange) and *khatta,* 2:1 by weight (shreds of *malta* orange peel).

3. *Khatta* alone (shreds of *malta* orange peel).
4. *Malta* or sweet orange and *galgal* (*Citrus limonia*), 2:1 by weight.

Cruess and McNair recommend the use of two whole oranges with one whole lemon for making marmalade.

Selection of Fruit

Only sun-ripened fruits should be used. Size is immaterial as long as the fruits are free from blemishes.

Preparing the Fruit

The outer yellow portions of the skins of citrus fruits contain colouring matter and volatile oils, while the white inner portion contains pectin. The yellow skin (flavedo) is peeled off from the fruits. For work on a small scale, an ordinary table-knife suffices, but for large-scale work special peeling and stredding machines are used. Care should be taken to see that very little of the white portion is removed. Loose skin oranges are peeled by hand.

The peels, after proper shedding, are kept separate and are incorporated in the jelly.

The peeled fruits are cut into 1/8″-3/16″ thick slices or crushed in an apple grater to facilitate extraction of pectin. For work on a small scale, a table-knife will do.

Boiling for Extraction of Pectin

The sliced fruit is boiled with 2-3 times its weight of water to extract pectin. While it is being boiled, a teaspoonful of the clear extract is drawn out from the pan and tested with alcohol for its pectin content. Boiling is stopped when sufficient pectin has been extracted. The process usually takes 45-60 minutes.

The aqueous pectin solution from the boiled fruit is separated by pressing the fruit in a rack and cloth press or by using cheese cloth or jelly bags. If desired, a second or third extraction may be taken in a similar manner, but using smaller amounts of water. If more than one extract is taken, all the extracts should be mixed together to get a solution of uniform quality.

Clearing of Pectin Extract

For work on a small scale, the pectin extract is placed in an aluminium or enamelled or stainless steel vessel and allowed to stand overnight. When the sediment settles down, the supernatant clear juice is syphoned off or decanted. For large-scale work, the juice is mixed with wood pulp or with other filter-aids and passed through jelly bags or a filter press.

Preparation of Peels

While the pectin solution is being clarified, the peels are cut into shreds, ¾"-1" long and about 1/32"-1/20" thick. The peels become tough if they are boiled as such with the sugar solution. It is, therefore, necessary to soften them before use. Generally, the following methods are used for this:

1. Boiling the shredded peels for 10-15 minutes in several changes of water. Incidentally, the bitter principles of the peels are also removed in the process.
2. Boiling the peels in 0.25 per cent. solution of sodium carbonate or 0.1 per cent. ammonia solution.
3. Heating the peels in an autoclave at 240°-250°F. The time required to soften the peels depends on their size and shape.

The shreds should not be unduly heated at high temperatures for a long time as there is danger of their discolouration. After softening, they should be kept covered with water for use later on.

Cooking

In order to determine the quantity of sugar to be added, the pectin solution is tested with alcohol or with a jelmeter as is done in the case of jelly. The solution is brought to a boil and the requisite sugar added to it. The boiling is continued and the impurities rising to the surface are skimmed off. Shreds are added at the rate of about one ounce per pound of the original extract, when the temperature of the mixture reaches 218°F. (at sea level). The boiling is continued till the jellying point is reached. The end-point can be determined as in the case of jelly, i.e. by, (a) sheeting test, (b) drop test, (c) weight test and (d) finding out the temperature of the mixture. Marmalade containing 65 per cent. sugar boils at 221°F. (at sea level). Boiling should not take more than 20 minutes. Short boiling produces a bright and sparkling marmalade.

Cooling

When the marmalade is ready, it is cooled in shallow or water-cooled pans in which it is stirred slowly all the while. This operation is very essential to keep the shreds evenly distributed. When the temperature reaches 180°-190°F., a thin skin begins to form on the surface of the marmalade, and it becomes sufficiently thick to prevent floating of the shreds.

Flavouring

It is desirable to add flavour because the natural flavour evaporates during boiling and cooking. Generally, a small quantity of orange oil may be added to the marmalade at the time of packing.

Canning and Sterilization

After cooling, the marmalade may be filled into jelly glasses or jars, which can be sealed air-tight, or packed in cans. When it is filled in jelly glasses, it is allowed to set overnight and sealed on the following morning with very hot paraffin wax as is done in the case of jellies. If jars or cans are used, these should be sealed hermetically and sterilized at 180°F.-190°F. for 25-30 minutes.

Darkening

Marmalades tend to darken during storage. To prevent this, Lal Singh and Girdhari Lal recommended adding 4 grams of potassium metabisulphite per 100 pounds of marmalade, provided that the product is not packed in tin containers. Potassium metabisulphite is dissolved in a small quantity of water and added during the cooling of the marmalade. Incidentally, this small quantity of potassium metabisulphite also removes any chance of spoilage by moulds.

JAM MARMALADE

The method of preparing jam marmalade is precisely the same as that for making jelly marmalade. No attempt is, however, made to clear the pectin extract of the fruit. The whole of the pulp mass is used.

Fruits are taken in the same proportion as recommended for jelly marmalade. The orange peel is removed along with the inner white skin (albedo) and the fruit is sliced into 1/8″-3/16″ pieces. The peels are shredded and boiled as in the case of jelly marmalade and kept separately for use later on. In the case of *khatta* (*Citrus aurantia*) or lemon, the outer yellow skin is peeled off and discarded.

The sliced oranges and lemons or *khattas* are mixed and boiled thoroughly till the slices become tender and sufficient pectin is extracted. The boiled fruit mixture is passed through a coarse sieve or through a pulper to remove seeds and coarser material. To the pulp thus obtained, the boiled shreds are added, and the mixture is boiled with sugar to get a jam marmalade.

In the preparation of jam marmalade, the pectin test is not essential since it will not give any indication of the amount of sugar needed, because the pulp will make the marmalade thicker in consistency. Sugar is, therefore, added on the basis of the weight of the fruit taken, generally in the ratio of 1 : 1.

The pulp and sugar are cooked till the marmalade contains 65 per cent. sugar.

After cooking, a small quantity of orange oil is added to enhance the flavour of the marmalade as is done in the case of jelly marmalade.

When the marmalade is ready, it is filled into cans, scalding hot. The cans are then sealed airtight.

After sealing, the cans are immediately inverted to sterilize their lids, and no further heat treatment is given. For large scale production, however, it is necessary to pasteurize the product at 180°-190°F. for about 30 minutes in the case of A2½ size cans. Pasteurization time will vary slightly for containers of other sizes.

CHAPTER XII

PRESERVES, CANDIES AND CRYSTALLIZED FRUITS

A preserve is made from properly matured fruit, by cooking it whole or in large pieces in a heavy syrup till it becomes tender and transparent. In its preparation not less than 45 pounds of the fruit are used for every 55 pounds of sugar, and cooking is continued till a concentration of at least 68 per cent. of soluble solids is achieved.

Freshly made preserves are wholesome and attractive. However, when kept in storage for long periods, their natural colour and flavour deteriorate on account of oxidative changes. They should, therefore, be made only during the season unless there are adequate facilities for keeping the fruits so that they can be had in the off-season also. Preserves made from frozen fruits are generally superior in colour and flavour to those made from fresh fruits stored at room temperature.

Preliminary Processing

The fruit should be washed thoroughly. If it has been sprayed with Bordeaux mixture or lead arsenate to check blight, it should be washed with dilute hydrochloric acid, especially if peels also are to be consumed.

The preliminary processing varies with the kind of fruit used. For example, apples and pears are just peeled and punctured if they are to be kept whole ; otherwise they are peeled, halved or quartered, cored and punctured. Mangoes are peeled, sliced and punctured. Peaches are destoned and lye peeled. Apricots, cherries and greengages are only destoned. Oranges, lemons, grapefruits and citrons are halved and depulped. Pumpkins (*petha*) are sliced, peeled, pricked and placed in dilute lime water for some time. Strawberries and raspberries are not given any treatment.

The fruit is first cooked slightly in water to make it just soft for absorption of sugar. Cooking of fruit in syrup is a very difficult process, because the syrup has to be maintained at a proper degree of consistency so that it can permeate the entire body of the fruit without causing it to shrink or become tough. If the fruit is cooked in a heavy syrup straightaway, its juice will be drawn out rapidly due to osmosis, with the result that it would shrink and very little sugar would be absorbed. The fruit should, therefore, be boiled initially in water before putting it into syrup, or cooked in a syrup of low concentration. Very juicy fruits may, however, be put into even a thick syrup from the beginning because the excess of juice present in them will serve to dilute the syrup.

Cooking in Syrup

There are three ways of cooking a fruit in a syrup, namely, (i) open-kettle one-period process, (ii) open-kettle-slow process, and (iii) vacuum cooking process. In all these processes care has to be taken to ensure that the fruit is kept covered with the syrup during cooking as well as afterwards; otherwise it will dry up and the quality of the product will be impaired.

Open-kettle One-period Process. To start with, the syrup in which the fruit is cooked should be of low sugar content. Boiling should be continued with gentle heating until the syrup thickens sufficiently. Rapid boiling will make the fruit tough, especially when heating is done in large shallow pans with only a small quantity of syrup. Soft fruits such as strawberries and raspberries which, unlike hard fruits (e.g., apples, pears, peaches, etc.) require little boiling, can, however, be safely cooked in heavy syrup. The final concentration of sugar should not be less than 68° Brix, which corresponds to a boiling point of 222.2°F. (at sea level). The main drawback of this simple and cheap process is that the flavour and colour of the product suffer considerably during boiling.

Open-kettle Slow Process. The fruit is cooked in water until it becomes tender. Sugar, equal to half the weight of fruit, is then put on the boiled pieces in alternate layers, and the mass allowed to stand for 24 hours in a vessel. The fruit gives out excess of water, and the sugar goes into solution, giving a syrup of about 37-38° Brix. More sugar is added to raise the strength of the syrup to about 60° Brix. A small quantity of citric or tartaric acid (1-2 ounce per 100 lb. of sugar used at the start) is also added to invert a portion of the cane sugar. The whole mass is then boiled for 4-5 minutes and left for 24 hours. On the third day, the strength of the syrup is raised to about 68° Brix, and the mass boiled again for 4-5 minutes. The fruit is then left in the syrup for 3-4 days. Finally, the strength of the syrup is raised to 70° Brix and the product packed in containers.

Vacuum Cooking. Preserves made by cooking under vacuum keep their flavour and colour better than those made in the open kettles. In this process, the fruit is boiled to soften it before being placed in the syrup. To begin with, the syrup should be of 30-35° Brix. It is subsequently concentrated under vacuum (along with the fruit) to 70° Brix. Hard fruits like apples and pears require slow boiling to facilitate the penetration of sugar, while soft fruits can be boiled briskly.

Cooling and Packing

If the preserve is to be stored in bulk, it should be cooled immediately after final boiling to avoid discolouration of the product.

The fruit is drained from the syrup and put into dry containers. Freshly prepared boiling syrup of 68° Brix is then poured into the containers (A2½ size cans) which are exhausted for 8-10 minutes at 212°F. and thereafter sealed airtight.

If the preserve is packed scalding-hot in dry containers, subsequent sterilization may be omitted. In large-scale production, however, it is, desirable to sterilize the sealed containers to preclude any chance of spoilage. The cans (A2½ size) may be sterilized for 25 minutes at 212°F. and cooled immediately afterwards.

CANDIED, GLACÉD, AND CRYSTALLIZED FRUITS

A fruit impregnated with cane sugar and glucose, and subsequently drained and dried, is called candied fruit. Candied fruit covered with a thin, transparent coating of sugar which imparts to it a glossy appearance is called glaced fruit. When candied fruit is coated with crystals of sugar, either by rolling it in finely powdered sugar or by allowing the sugar crystals to deposit on it, it becomes what is called crystallized fruit.

CANDY MAKING

The process for making candy is the same as that employed for preparing preserves, with only this difference that the fruit is impregnated with a higher percentage of sugar or glucose. A certain amount of invert sugar or glucose is substituted in place of cane sugar. The total sugar content of the impregnated fruit is kept at 75 per cent. to prevent fermentation. The process of impregnation with sugar must not be hurried through because otherwise, the fruit would shrivel and sweat and become unfit for glacing and crystallizing.

Fruits and sugar are the main raw materials used for candy making. The most suitable fruits are those which possess pronounced flavour, such as pineapple, peach ; peels of orange, lemon, grapefruit, citron, cherry and ginger. Slightly unripe fruits should be used because fully ripe and over-ripe fruits develop jam-like consistency in the syruping process. Canned fruits of good quality can also be used.

Cane sugar is employed in conjunction with glucose or invert sugar. These latter sugars are briefly described below:

Confectioner's Glucose. It is also known as corn syrup, crystal syrup, or commercial glucose. It is a heavy, slightly sweet, colourless and semi-fluid substance. In Germany and France, it is made from potato starch, and in U.K. and U.S.A., from maize starch.

Dextrose. It is used in candy manufacture in the U.K. and the U.S.A. It is slightly less sweet than cane sugar and is quite stable. It gives very fine crystals, and when mixed in small proportions with cane sugar induces crystal formation in that as well. Thus it helps in imparting smoothness and softness to the candies.

Invert Sugar. When cane sugar is boiled with a small quantity of an organic acid like acetic, citric or tartaric acid, or with cream of tartar, it is hydrolysed into invert sugar. Usually half an ounce of acid is added for every cwt. of sugar used. On hydrolysis, dextrose and levulose are formed in equal proportion, and the mixture is much sweeter than the cane sugar alone. Moreover, invert sugar does not crystallize. It also prevents crystallization of cane sugar in heavy syrups.

Ordinarily, it is not easy to know the extent to which inversion of cane sugar takes place under the above process. The speed with which inversion is effected depends directly on the temperature at which heating is done. But above 200°F., the colour of the syrup begins to darken. To overcome this difficulty, a small quantity of the invert sugar or glucose syrup is employed in conjunction with cane sugar.

Fruits like *amla* and *myrobalan,* and citrus peels are kept in a strong solution of common salt to remove their astringency. They are usually stored tightly packed in barrels to which brine containing 15 per cent. common salt, and sulphurous acid equal to 2,000 p.p.m. of sulphur dioxide, are added to avoid fermentation and softening of the fruit. At the time of use, the stored fruit or peel is taken out from the barrel and washed thoroughly in running cold water to leach out as much of the brine as possible. The fruit or peel is then placed in a cooking vessel and boiled for about 15 minutes to remove traces of salt and to soften its texture. It is then soaked in fresh cold water for about 12 hours, the water being changed 4-5 times. This completes the leaching process and makes the fruit firm in texture.

Syrup Treatment

The prepared fruit or peel is boiled in a syrup of 30° Brix containing 3 parts of cane sugar and 1 part of corn syrup or confectioner's glucose or invert sugar, and thereafter left in the syrup for about 24 hours. Next, the Brix of the syrup, which would have fallen below 30 degrees, is raised to 40 degrees by adding a mixture of cane sugar and corn syrup or confectioner's glucose or invert sugar in equal parts. The process is repeated and the strength of the syrup raised by 10° Brix upto 65° Brix and then by 5° Brix, on alternate days until the final concentration of the sugar reaches about 75° Brix.

In India, corn syrup and confectioner's glucose are not manufactured. Candy manufacturers, therefore, use only cane sugar, a portion of which is inverted. The method adopted is as follows:

The fruit or peel (after brining, where necessary) is boiled in cane sugar syrup of 30° Brix containing 0.1 per cent. citric or tartaric acid (about 1½ oz. acid per 100 pounds of syrup) for 10-15 minutes and, thereafter, left in the syrup for 24 hours. Next, the Brix of the syrup is raised to 40 degrees by adding more cane sugar. The whole mass is boiled for about 5 minutes and left for 24 hours. This is repeated until the Brix of the syrup reaches 60 degrees. After that, the strength of the syrup is progressively increased (by 5 degrees at a time) by adding more sugar and boiling the mass on every alternate day until the final concentration reaches about 75 per cent.

It is desirable that the cane sugar and the invert sugar should be in equal proportion. To achieve this, the syrup should be analysed daily. If sufficient inversion of cane sugar is not noticed, the syrup should be boiled for longer periods. But if even on prolonged boiling inversion does not occur to the desired degree, a little more acid should be added. The acidity, if maintained at 0.1 per cent. by adding small doses of acid daily along with sugar until the syrup reaches 60° Brix, would ensure proper inversion.

The total amount of sugar required in candy making is much more than what is actually absorbed by the fruit. It, varies of course, with the kind of fruit used. The quantity required for preparing one pound of candied orange or lemon peels, *petha* or ash gourd (*Benincasa cerifera*), and carrot is given in the following Table:

TABLE 20. SUGAR REQUIREMENTS FOR CANDYING

(*After Girdhari Lal & Jain, N. L.—1948*)

Fruit	Total sugar required per pound of candy	Sugar actually absorbed by the fruit
	lb. oz.	oz.
Orange peels	2 3¼	14.3
Lemon peels	2 4	13.4
Petha (Ash gourd)	1 12	12.5
Carrots	1 6	13.3

The syrup left over from the candying process can be used in various ways, i.e., for sweetening chutneys, sauces and pickles, in vinegar making, for candying another batch of the same kind of fruit after suitable dilution, etc.

Draining and Drying

After the above treatment has been completed satisfactorily, the fruit may be removed from the syrup. It is drained for half an hour and placed on the sorting tables to separate the unwanted pieces. The fruits or peels are next wiped with a wet sponge. Sometimes they are dipped for a moment in boiling water to remove the adhering syrup. This is followed by slow drying in shade, or for 8-10 hours in a drier at about 150°F. Citrus peels need drying for 10-12 hours.

GLACÉING

According to Cruess, syrup just sufficient for the glacéing process is made by boiling a mixture of cane sugar and water in the proportion of 2:1 in a pan at a temperature of 236°-238°F. and skimming the impurities as these come up. Heating is then discontinued and the syrup cooled to 200°F. Granulation of the sugar is achieved by rubbing the syrup with a wooden ladle on the side of the pan. Dried candied fruits are passed through this granulated portion of the syrup, one by one with a fork, and placed on waxed tin sheets in a warm dry room. To hasten the process, the fruit may be dried in a drier at 120°F. for 2-3 hours. When it becomes crisp, it is packed in airtight containers.

CRYSTALLIZED FRUIT

The process of 'crystallizing' candied fruit is quite different from that employed for glacéing, but is similar to the crystallizing of confectionery. Syrup of 70° Brix is used. It is placed in a large deep vessel and allowed to cool to room temperature. To avoid premature granulation of sugar, a wax paper is placed on the surface of the syrup. The candied fruit is put in a wire tray which, in turn, is placed in a deep vessel. The cooled syrup is then gently poured covering the entire fruit. To prevent the fruit from floating, another wire tray is put on it, and a waxed paper is placed on the surface of the syrup. The whole mass is left undisturbed for 12-18 hours at the end of which a thin crust of crystallized sugar will be formed. The tray containing the fruit is then removed carefully from the pan, and the surplus syrup drained off. The drained fruits are placed separately on wire trays and dried at room temperature or at 120°F. in driers.

Spoilage

There is a likelihood of spoilage occurring due to fermentation in the initial stages of preparation of preserves and candies when the percentage of sugar in the syrup is low. This can, however, be controlled by boiling the product at proper intervals. If candied and glacéd fruits are kept under humid conditions they throw off some of their sugar due to absorption of moisture from the air. Again, moulding takes place if they are packed in wet containers. There is also danger of their being attacked by mould if not sufficiently dried.

SOME COMMON PREPARATIONS

Amla (*Phyllanthus emblica*)

Select large-sized fruits for making a preserve. Wash them in water. Prick them with stainless steel, silver or wooden needles and place them in 2 per cent. common salt solution. Raise the strength of the solution progressively by 2.0 per cent. on subsequent days until it reaches 8.0 per cent. Wash the fruits and place them in freshly prepared 8.0 per cent. brine for a week. This treatment would remove most of the astringency. Wash the fruits again. Ordinary iron equipment should not be used, as on account of the reaction of tannins the fruits would go black. Blanch the *amlas* in 2.0 per cent. alum solution until they become soft. Care should be taken to prevent breaking or cracking of the segments in the process. The syrup treatment is similar to that employed for apples. For packing use only lacquered cans.

Apple

Although several varieties of apples are grown in India, only two kinds, the sweet and the sour, are important from the point of view of making preserves and candies.

Peel the apples thinly, but do not remove the stems and cores. Prick the apples with stainless needles or forks. Place the sweet variety in 2-3 per cent. common salt solution and the sour variety in plain water to prevent browning and also disintegration during blanching. Transfer them, next, to diluted lime water (2 parts of lime water and 1 part of water) and leave them for 24 hours. Prepare 2-3 per cent. alum solution and boil it in a pan. Now place the apples in the boiling solution. Add a small quantity of sodium bisulphite to whiten the colour. Boil until they become soft. Next, place them in cold water discarding the blanching solution. Prepare fresh alum solution for every lot. They are now ready for sugar treatment.

Take sugar equal to half the weight of the prepared apples. Usually 37-38 pounds of sugar will be required for every 50 pounds of the unprocessed fruit. Place the sugar and apples in alternate layers in a vessel and leave the mass undisturbed for 24 hours. During this period, the fruit would give out sufficient water and the sugar would go into solution. Ordinarily, the syrup formed is of about 36-38° Brix. Next, boil the mass for a few minutes and raise the strength of the syrup to about 59-60° Brix by adding more sugar. Also add a small quantity of citric or tartaric acid or 25 per cent. by weight, of invert sugar or corn syrup. After boiling, let the apples remain in the syrup for another 24 hours. On the third day, raise the strength of the syrup to 70° Brix and let the product stand for a week. After this, the preserve is ready for canning.

If it is to be candied, the Brix of the syrup should be raised to 75 degrees, and again kept for one week before canning.

Bael (*Aegle marmelos*)

The *bael* has a very hard rind which is difficult to cut and peel with an ordinary knife. The usual procedure is to make a slit at the blossom end of the fruit with a strong knife, insert the pointed end of the knife under the skin to crack it, and remove the rind in pieces.

Slice the peeled fruit crosswise into about an inch thick slices, and wash these in water. Prick them on both sides with stainless steel needles or forks, and soak them in cold water overnight. Next, blanch them in boiling water containing a suitable edible red colour until they become soft and absorb sufficient colour.

Now take sugar, equal to half the weight of the prepared fruit, and place it and the slices in alternate layers in a vessel. Allow the mass to stand for 24 hours. Next day, drain the syrup and raise it to 59°-60° Brix by adding more sugar. Also add a small quantity of citric or tartaric acid. Alternately, add 25 per cent. by weight, of invert sugar or corn syrup to raise the strength of the syrup to 70° Brix. Then leave the product for two weeks. The preserve would be ready for canning after this period. If it is to be candied, the Brix of the syrup should be raised to 75 degrees, and the product kept for another two weeks before canning.

Ber *(Zizyphus jujube)*

Take large-sized *bers,* wash and prick them with wooden needles or forks. Then place them in 2.0 per cent. common salt solution. Raise its strength by about 2.0 per cent. every day till it reaches 8.0 per cent. Next transfer them to fresh brine of 8.0 per cent. strength containing 0.2 per cent. potassium meta-bisulphite and allow the mass to stand for 1-3 months. After that they should be taken out, washed in water and boiled till they become tender. They can then be candied in the usual way.

Carrot

There are two kinds of carrots available in the market, i.e., those with orange yellow skin and flesh, and those having purple skin but white flesh. Usually, carrots with orange yellow flesh are preferred for making preserve and candy.

Take young, tender carrots with a soft pith. Srape off the peel. Prick the carrots with stainless steel needles or forks, and cut them into pieces of suitable size. Boil them in water until they become tender. Further processing is to be done in the same way as recommended for apples.

Cherry

Keep cherries in 8.0 per cent. common salt solution containing calcium bisulphite equal to 600 p.p.m. of sulphur dioxide, until their natural colour disappears. With this treatment, cherries can be kept in good condition for a year or even longer. When required for preserve making, they should be taken out of the brine solution and washed thoroughly.

Pit and blanch the cherries to make them soft. Next cover them in a vat with cold syrup of 36-37° Brix containing 0.02-0.05 per cent. Erythrosine or Ponceau 3R dye or a mixture of both (to get the shade required). On the following day, drain off the syrup and raise its strength by 5° Brix. Bring it to a boil, and add the boiling hot syrup to the fruit. Allow the mass to stand for 24 hours. Repeat this until the Brix of the syrup reaches 60 degrees. At this stage, add either citric acid, 1 oz. for every 50 pounds of the fruit, or invert sugar or corn syrup to the extent of 25 per cent. of the syrup and continue the process of progressively raising the Brix of the syrup till it reaches 75°. Keep the cherries in this syrup for a week before packing.

For glacéing, boil the cherries with the syrup for a few minutes and when still hot, drain off the syrup by spreading the fruit on wire trays. Further processing is to be on the lines suggested for candied peels.

Candied Citrus Peels

Thick rinds of citrus fruits like orange, lemon, grapefruit, citron, and pummelo, are used for candying. Various methods are employed for their preliminary processing. The more important of these are given below:

Method I. The fruits are cut into halves, and the pulp is reamed out. The cups, after removing the rags, are placed in 1-2 per cent. hot sodium bicarbonate solution for 20-30 minutes. They are then rinsed in cold water, pricked with stainless steel forks and boiled in water to remove bitterness and to make them tender.

Method II. The de-pulped fruit, from which the rags have been removed, is cured by placing it in 5-10 per cent. common salt solution. To hasten the process, a small quantity of glucose is sometimes added to the brine. When curing is complete—which usually takes 5-7 weeks—the peels become translucent. The peels are then sorted and placed in a freshly prepared 10-12 per cent. common salt solution containing 500-600 p.p.m. of sulphur dioxide. When required for candying, they are rid of salt by repeated washing and soaking in warm water. The cups are then pricked from inside with forks to facilitate absorption of syrup.

Method III. The peels are preserved in water containing 3500 p.p.m. of sulphur dioxide for use in the off-season. This gives a firmer product with a more pleasing colour and flavour. When required, the peels are punctured and boiled to make them tender.

Method IV. The fruit is de-pulped, and rags are removed from inside the cups. The peels are then placed in 2.0 per cent. common salt solution. The strength of the solution is increased by 2.0 per cent. every 24 hours until it reaches 8.0 per cent. This takes 4 days. On the fifth day, the peels are washed and placed in a freshly prepared 8.0 per cent. common salt solution containing about 0.2 per cent. sodium or potassium metabisulphite and 1.0 per cent. calcium chloride, and stored (for 1-3 months). Calcium chloride helps in keeping the peels firm. When required, they are washed with several changes of water, and then boiled to effect softening.

After the peels have been prepared by any of the above methods, they are covered with a cold syrup 30° Brix in a vessel, and left for 48 hours. On the third day, the Brix will be less than 30 degrees. It is raised by 10 degrees, and the peels are boiled with the syrup for about 5 minutes. The process is repeated until the Brix reaches 60 degrees. At this stage, citric or tartaric acid is added—1 oz. for every 50 pounds of the peels. Alternatively, glucose or invert sugar may be added up to a maximum of 50 per cent. of the cane sugar used. The strength of the syrup is then raised to 75° Brix –5° on every day. The peels are then left in the syrup for 2-3 weeks. Finally, they are dried on wire trays at room temperature till they are no longer sticky. They may also be dried at 120°F. for 2-3 hours.

Ginger Candy

The best ginger for candy making is Canton ginger which is extensively grown near Canton in China. It is rich in flavour, juicy and succulent unlike the Indian variety which is hard, knotted and fibrous. The difference is largely due to the better method of cultivation adopted in China. Careful selection of the embryo stem and cultivation under controlled conditions in loose sandy soils may, however, improve the quality of Indian ginger also.

The method of candying Indian ginger is as follows:

Select only very tender, fibreless and large-sized rhizomes. Three to four months old ginger grown on sandy loam soil gives the best results. Remove any adhering soil by thorough washing. Scrape off the skin with a knife, and cut pieces of the desired shape and size. Next soften the pieces by cooking them for an hour with sufficient 0.5 per cent. citric acid solution in an enamelled basin at 10 pound pressure in an autoclave (pressure cooker). Citric acid improves the colour. If an autoclave is not available, boil pieces with 0.5 per cent. citric acid solution for 6 hours in a copper pan heavily lined with tin. The temperature and time may, however, be altered to suit the age and tenderness of the ginger. After cooking, wash pieces throughly with cold water. When sufficiently cooled, prick them with stainless steel, silver or wooden pricks. Wash them again. Next boil them in 30 per cent. sugar solution for 15 minutes and leave them in the syrup overnight. Next day, increase the concentration of the syrup by about 5° Brix by adding more sugar. Boil them again with the syrup. Repeat this every day until the syrup is of about 60° Brix. At this stage, add either a small quantity of citric or tartaric acid, or 25 per cent., by weight, of invert sugar or corn syrup. Boil again and leave the product for 24 hours. Then raise the strength of the syrup to 75° Brix and allow the mass to stand for 2-3 weeks so that sugar may penetrate the ginger pieces thoroughly. The product obtained is generally known as 'ginger-in-syrup'. For candying, boil it for about 5 minutes, and, when still hot, drain the syrup and roll the pieces in finely ground sugar. Place the pieces on wooden trays and dry them in shade till they are no longer sticky. They may also be dried at 120°F. in a drier. The dried product will keep good for a long time if stored in a cool and dry place. The syrup left over after candying can be used again for candying more ginger. It can also be used as ginger syrup for flavouring aerated waters.

Karonda (*Carrisa carandas*)

Wash the fruit and de-stone it. Next, blanch it in 2 per cent. alum solution containing a small quantity of sodium bisulphite. The original pink colour of the fruit would be bleached to white. The method of colouring and syruping is similar to that employed for cherries.

Mango

Select large-sized slightly underripe mangoes of sweet variety and wash them. Peel them with a sharp knife, taking care that no green patches of the skin are left over, for these would turn black during subsequent treatments and spoil thereby the appearance of the product. Now cut the mangoes lengthwise into large slices. Place the slices in boiling water and heat until they become tender. Then cool and prick them with stainless steel needles or forks. Subsequent syruping, processing and packing processes are similar to those suggested for apple candy and preserve.

Pear

Use only fully ripe pears of good variety. Peel the fruit and cut it into halves or quarters (or keep it whole), and core. Next, prick it with stainless steel needles or forks. Then place the fruit immediately in 2-3 per cent. common salt solution to prevent browning. When required, cook it in boiling water to remove brine and also to soften it. To make the candy attractive, boil the pieces for a short time in a solution of some suitable edible colour (say deep green or red). When sufficient colour has been absorbed by the fruit, wash it in running cold water. Now place it in syrup of 30° Brix and leave it for 24 hours. Raise the strength of the syrup by 5° Brix every day until it reaches 50 degrees. At this stage, add either a small quantity of citric or tartaric acid or 25 per cent. by weight, of invert sugar or corn syrup. Continue raising the strength of the syrup till it is 70° Brix. Then keep the product for 2-3 weeks. It would be ready after that for packing as preserve. If it is to be candied, the Brix of the syrup should be raised to 75°, and the fruit kept again in it for 2-3 weeks.

Petha (*Benincasa cerifera*)

Take fully ripe *petha* and cut it longitudinally into large slices. Remove the inside fluffy portion of the slices and peel each slice separately. Soak the peeled slices for half an hour in lime water diluted with three times the quantity of water. Prick them with stainless steel needles or forks and cut them into pieces of suitable size. Keep the prepared pieces soaked in diluted lime water overnight. Next, prepare 2-3 per cent. alum solution and bring it to a boil. Boil the pieces in the solution till they become tender. Then remove them and cool in running cold water. If it is desired to make the pieces perfectly white, a small quantity of sodium sulphite may be added to the alum solution while cooking. Now place the prepared pieces in alternate layers with sugar (half their weight), in a vessel and keep for 24 hours. The pieces will give out sufficient water and the sugar will go into solution. Ordinarily, the syrup formed is of 36°-38° Brix. Now add more sugar to raise its strength to about 59°-60° Brix. Also add citric or tartaric acid, 1 oz. for every 100 lb. of sugar used. Alternatively, add 25 per cent. by weight, of invert sugar or corn syrup to raise the syrup strength. Boil the pieces and the syrup for about 10 minutes and leave the mass for 24 hours. Subsequently, increase the strength of the syrup by 5° on every alternate day till it is 70° Brix. Allow the pieces to remain in the syrup for 4-6 weeks. The product thus got is known as 'Petha' preserve. For candying, bring the whole mass to a boil and, when still hot, drain the syrup. Roll the pieces in finely powdered sugar and dry them on trays at room temperature.

Pineapple

Prepare the fruit in the same way as recommended for canning. Prick on both sides with stainless steel needles or forks to facilitate absorption of sugar. Next, place it in 2.0 per cent. common salt solution for 24 hours. After that raise the strength of the salt solution by 2.0 per cent. every day till it reaches 8.0 per cent. Keep the fruit in the brine until slight fermentation takes place. This treatment softens the fruit. If the fruit is to be used immediately, leach out the brine by soaking the pieces for 12 hours in water; which should be changed several times. If it is to be used in the off-season, the fruit may be stored in a freshly prepared 8 per cent. common salt solution containing 350 p.p.m. of sulphur dioxide. When required, boil the fruit for a short time to remove common salt and sulphur dioxide. Place the fruit in a syrup of 30° Brix containing 0.1 per cent. citric or tartaric acid and boil for 10 minutes. Raise the strength of the syrup by 5° Brix every day until it reaches 50 degrees. At this stage, analyse the syrup for its acid content and, if necessary, add more of acid to bring it to 0.1 per cent. strength. Alternatively, add 25 per cent., by weight, of invert sugar or corn syrup. Repeat the process of raising the syrup strength till it is 70° Brix. Let the fruit remain in the syrup for 10 days. It will then be ready for packing as preserve. If it is to be candied, the Brix of the syrup should be raised to 75° and the fruit again kept in it for 10 days.

Strawberry

Take firm ripe berries of good colour and flavour. Sort them carefully and remove the stems. Wash the berries to remove dirt. Next, put them along with an equal quantity of sugar and some water in a boiling pan. Warm the mixture to dissolve sugar, skimming off impurities in the process. Cook the syrup to a temperature of about 220°F. Then cool it to 200°F. and put the berries in it. To prevent floating of the fruit, place a wire tray over it and then leave it for 24 hours. Thereafter boil the mass again to a temperature of 220°F. Repeat this once. The preserve is ready.

CHAPTER XIII

TOMATO PRODUCTS

Fresh tomatoes are very refreshing and appetizing. They are a good source of vitamins, particularly of vitamin C. In India, tomatoes are grown both in summer and winter. But the winter tomatoes are superior because they generally contain more solids. Two varieties of tomatoes are more commonly grown in India—they are the large and round ones and the small and oval ones. In other countries, well-known varieties like Marglobe, Sanjose, etc., are grown because they are better for preserving and processing.

The tomato changes in colour during various stages of ripening, i.e., from green to pale white, yellow and red. The yellow colour is due to the presence of carotene. The red colour appears when lycopene is formed in the fibres.

Since tomatoes are available in India throughout the year, a good tomato products industry can be developed. Tomato products are judged by their colour which in turn depends on the degree of redness of the tomatoes used.

The following rules should be kept in mind to get a product of good quality:

1. Use only plant-ripened red fruits as far as possible. The yellow and greenish portions not only mask the red colour of the fully ripe tomatoes, but also turn brown due to oxidation.
2. Never use iron equipment. Lycopene (a self-oxidizing isomer of carotene) to which tomatoes owe their red colour, turns brown when it comes in contact with iron. Iron also forms black compounds with the tannin of the tomatoes or of the spices used. Equipment should be glass-lined or made of monel metal or stainless steel. Copper equipment also spoils the colour of the product.
3. Avoid prolonged heating and cool the product quickly after preparation.

Tomato juice cocktail, ketchup, sauce and soup, and chilli sauce are some of the important products made from tomatoes. The methods of preparing these are described below:

TOMATO JUICE

For this product, only plant-ripened tomatoes should be used. All green, blemished and over-ripe fruits should be rejected as they adversely affect the quality of the pack. Juice made from over-ripe tomatoes is usually thin and unpleasant in taste and aroma.

The yield, colour and flavour of the juice depend on the ripeness of tomatoes, the variety used and the place where grown. The following points should be kept in view to ensure good quality of the juice:

1. The juice should be of deep red colour. As the red colour in tomatoes is contained in the fibres, as much of the fibrous portion as possible should be incorporated in the juice.
2. The juice should have the characteristic flavour of tomatoes.
3. The acidity of the juice should be about 0.4 per cent.
4. The vitamins present in fresh tomatoes should go into the juice. Their retention depends on the method of extraction employed. It has been found that while carotene is fairly resistant to heat and oxidation in the various processes of preparation, Vitamin C is lost appreciably, particularly during the screening of the juice, due to oxidation.
5. For uniformity in quality, either the tomatoes used should be from one stock and place, or the juice should be suitably blended.

Washing and Trimming

Mere rinsing of tomatoes in water is not enough, because mould filaments and other micro-organisms, found in their cracks, wrinkles, folds and stem cavities, are not easily dislodged. For thorough cleaning, they should be washed in running water. For work on a large scale, rotary-washers are used.

Great care should be taken in trimming. The loss on account of trimming etc., as worked out in India, varies from 4.0 to 17.0 per cent. with an average of about 8.0 per cent. This heavy wastage is largely due to the absence of standard varieties and defects in picking, transport and marketing of the produce.

Crushing

After trimming, tomatoes are cut into small pieces before boiling. Alternately, they may be crushed by means of wooden roller-crushers.

Pulping

Tomatoes can be pulped by the hot or cold process described below:

Hot Pulping. The crushed tomatoes are boiled in their own juice in steam-jacketed kettles or aluminium pans (Fig. 54) for 3-5 minutes to facilitate pulping. The process has the following advantages:

1. The tendency of the juice to separate into liquid and pulp can be overcome if the natural pectin present in the seeds and the skin can be incorporated. During boiling, the pectin is released, and this thickens the pulp. The pectase enzymes, which would otherwise hydrolyse the natural pectins present in tomatoes and make the juice thin, are also destroyed during boiling.

2. Heating sterilizes the juice partly thereby checking to some extent the growth of living organisms which cause fermentation, etc. It also inactivates the oxidative enzymes which destroy Vitamin C.
3. A light cooking releases the colour present in the skin.
4. The yield of juice is higher than in cold pulping.

Cold Pulping. The tomatoes are crushed and passed as such through a pulper. This process has the following defects:

1. As compared to the hot process, the extraction of juice is somewhat difficult. The yield also is smaller.
2. Air gets incorporated in the juice in the process of extraction and oxidizes Vitamin C. There are, however, machines available nowadays which considerably eliminate the mixing-up of air.
3. The juice extracted by this process is somewhat light in colour.
4. The process has to be finished quickly to avoid spoilage, especially during the initial stages of preparation.

Recently, Penfold has pointed out that cold pulping gives a juice whose flavour and consistency are different from those of the hot-break juice. The manufacturers have, therefore, to decide about the type most likely to satisfy the market demand. The flavour of the cold-pulped juice is much sharper and more acidic. This is due to the pressure applied in this process whereby the juice surrounding the seeds which is richer in acid and poorer in sugar than the other portions of the tomato, is extracted first. On account of this, the cold-break juice is also of lighter consistency than that obtained from hot pulping. It has, however, a good fresh flavour.

Extraction of Juice

There are two types of extractors in use, the continuous spiral press and the cyclone.

Continuous Spiral Press. This consists of a long spiral screw which presses the tomatoes against a tapered screen of fine mesh having 25 holes per linear inch, each hole with a diameter of 20/1000 of an inch. The juice passes through the screen while the skin and seeds are expelled at the other end of the machine. When these machines are operated at a speed of about 250 revolutions per minute, there is little or no incorporation of air in the juice. The tomatoes passing through the hopper should have a jet of steam playing on them to prevent oxidation and destruction of the vitamins.

Cyclone or Pulper. Tomato juice can also be extracted by passing the tomatoes through a cyclone or pulper. The main defect in this type of machine is that a considerable amount of air is incorporated into the juice. Special attachments for the cyclone can, however, be obtained nowadays to avoid this. In these machines the insoluble solids of the juice are very finely divided and stay in suspension for longer periods.

For work on a small scale, tomatoes can be strained through sieves of nickel or monel metal having a one millimeter holes. Not more than 60 per cent. of the fruit should be recovered as juice because, with higher yields, the juice becomes thick and harsh in flavour.

Total Solids

On an average, tomato juice should have a total solid content of 5.66 per cent. (Sp. Gr. 1.0240) at 68°F. The amount of total solids present can be determined in a number of ways, such as by weighing the dried sample, by the refractive index and by the specific gravity hydrometer. For routine work, the specific gravity method gives fairly satisfactory results. The juice is strained through a thick cloth and the specific gravity of the strained juice determined with a hydrometer at 68°F. If the specific gravity is obtained at temperatures other than 68°F., then a temperature correction is applied. The percentage of total solids is then determined from standard tables showing the relationship between specific gravity and the percentage of solids (see Appendix I).

Common Salt and Sugar

On an average, 4-6 lb. of common salt is added per 100 gallons of juice to counteract the astringent taste of the juice.

Sometimes sugar is added to improve the taste. According to Lal Singh and Girdhari Lal, addition of about 1.0 per cent. cane sugar improves the flavour.

Packing

The juice can be packed in bottles or cans. Canned juice has a better taste, aroma, colour and preservability than the bottled product.

Size of can	Sterilization time (when the can is filled at 180°-190°F.)	Sterilization temperature
	Min.	°F.
No. 1	15	212
No. 2	25	"
No. 2½	30	"
No. 10	40	"

The juice is generally homogenized to retard separation of liquid from the pulp and to give it a thick and uniform appearance. It is heated to about 150°F. and forced through a small orifice under a pressure of about 1,000 lb. per square inch. This shears the particles and tends to reduce them all to about the same size. The juice is afterwards heated to about 180°-190°F. and poured into hot sterilized bottles (of 12-16 oz.). The bottles are then hermetically sealed and sterilized for about half an hour in boiling water.

Plain cans are the best, although enamelled ones can also be used. In this case also, the juice is canned at 180°-190°F., leaving practically no headspace, otherwise marked loss in colour, flavour and Vitamin C occurs. The cans are then sealed and processed according to their sizes, as follows:

After processing, the cans are cooled in running cold water.

Since No. 10 can is processed for a longer period, juice in it usually has a cooked flavour.

According to Tressler, Joslyn and Marsh, tomato juice may be pre-sterilized by heating in continuous heat exchangers to temperatures much above the boiling point. The following time-temperature relationships are considered to be approximately equivalent in sterilizing value.

Temperature of juice °F.	Holding time Min.	
240	3.3	
245	1.5	
250	0.7	standard process
255	0.32	
260	0.15	
265	0.07	

This procedure is effective for destroying the flat-souring organism, *B. thermoacidurans*. Before filling, the juice must be cooled slightly below the boiling point, but should still be sufficiently hot to sterilize the containers.

Analysis of Juice

Lal Singh and Girdhari Lal have made a comparative analysis of four foreign and two Indian brands of tomato juice and the data is given in the Table below:

TABLE 21. ANALYSIS OF VARIOUS BRANDS OF TOMATO JUICE OBTAINABLE IN INDIAN MARKET

No.	Brand of juice	Sp. gr. of juice at 68°F.	Sp. gr. of filtrate at 68°F.	Per cent. solids in juice	Salt as sodium chloride in 100 c.c. juice	Total acid as malic acid in 100 c.c. juice
1.	Foreign I	1.0240	1.022	5.66	0.89	0.38
2.	„ II	1.0240	1.022	5.66	0.79	0.36
3.	„ III	1.0334	1.031	7.99	0.84	0.49
4.	„ IV	1.0250	1.023	5.91	0.82	0.38
5.	Indian I	1.0387	1.036	9.27	1.74	0.59
6.	„ II	1.0292	1.027	6.95	1.11	0.56

TOMATO PUREE

Concentrated tomato pulp without skin or seeds, with or without added salt and containing not less than 8.37 per cent. of salt-free tomato solids, is called 'Medium tomato puree'. If it is further concentrated so that it contains not less than 12 per cent. solids, it is called 'Heavy tomato puree'.

Preparation

The first step is the preparation of tomato pulp. This is made from plant-ripened tomatoes in the same manner as tomato juice.

Pulp Concentration

Concentration of the pulp is done in two types of vessels, namely, (i) open cookers and (ii) vacuum pans.

Open Cookers. For work on a small scale, aluminium *patilas* will do. For large-scale production, glass-lined tanks or tanks made of stainless steel, monel metal or nickel and fitted with flash coils are used. The open pan method although employed generally, has obvious disadvantages. During boiling, the juice comes into contact with the oxygen of the air which not only destroys the Vitamin C in it, but also makes the juice brown. Lal Singh and Girdhari Lal have pointed out that unless special equipment is used to prevent the incorporation of air during the entire manufacturing process, a considerable loss of Vitamin C takes place. Butter or an edible oil is added to the juice during boiling to prevent it from foaming, boiling-over, sticking or burning. Incidentally it also helps in lessening oxidation. This method has now, however, been superseded by the vacuum pan method which gives a product of superior quality.

Vacuum Pan. The installation of a vacuum pan is rather expensive. Its main advantage is that the juice can be boiled at a much lower temperature, i.e., at about 160°F., thus helping in the retention of the original colour and flavour of the tomatoes to a marked degree. As air also is removed during boiling, there is very little likelihood of oxidation or Vitamin C losses. In order to sterilize the product, the vacuum is broken towards the end and the temperature raised to 212°F. for about 10 minutes.

Pulp Consistency

The processes used for concentration of tomato pulp are as follows:

Method I. The pulp is poured into the boiling pan till the heating coils are covered. Heating is then commenced. More juice is added and the heating continued till the pan is full of pulp. Heating is then stopped and the total solid content of the pulp is determined. If the solid content is higher than the required percentage, more juice is added to lower it; if it is lower, concentration is continued till the desired consistency is reached. Manufacturers find this method easy to follow.

Method II. In this case, a known volume of the juice is concentrated to a known volume of the finished pulp. The juice is let into the boiling tank and, when the coils have been covered, heating is started and the tank is filled to capacity. Heating is continued till the pulp begins to boil vigorously. Steam is then shut off momentarily and the volume of hot pulp is measured with a measuring rod. Then a small sample is drawn for determining the tomato solids by the specific gravity method. While the determination of the solids is being done, boiling of the pulp in the pan is continued. By making use of standard Tables (see Appendix I) the pulp is boiled to the desired specific gravity. Since both the original and final measurements of volume are taken at the boiling point, temperature correction is not necessary for the readings.

The End Point

The total solids in the juice, at the start, during cooking and at the finishing point can be determined either with a specific gravity hydrometer or with an Abbé or pocket refractometer, or by drying the juice in vacuum at 70°C. In practice, the first two methods are used as they are simple.

Packing

Puree can be packed in plain as well as in enamelled cans. The cans are usually filled with scalding-hot puree at 180°F.-185°F. and sealed without exhausting. Sixteen-ounce cans are processed at 212°F. for 20 minutes. Larger cans are not generally processed, the temperature of the hot puree itself being sufficient for sterilization.

TOMATO PASTE

A concentrated tomato juice or pulp, without seeds and skins and containing not less than 25 per cent. of solids, is known as tomato paste. If the pulp is further concentrated so as to contain 33 per cent. or more of tomato solids, it is called concentrated tomato paste. Common salt, basil leaf or sweet oil of basil leaf also may be added. Part of its acidity may be neutralized with sodium bicarbonate or carbonate. Ordinarily tomato juice can be concentrated to about 14-15 per cent. tomato solids in open pans, but for higher concentration, vacuum pans are necessary. The initial concentration is generally carried out in open pans and the product is finished in vacuum pans.

Since the product is very thick, the total solids are determined by an Abbé refractometer.

TOMATO COCKTAIL

Tomato cocktail is gaining popularity in many high class hotels and restaurants. It is prepared just before serving and is also served from stock.

In the latter case, the cocktail is preserved by pasteurizing it in bottles. Recipes may differ, but the main constituent is tomato juice to which common salt, vinegar, Worcestershire sauce, lemon or lime juice, tabasco sauce, etc., are added in different proportions to suit the palate. Two typical formulae are given below:

FORMULA I

Tomato juice (Sp. Gr. 1.020)	10 lb.
Cloves (headless), whole	1.5 gm.
Cumin, black pepper and cardamom in equal quantities	4.5 ,,
Cinnamon, broken	1.5 ,,
Coriander seeds	1.5 ,,
Red chillies, Kashmiri (finely ground)	0.25 ,,
Vinegar (10 per cent. acetic acid)	10 oz.
Common salt	45 gm.

Simmer the tomato juice with the spices loosely tied in a cloth bag for about 20 minutes in a covered vessel and then add lime juice, vinegar and common salt.

FORMULA II

Tomato juice (Sp. Gr. 1.020)	10 lb.
Cloves (headless), whole	1.5 gm.
Cumin	1 ,,
Black pepper	1 ,,
Cardamom	1 ,,
Red chillies, Kashmiri (finely ground)	0.25 ,,
Ginger	1.5 ,,
Lime juice	1.5 oz.
Vinegar (10 per cent. acetic acid)	7.5 ,,
Common salt	45 gm.

Quality of Ingredients

Tomato Juice. If possible, use fresh juice; otherwise, use canned product.

Vinegar. Use only malt or cider vinegar of good quality and not acetic acid.

Lime Juice. Only crystal clear lime juice should be used because any sediment in it will impart an undesirable flavour. Moreover, it gives a 'foreign' taste to the product when it is pateurized for stocking. Citric acid is not a good substitute as it does not produce as good a taste as natural lime juice does.

Sugar. It should be of good quality.

Common Salt. Refined table salt should be used.

Pasteurization

When all the ingredients have been mixed and the cocktail is ready for bottling, heat it to 180-190°F. and fill it into 12 oz. hot sterilized bottles.

Seal the bottles and immerse them in boiling water (212°F.) for 30 minutes and then cool.

TOMATO KETCHUP

Tomato ketchup is made by concentrating tomato juice or pulp without seeds and pieces of skin. Spices, salt, sugar, vinegar, onions, garlic, etc., are added to the extent that it contains not less than 12 per cent. tomato solids and 28 per cent. total solids.

Raw Material

Select only sound ripe tomatoes of deep red colour. Cut off all green and yellowish portions. Green fruit should not be used as it will make the ketchup inferior in colour and flavour.

Juice Extraction

The juice is extracted in the same manner as in tomato juice or puree.

Juice Standardisation

The raw juice is a thin watery fluid and its specific gravity varies with the kind of fruit and the duration of boiling. It follows, therefore, that spices have to be added each time in varying proportions. This would, therefore, not yield a standard product. Standardisation can be achieved by using a recipe for juice of 1.0220 specific gravity (filtrate of pulp of 5.66° Brix). Keeping the other ingredients constant, an equivalent amount of juice of any other specific gravity can be conveniently added.

Recipes

There are several recipes which give good ketchup. Recipe I given by Lal Singh and Girdhari Lal, with slight variation has become popular with the manufacturers in this country. The remaining three recipes are popular in other countries.

RECIPE I

Tomato juice (Sp. Gr. 1.022-1.027)	6 gal.
Onions, chopped	375 gm.
Garlic, chopped	25 ,,
Cloves, whole, headless	10 ,,
Cardamom	4 ,,
Black pepper	4 ,,
Zira	4 ,,
Mace (*Jalvatri*), not ground	2.5 ,,
Cinnamon (broken)	17.5 ,,
Vinegar, 6% acetic acid	2.5 lb.
Sugar	2.0 ,,
Salt	312 gm.
Red chillies	12.5 ,,

RECIPE II

Tomato pulp (Sp. Gr. 1.020)	330 gal.
Sugar	120 lb.
Salt	27 „
Vinegar, 100 grain, white, distilled	7 gal.
Cloves, headless	15 oz.
Cinnamon, broken and sifted	15 „
Mace	1 „
Cayenne pepper	5 „
Garlic, freshly ground (or onions 25 oz. and garlic 5 oz.)	25 „

Cook to a finish of 125 gallons. This makes a mildly spiced product.

RECIPE III

Tomato pulp (Sp. Gr. 1.022)	600 gal.
Sugar	300 lb.
Salt	50 „
Paprika	8 „
Onions, chopped or ground	10 „
Garlic	2 „
Mace	12 oz.
Cinnamon, broken and sifted	10 „
Cloves, headless	12 „
Cayenne pepper	13 „
Vinegar, 100 grain	16 gal.

Cook to a finish of 200 gallons. This makes a spiced ketchup with a good colour which is partly due to the paprika.

RECIPE IV

Heavy puree (Sp. Gr. 1.06)	100 gal.
Salt	28 lb.
Sugar	125 „
Chopped onions	25 „
Cinnamon (broken bark)	25 oz.
Mace	3½ „
Cloves, whole, headless	15 „
Allspice	15 „
Cayenne pepper	3½ „
Chopped garlic (optional)	4 „
Vinegar (distilled, of 10% acetic acid)	12 gal.
Paprika, ground (optional)	2 lb.

Place all the spices except paprika, onions and garlic, in vinegar in a covered kettle and simmer the mass for about 2 hours. Add sugar and salt to the vinegar and stir. Add the extract thus obtained, after removing the spice residues, to the ketchup towards the end of the boiling process. If desired, add the paprika powder directly to the ketchup. The above formula yields slightly more than 100 gallons of ketchup.

ADDITION OF INGREDIENTS

Spices

The spices should be of good quality and should be added in proper proportions to give an agreeable flavour. The mixture made should be such that no one spice dominates the natural flavour of tomatoes. The spices can be used in the following ways:

Bag Method. The spices are tied loosely in a muslin bag and it is placed in the juice during boiling. It is removed before bottling the product. This method has the following drawbacks:

(i) The bag may give way and spoil the whole product. In that case, even if the pulp is again forced through a very fine sieve, particles of the spices will still pass and darken the product.

(ii) The taste and flavour may vary every time according to the duration of boiling and variation in the composition of spices used on different occasions.

(iii) All the flavours are not extracted in the first boiling. Moreover, some of the volatile flavouring substances may be lost during boiling. To counteract these, a quantity of spices, larger than what is actually required, will have to be used. This will add to the cost, although the used spices can be utilized for the preparation of pickles.

In spite of these drawbacks, the bag method gives a ketchup of high quality.

Use of Essential Oils. These oils do not contain tannins and, therefore, do not spoil the colour of the product in the way the whole spices do. Essential oils of spices may be blended suitably. The essential oil of a spice does not, however, give the true aroma of the spice.

According to Campbell, comparative strength of a whole spice *vis-a-vis* its essential oil is as follows:

Spice (100 lb.)	Equivalent weight of oil
	lb.
Cinnamon	0.5
Clove	15.0
Mace	3.5
Pepper	1.0
Cardamom	3.0

Use of Oleo Resins. These are true aromas of spices and can be used with advantage in large-scale production. Oleo resins are added to the ketchup a few minutes before the boiling is complete.

Use of Extracts. Spice extracts can be prepared on a large scale by prolonged soaking or boiling of spices in vinegar. The use of these extracts helps to standardise the proportion of different spices, and have the taste and aroma of the product. This process is employed by some ketchup manufacturers in India.

Sugar

Only about a third of the total amount of sugar required is added before cooking. This helps to intensify and fix tomato colour. The rest of the sugar is added a little before the ketchup is ready. If the whole of the sugar is added in the beginning, the pulp will have to be boiled for a longer time and at a higher temperature, which may spoil the colour of the ketchup. In commercial tomato ketchups, the percentage of sugar varies from 10 to 26.

Common Salt

Salt bleaches the tomato colour and to some extent dissolves the copper of the kettle or the coil. It is, therefore, desirable to add it towards the end. Finely powdered salt is evenly sprinkled on the surface of the ketchup and stirred. In commercial ketchups the percentage of salt varies from 1.3 to 3.5.

Vinegar

Well-matured malt vinegar is essential for the manufacture of a good ketchup. Good flavour cannot be obtained by using spirit vinegar. Cider vinegar, although very pleasant, has a rather mild flavour. Good vinegar should have 5.0-5.5 per cent. acidity in the form of acetic acid. It is necessary to use vinegar of the same acid strength and quality to obtain a ketchup of standard quality. Vinegar should be added only towards the end when the ketchup has thickened considerably, so that it does not volatilize, rendering the product deficient in acid and flavour.

A tomato ketchup generally contains 1.25-1.5 per cent. acid in the form of acetic acid. Glacial acetic acid is sometimes used, as it has the following advantages:

1. It is cheaper than vinegar.
2. Being colourless like water, it does not impart any colour of its own to the product.
3. It is 100 per cent. acetic acid and can be added towards the end without causing any loss of flavour and acid.

When spiced vinegar or acetic acid is used, the acidity of the vinegar already present in it should be taken into account at the time of adding the vinegar, according to the recipe.

Thickening Agents

The tendency of tomato ketchup to separate into pulp and clear juice largely depends upon the amount of pectin present in it. In order to increase its viscosity and prevent the separation of pulp, pectin is usually added up to about 0.1-0.2 per cent., by weight of the finished product.

Cooking and Concentration

To get a product of uniform taste and flavour and also of fine texture and thickness, the total solids in the finished product should be kept constant. In commercial ketchups, the percentage of the total solids varies from 20 to 37. A ketchup with 28-30 per cent. total solids has a better flavour than a ketchup with more than 30 per cent. solids. A higher proportion dilutes the tomato solids because it contains more sugar and vinegar. As a ketchup with 28-30 per cent. solids does not keep for long after opening the bottles once, the general tendency is to increase the total solids to 32-37 per cent. This increases its keeping quality on account of its higher sugar, salt and vinegar contents.

Some well-known brands of tomato ketchup contain 31.5-32.6 per cent. of total solids.

Total solids in the ketchup can be determined by means of a specific gravity hydrometer. But this method is tedious. The refractometer method is more convenient although it does not give very accurate results owing to the presence of salt, acetic acid, etc. There is also a slight deviation in the relationship between total solids and refractometer solids. According to Cruess, in commercial practice, the juice (Sp. Gr. 1.0220) is concentrated to one-third of its original volume as determined with a gauge-stick.

Bottling

When the ketchup has been cooked, it is passed through a finishing machine with a very fine sieve to removo any tomato fibre and small pieces of paper or wood that might have got in through sugar or spices.

The ketchup should be bottled at about 190°F. to prevent darkening of its colour and loss of vitamin contents during the storage. On cooling, the ketchup shrinks in volume producing thereby a high degree of vacuum in the bottle. Sometimes, a black ring is formed on the surface of the ketchup i.e., in the neck of the bottle. This is known as 'black-neck'. It is stated to be due to the oxidation of iron compounds which enter into the ketchup from the boiling equipment, and from the metal of the cap through the action of acetic acid. When iron comes in contact with the spice tannins, it forms ferrous tannate which on oxidation, forms the black ferric tannate. To overcome this defect, the ketchup should be deaerated and a tin foil-faced liner should be inserted under the caps. Recently, Siddappa, *et al*, have studied the beneficial effect of addition of ascorbic acid in preventing black-neck formation.

Pasteurization

Even under the most favourable conditions, pasteurization of tomato ketchup is essential. Some manufacturers are of the view that after sealing, the bottles should be placed along their sides so that the hot ketchup may come in contact with the cap and thus sterilize it. This is not always safe on account of the wide variation in temperatures at different points in the container. The temperature at the centre approaches the filling temperature while that at the bottom, sides and the neck, is considerably lower. Thus, it is not possible to know definitely whether the caps will actually get sterilized by simple contact with the ketchup. It is, therefore, necessary to pasteurize the product in bottles. The bottles are filled at about 190°F., sealed and pasteurized for 30-35 minutes in hot water.

With a modern type filling machine, the bottles are filled at 190°F., sealed and then washed with warm water to remove any adhering ketchup. Further sterilization of the filled bottles is not done, the filling temperature being considered adequate for sterilization. During filling, the temperature is not, however, allowed to fall below 190°F. at any stage.

A ketchup made from tomatoes of good quality using vinegar, sugar, salt and spices in right proportions, does not generally get spoiled for a fairly long time even after the bottle has been opened, and stored in a cool place. It is, however, better to add 0.025 per cent. of sodium benzoate to the product before bottling and pasteurize it as a safeguard against spoilage during use for 3-4 weeks. The sodium benzoate in the ketchup can be determined by the methods given in A.O.A.C.

CHILI SAUCE

This is a highly spiced product and is prepared from plant-ripened and peeled tomatoes. It is mostly used as a flavouring material in cooking and to some extent, as a table relish also.

Preparation

The tomatoes are washed thoroughly rejecting any blemished or rotten portions. These are blanched in hot water or steam till the skin becomes loose. Next they are dipped in cold water to stop further cooking and softening. The tomatoes are peeled and chopped without removing the seeds. The spice bag is placed in the tomatoes during cooking.

The following method has been recommended by Lal Singh, Girdhari Lal and their colleagues for the preparation of the chilli sauce:

To 100 lb. of peeled tomatoes, add 2¼ lb. of sugar, 10 gm. of red (Kashmiri) chillies, 2 lb. (washed, peeled and finely chopped) of onions, and the following spices tied loosely in a cloth bag:

Mace (not ground)	7 gm.
Cinnamon, broken	18 ,,
Cumin, cardamom and black pepper in equal quantities	22.5 ,,
Ground white pepper	10 ,,
Ground ginger	10 ,,

Cook the whole mass in a steam-jacketed kettle down to about 56 lb crushing tomatoes with a ladle, if necessary, during the process. Add 4¾ lb of sugar, 1½ lb. of common salt and finally 3½ lb. (10 per cent.) vinegar. Continue the cooking of the mass further for about 5-10 minutes after which, pack immediately in plain A2½ cans, seal and sterilize for half an hour in boiling water.

According to Tandon, the following recipe gives a sauce of good quality:

Tomatoes, peeled	50 lb.
Sugar	5 lb. 10 oz.
Common salt	9 oz.
Chillies, ground	1½ oz.
Garlic, chopped	9 oz.
Onions, chopped	3½ oz.
Vinegar (5% acetic acid)	19 lb.

To the tomatoes add all the ingredients except vinegar and cook to a thick consistency. Add the vinegar and boil for a few minutes. Then pack hot into wide-mouthed bottles and sterilize for 30 minutes in boiling water.

TOMATO SAUCE

Siddappa, Bhatia and Girdhari Lal have standardised a method for the preparation of tomato sauce. It has been found satisfactory also for canning baked beans in tomato sauce.

RECIPE

Tomato pulp (6% soluble solids)	65 lb.
Cardamom, pepper and cumin (Zira) in equal quantities	8.5 gm.
Cinnamon, broken	10 gm.
Cloves, headless	8.5 gm.
Mace (not ground)	5.7 gm.
Common salt	1½ lb.
Onions, chopped	5½ oz.
Garlic, ground	18 gm.
Sugar	4¾ lb.
White vinegar, 100 grain	580 c.c. (58 c.c. of 100% acetic acid)
Red chilli powder	15 gm.

Cook to about half its volume, i.e., to 26-28 per cent. refractometer solids, taking necessary precautions as in the case of tomato ketchup. Fill into plain A2½ cans and process for 45 minutes in boiling water.

TOMATO SOUP

In preparing tomato soup, the first step is to make tomato pulp, in the same way as for tomato juice. The main constituents of this soup are: tomato juice, butter or cream, spices, arrowroot (a thickening agent), etc. These are added in various proportions to suit the taste.

The following typical formula yields a good soup:

Tomato juice (Sp. Gr. 1.0220)	7 gal.
Onions, finely chopped	13 oz.
Cinnamon, broken	5 gm.
Cloves whole, headless	5 ,,
Ground white pepper	7 ,,
Red chillies, ground (Kashmiri)	0.7 ,,

Cumin (Zira), cardamom and black pepper in equal quantities	5.3 ,,
Ginger dry, ground	4.2 ,,
Cream (30 per cent.) or butter	1¼ lb. or butter 6¾ oz.
Arrowroot starch	4¼ oz.
Sugar	17 ,,
Common salt	11¼ ,,

Preparation

Neutralize about 1/6 acidity of the juice by adding a thin paste of sodium bicarbonate made with water. Place 6 gallons of the juice in a boiling pan and heat it. While it is being concentrated, add spices tied loosely in a muslin bag as is done in the case of tomato ketchup. In the meantime, mix arrowroot and butter (or cream) with the remaining one gallon of juice to form a smooth paste. When the juice in the pan gets concentrated, add this mixture. Again boil to the desired consistency, stirring it continuously to prevent clotting of the starch, etc. At the end, add sugar and salt, and boil the mixture for about two minutes to dissolve them. Fill the soup into cans.

Sterilization

Sterilize at 240°F. for 45 minutes in the case of A2 cans and for 40 minutes in the case of 1 lb. milk or jam-size cans. Cool quickly after processing.

MICROBIOLOGY

When tomatoes of poor quality are used in the preparation of tomato products, excessive amounts of moulds, yeasts, bacteria and fragments of insects lower the quality of the product. The U.S. Department of Agriculture has prescribed limits up to which moulds, yeasts and bacteria may be permitted in tomato products. The mould count is the most important of these.

The Government of India have regulated the manufacture of tomato juice, puree and ketchup by laying down proper specifications (Appendix II). Figs. 55 and 56.

Bigelow, Smith and Greenleaf of the National Canners Association Research Laboratory, U.S.A., have prepared tables showing relationships between total solids, specific gravity, refractometer reading and the specific gravity of filtrate in the case of tomato pulp, tomato puree and tomato paste; and between percentage of total solids, specific gravity and Abbé Refractometer reading in tomato ketchup. They have also given correction tables for specific gravity, Brix readings and refractive index. These Tables are given in Appendix I.

CHAPTER XIV

CHUTNEYS, SAUCES AND PICKLES

Chutneys, sauces and pickles of various kinds are prepared in Indian homes and also on a commercial scale. In the first case, standard recipes have been modified by local taste. Fruits such as apples, peaches, plums, apricots and mangoes, and vegetables like turnips, cauliflowers, carrots, etc., are the basic raw materials for these products. Onion, garlic, spices, herbs, etc., are added for flavour. Vinegar, common salt and sugar also are used to make them more palatable. Vinegar serves as a preservative to some extent.

CHUTNEYS

A good chutney should be palatable and appetising. Raw materials are generally cut into pieces or slices of the desired size and cooked till they are soft. Slow cooking at temperatures below the boiling point, yields better results than brisk treatment at comparatively higher temperatures. Onion and garlic are added at the start to mellow their strong flavours. Spices are coarsely powdered before they are added. Sometimes a vinegar extract of spices is used instead. The boiling of spices in a cloth bag along with the fruit is also practised by some manufacturers. If spices are added as such or vinegar extracts are used, these should be added just a little before the final stage of boiling is reached because during prolonged boiling, some of the essential oils of the spices, as also the vinegar, will volatilize.

Cooking Process

Sweet chutneys are usually cooked to the consistency of jam to avoid fermentation during storage. Where vinegar is used in large quantities, the amount of sugar may be kept low as vinegar itself partly serves as a preservative.

Bottling

Only clean, dry bottles, sterilized in boiling water should be used when they are still warm. If containers are not properly cleaned, fermentation caused by some fermentative organisms adhering to their walls will spoil the chutney. It is safer to pasteurize the filled bottles (1 lb. size) for about 30 minutes at 180°F.

Equipment

Iron and copper vessels should not be used as they are acted upon by vinegar. Further, it has also been found that small amounts of these metals dissolved in oil act as catalytic agents for rancidity. These metals also form black compounds with the tannins of fruits and spices, and thus spoil the colour and flavour of the product. The vessels should be glass-lined or made of stainless steel or nickel. Freshly tinned copper utensils also can be used without risk.

Recipes

There are a large number of chutney recipes. Apricot and mango chutneys, however, are of particular interest to India and considerable research has been done to standardise the methods of their preparation. Recipes for peach, plum, date, tomato and various mixed chutneys are given in several books and bulletins on pickling and preserving (see Appendix). The recipes recommended in these publications should, however, be tried on a small scale first and, if necessary, modified, for larger production.

Some chutney recipes, which have been tried with success, are given in the following paragraphs.

Apple Chutney

Poultney gives the following recipes for apple chutney:

RECIPE I

Apples	40 lb.
Sultanas	20 ,,
Onion powder	8 oz.
Sugar	30 lb.
Salt	3 ,,
Cassia, ground	1 oz.
Mace, ground	1 ,,
Pimento, ground	1 ,,
Nutmeg, ground	½ ,,
Caramel	10 ,,
Acetic acid	2 lb.
Malt vinegar	3 gal.

Peel, core and slice the apples. Cook the slices along with other ingredients till they are tender. Bottle the product hot. The final acidity should not be less than 2.4 per cent.

RECIPE II

Another recipe is as follows:

Apples	6 lb.
Onions	to taste
Brown sugar	4 pints
Preserving ginger	2 heads
Cayenne (Red chilli powder)	¼ teaspoonful
Garlic	¼ ,,
Salt	3 ,,
Vinegar	2 ,,

Peel, core and cut apples into small pieces. Cut the onions very finely. Mix all the ingredients with the vinegar and boil gently till the chutney becomes thick. Pack while hot and seal the bottles airtight.

Apricot Chutney

Siddappa and Mustafa have recommended the following process for apricot chutney:

Take firm, but fully ripe apricots of the white or yellow variety. Cut them into slices of about 1/8 inch thickness. Cover them with sugar and allow them to stand for 1-2 hours so that the mixture becomes thin due to diffusion. Tie the spices loosely in a muslin bag and place the latter in the mixture. Boil the mixture to about 220°F. (at sea level). Add salt and vinegar and continue boiling for another 5 minutes. Fill the chutney into hot sterilized bottles and seal them.

RECIPE

Apricot slices	3 lb.
Sugar	3 ,,
Salt	2 oz.
Cardamom, not finely powdered	2 gm.
Black pepper, broken grains	2 ,,
Cumin (Zira), whole	2 ,,
Cinnamon, whole	2 ,,
Red chilli powder (according to taste)	7 ,,
Cloves (headless)	1 ,,
Mace, broken	0.5 ,,
Onions, sliced and gently crushed	1 oz.
Vinegar, 4-5% strength	8 ,,

This recipe will yield about 5 lb. of the chutney.

Bamboo Chutney

Tender bamboo shoots make a sweet chutney. Select tender bamboo shoots and remove the outer leaves. Cut the tender portion into small pieces. Boil them in water twice or thrice each time for half an hour to remove the poisonous bitter principle. Mince the boiled pieces finely.

RECIPE

Minced pieces	4 lb.
Sugar	4 ,,
Salt	3 oz.
Cardamom, cinnamon and cumin mixed in equal proportion	2 ,,
Red chilli powder	1 ,,
Onions, chopped	1 ,,
Garlic, chopped	1 ,,
Vinegar	3 ,,

Add the sugar, salt and a little water to the minced bamboo pieces and warm the mass to dissolve the sugar and salt. Place the spices in a loose muslin bag and place the latter in the vessel. Cook slowly till the mass attains the consistency of jam. Remove the spice bag and add vinegar. Boil the mass for a short while to obtain the desired consistency. After cooling, pack the product in wide-mouthed glass bottles and seal them.

Mango Chutney

For mango chutney, slightly immature fruits of seedling varieties are preferable. This chutney can be prepared from fresh as well as brined and peeled mango slices. The industry follows both methods. The latter is used to extend the manufacture beyond the season. In this method, slices are preserved in a brine of 15 per cent. strength, the percentage of salt being maintained by adding more salt from time to time. Some manufacturers prefer to add dry salt to the slices but the main drawback in this method is that the slices shrivel and do not regain their original size and shape in the final product. It also hardens the slices. Usually one lb. of finely powdered salt is added for every 4 lb. of slices. The amounts of sugar, spices, vinegar, etc., required depend largely on the local taste.

Sweet Mango Chutney

The following recipe has been recommended by Lal Singh and Girdhari Lal:

RECIPE

Peeled mango slices	2 lb.
Sugar	2 lb.
Salt	2 oz.
Mixed spices (Cardamom, cinnamon, cumin, etc., in equal proportions)	1 ,,
Garlic, chopped	1/5 ,,
Red chillies, finely ground	½ ,,
Vinegar	4 ,,
Onions, chopped	1 ,,
Ginger, green	4 ,,

Peel slightly under-ripe mangoes and cut the flesh into thin slices. Warm the slices in a small amount of water to make them soft. Add sugar and salt. Put the other ingredients tied in a loose cloth bag and cook the mass to the consistency of jam. Then add vinegar and boil the mass for about 5 minutes. Remove the spice bag. Fill the product into hot, sterilized, dry bottles and seal them airtight. The product keeps well and is of very high quality.

Sliced Mango Chutney

The following are some tentative recipes for sliced mango chutney, in which some of the spices, garlic and other ingredients have been varied or omitted:

RECIPES

	I	II	III
Sliced mangoes	8 lb.	5 lb.	5 lb.
Sugar	6 „	5 „	3¼ „
Almonds (blanched and peeled)	1 „	—	—
Raisins (stemmed)	1 „	—	—
Salt, finely ground	6 oz.	5 oz.	4 oz.
Ginger, finely ground	8 „	—	—
Vinegar	1¾ lb.	1¾ lb.	1½ lb.
Red chillies, finely ground	2 oz.	2 oz.	1 oz.
Cinnamon, broken	½ „	—	—
Cumin, black	1 „	½ oz.	—
Mustard (finely ground)	—	—	2 oz.
Garlic, chopped	—	—	2 oz.

The method of preparation is precisely the same as that for sweet mango chutney.

Peach Chutney

Sarson gives the following recipe for peach chutney:

RECIPE

Dried peaches	2 lb. (equal to 10 lb. of fresh peeled peaches)
Onions	1 „
Raisins	1 „
Sultanas	½ „
Cinnamon, powdered	¼ oz.
Ginger, ground	½ „
Vinegar	1 quart

Cut the peaches into quarters. Place them in a shallow pan and cover with vinegar. Let them stand for 24 hours or till the fruit has swollen. Chop the onions finely and cut the raisins into halves. Then add them along with the spices to the rest of the vinegar. Bring the mass to a boil and let it simmer for 15 minutes. Put in the peaches and the vinegar and continue to cook till it thickens. Bottle hot.

In the case of fresh peaches, the peeled slices can be cooked directly with vinegar till they become soft. The rest of the process is the same as for dried peaches.

Plum Chutney

The following recipe for a good plum chutney has been recommended by Tandon:

RECIPE

Plums, fully ripe	4 lb.
Sugar	4 „
Vinegar	1 „
Mace (Jalvatri), not ground	1 blade
Cloves (headless)	6 *in number*
Pepper, black (ground)	10 *in number*
Chillies, Kashmiri, finely ground	¼ oz.
Salt, finely ground	½ „

Wash the plums and place them in a large cooking vessel along with other ingredients except sugar and vinegar. Heat the mixture with a small quantity of water till the plums become soft. Pass the whole mass through a coarse sieve of aluminium or monel metal to remove the stones and skins. Add sugar and boil the pulp till it thickens and then add vinegar. Stir well all the time and continue boiling till the chutney is ready. Pack in sterilized bottles and seal them airtight.

Tomato Chutney

According to Binstead, the following recipe gives a good tomato chutney:

RECIPE

Tomatoes	30 lb.
Onions, chopped	21 „
Sugar	40 „
Salt	2 „
Ginger	2 oz.
Chillies	½ „
Vinegar	4½ gal.
Garlic vinegar	2 „

Peel the tomatoes by blanching. Place all the ingredients except vinegar in a pan and cook to a thick consistency. Add the vinegar, cook for another 5 minutes and pack the chutney in wide-mouthed, sterilized dry bottles and seal them airtight.

Chutneys can also be made from other fruits like pear, greengage, date, banana and papaya by using the above mentioned recipes with slight modifications.

Siddappa and Mustafa have reported that by using a recipe similar to that for apricot chutney, a good chutney can be prepared from the rind of watermelon.

THIN SAUCES

Sauces are generally of two kinds, i.e., thin and thick. Thin sauces mainly consist of a vinegar extract of various flavouring materials like spices and herbs. Their quality depends mostly on the piquancy of the material used.

Some sauces are matured by storing them in wooden barrels. This develops their flavour and aroma. Freshly prepared products of this kind often taste raw and harsh. For sauces of high quality, the spices, herbs, fruits and vegetables are macerated in cold vinegar. Sometimes, extracts are prepared by boiling them in vinegar. The sauce is filtered through a fine or coarse mesh sieve of non-corrodible metal according to the quality required. The skins, seeds and stalks of spices should not be allowed to pass through the sieve as they spoil the appearance of the sauce. The usual commercial practice is to prepare vinegar extracts of each kind of spice and fruit separately either by maceration or by boiling and then to blend them suitably before putting them into barrels for subsequent maturing.

A few typical recipes for thin sauces are given below:

Mushroom Ketchup

Sarson recommends the following recipe:

Select dry, full-grown and unbruised mushrooms. Break them into pieces and place the mass in layers in a deep bowl. Sprinkle salt at the rate of 4 oz. for every 2 lb. of mushrooms. Allow them to stand in the brine for 4 days, stirring twice a day. Cook gently for 45 minutes and strain the liquor. To every quart of liquor, add the following:

*Allspice	1 teaspoonful
Pepper	1 ,,
Ginger	½ ,,
Mace	½ ,,
Cloves	A pinch
Cinnamon	A ,,

*A mixture of equal quantities of cumin, cimanon, and cardamom may be used instead of allspice.

Simmer the ketchup in a pan till it is reduced to about ⅓ of its original volume. Bottle hot.

Soya Sauce

Soya sauce is made from soyabeans. The sauce has usually a predominant saltish taste and has a dark brown colour. It is made by cooking soyabeans and wheat, and then allowing the mass to undergo mould fermentation for 3-4 days. The mass is then mixed with strong brine (15-20 per cent.) to form a mash which is placed in wooden barrels to bring about bacteriological and chemical changes. In due course, a thick brown liquid is formed. It is then boiled and filtered. To the filtered liquor molasses are added to taste, before bottling.

Walnut Ketchup

Sarson recommends the following recipe:

RECIPE

Tender green walnuts	100
Vinegar	2 quarts
Chopped onions	1 lb.
Salt	½ ,,
Pepper corns	1 oz.
*Allspice	½ ,,
Cloves	½ teaspoonful
Nutmeg	½ ,,

* Instead of allspice, cumin, cinnamon and cardamom mixed in equal quantities may be added.

Cut the walnuts into halves. Crush and place them in a deep jar. Place the rest of the ingredients in the vinegar, bring the mass to a boil and pour it over the crushed walnuts. Allow the mixture to stand for 2 weeks stirring it daily. Draw off the liquid, simmer it for about half an hour and fill into bottles.

Worcestershire Sauce

Tandon has reported the following recipe for the above sauce:

RECIPE

Malt vinegar	10 lb.
Tamarind	8 oz.
Garlic	2 „
Onions	2 „
Essence of lemon	1 „
Essence of vanilla	1 „
Dried ginger	2 „
Common salt	1 „
Cumin	1/3 „
Cardamom	1/3 „
Cloves, headless	1/3 „
Sugar	4 „
Lemon juice, refined	1 lb.
Ethyl acetate	1/64 oz.

Macerate tamarind in a small quantity of vinegar and filter the mixture through a muslin cloth. Take vinegar extract of garlic, onion, dried ginger, cumin, cardamom, cinnamon and clove and mix it with the first filtrate. Then add essences of lemon and vanilla, sugar, salt, lemon juice and ethyl acetate. Place the mixture thus obtained in wooden barrels for maturing for about two months. After this, filter the mixture again through a coarse sieve and bottle properly. If desired, a small amount of caramel may be added to give it an attractive colour. The recipe gives a good sauce.

The following recipe for Worcestershire sauce has been evolved by Eaton:

RECIPE

	Per cent.
Malt vinegar (6% acetic acid)	70.0
Sugar	4.0
Molasses	9.5
Caramel	0.5
Salt	2.5
Mixed spices	3.5
Onions (brined)	7.0
Tamarind	2.5
Protex (or meat extract)	0.5

The mixed spices are prepared by mixing the following ground spices:

	Per cent.
Capsicum	20
Hungarian paprika	15
Black pepper	25
Cloves	10
Allspice	15
Ginger	10
Mustard	5

Take tamarind extract by simmering in a portion of the vinegar. Prepare an infusion of the spices and crushed onions, preferably in the cold. Mix all extracts, place the mixture in a clean barrel and allow to stand for about 6 months for maturing. At the time of bottling, strain the sauce.

Meat extract may be avoided, if not desired.

THICK SAUCES

A sauce which does not flow freely and which has a high viscosity is called a thick sauce. It should contain at least 3 per cent. acetic acid so that it has good keeping quality. The acidity should not, however, exceed 3.4 per cent., otherwise, the sauce would taste sharp. The sugar content may vary from 15 to 30 per cent., according to the kind of sauce made. Usually, malt vinegar is used which in addition to producing acidity, improves the flavour. The sweetness is derived partly from fruits like date, raisin, sultanas, apple, and tomatoe and partly from the sugar. The colour of the sauce varies with the raw material used. Sometimes, a little caramel is added.

The manufacturing process is the same as for chutneys. Thickening agents also are added to prevent or retard sedimentation of the solid particles in suspension. In India, apple pulp is often used for this purpose. Sometimes, the fruit, which is used for making sauce, is boiled, pulped and used as a filler. The starches of maize, potato, arrowroot (Cassava starch), sago and rye also are used as thickening agents. The use of Indian gum, locust kernel gum, tragacanth, karaya gum, gelatin, Irish moss, pectin and other similar substances is also advised. These are not, however, as good as the starches.

PICKLES

The preservation of food in common salt or vinegar is called pickling. Spices and oil also may be added.

Pickles are good appetizers and add to the palatability of a meal. They aid digestion by stimulating the flow of gastric juices. Very little is known of their food value. Different kinds of pickles contain varying amounts of nutrients depending upon the kind of the raw material used. The food value of cucumber pickles exceeds that of eggs, rice, fresh onions and fresh tomatoes.

Various kinds of pickles are made in Indian homes in large quantities. Pickling is also done on a commercial scale. In Indian pickles, mustard oil, rapeseed oil and sesame oil are generally used. Some pickles are made in lime juice whereas imported pickles are preserved in vinegar.

Pickling Problems

The character of fruits and vegetables used largely determines the type of change that occurs when a particular organism attacks them. Yeast and mould can grow in the presence of acid. Thus fruits and acid vegetables spoil either by yeast fermentation or by moulding. As acidity is not favourable for the growth of putrefactive bacteria, fruits or acid vegetables are not spoiled by them. On the other hand, the decay of vegetables with little or no acid is always mainly due to the action of bacteria. In the preparation of pickles, however, the desired fermentation is caused by lactic acid-forming bacteria which are capable of growing in an acid medium. In this respect they differ from the putrefactive bacteria which cause decay of canned fruits and vegetables.

There are mainly two methods of preserving fruits and vegetables, namely, (i) by killing all micro-organisms responsible for spoilage, by heat or other means, and then checking the entry of fresh organisms into the preserved product, and (ii) by making the conditions most unfavourable for the growth and multiplication of micro-organisms. The first method is used in the preservation of fruits and vegetables and the second in the preparation of pickles.

Action of Preservatives

Salt, vinegar and lactic acid are the three important ingredients used in pickling. These substances, when used in sufficient quantities, act as preservatives either singly or collectively.

Salt. Vegetables do not ferment when covered with a strong brine or packed with a fairly large amount of salt. Spoilage is prevented by adding sufficient common salt, bringing its final percentage in the material to about 15 to 20. At this high salt concentration, mould and even lactic acid-forming bacteria do not grow. This method of preservation is applicable only to vegetables which contain very little sugar because in that case sufficient lactic acid cannot be formed to act as preservative.

Vinegar. Vinegar acts as a preservative in pickles. In order to ensure good results, the final percentage of acid (as acetic acid in the finished pickle) should not be below 2. To avoid the dilution of the vinegar by water from their tissues, the vegetables are generally put in strong vinegar of about 10 per cent. acidity for several days before final packing. This treatment, besides other advantages also helps to expel the gases present in the inter-cellular spaces of vegetable tissues.

Lactic Acid. Bacteria prefer material with little or no acid for their growth. The lactic acid bacteria, however, can grow in acid media and can themselves produce acid. These can grow even in the presence of 8-10 per cent. common salt. In pickling, advantage is taken of these two factors. The growth of undesirable micro-organisms is inhibited by adding salt, while lactic acid fermentation is allowed to proceed.

When vegetables are placed in brine, the soluble material present in them diffuses into the salt water due to osmosis and the liquid penetrates into their tissues. The soluble material, besides containing mineral matter, contains fermentable sugars also. The sugars serve as food for lactic acid bacteria which convert them into lactic and certain other volatile acids. In practice, usually 2-3 lb. of salt is mixed with every 100 lb. of the materials and the mixture is allowed to stand for about 12-24 hours, when sufficient juice comes out from the material to form brine. If the vegetable does not contain sufficient juice, it is covered with brine containing 5 per cent. salt. The soluble material extracted is fermented by lactic acid-forming bacteria which are naturally present in large numbers on the surface of fresh vegetables.

When lactic acid is formed in a sufficient quantity, the lactic acid bacteria cease to function, and any further change in the composition of the material is prevented. Although, at this stage, the pickle is ready for consumption, precautions should be taken to save it from spoilage by aerobic micro-organisms. The presence of salt and the lactic acid formed preserves the pickle by preventing the growth of putrefactive bacteria, provided air is excluded. In the presence of air, however, 'pickle scum' is formed and it destroys the lactic acid and brings about putrefaction. The acid brine formed during pickling cuts upon the vegetable tissues and produces the characteristic pickle taste and aroma.

Temperature is the most important factor for successful lactic acid fermentation. Lactic acid bacteria are most active at a temperature of about 86°F. It is, therefore, essential that the temperature of the product undergoing lactic acid fermentation should be kept as close to 86°F. as possible, especially at the start.

Raw Materials

Salt. For pickling, any variety of common salt is suitable, provided it is pure. At any rate, it should not contain more than 1 per cent. impurities. Nor should it contain chemicals like tri-calcium or magnesium phosphate which are generally added to reduce its tendency to cake. Salt should be free from lime (CaO), as it reduces the acidity of the vinegar in which brined vegetables are pickled and sometimes, also causes lime deposits at the bottom of the container. Salt should also be free from iron since the latter blackens the material by coming into contact with the tannin of the fruits, vegetables and spices. It should also not contain magnesium salts which make the pickles taste bitter. Carbonates which are alkaline in nature, make the pickle soft in texture, and lower its acidity.

Vinegar. Good vinegar should contain at least 4 per cent. acetic acid. Vinegars of a low acid content or imitation or synthetic vinegars sold in the market are not suitable for pickling. For pickles of high quality, vinegar of good quality, (of 40-60 grain strength, that is, 4-6 per cent. acetic acid) should be used. Usually malt or cider vinegar is used.

Some manufacturers prefer to use acetic acid because it is highly concentrated and is free from colour and sediment. If fruit vinegars are used, they should first be filtered to remove any sediment. Vinegar should not come in contact with iron as it leads to the blackening of the pickle. In order to ensure good keeping quality, the final percentage of acetic acid in the finished product should not be less than 2.0, in addition to other organic acids naturally present in the raw material.

Sugar. Only sugar of good quality should be used in making sweet pickles.

Spices. Spices are added to almost all pickles, their amount depending upon the kind of fruit or vegetable used and on the kind of flavour desired. The spices generally used are bay leaves, cardamom, chillies, cinnamon, clove, coriander, dill herb, ginger, mace, mustard, black pepper, cumin, turmeric, garlic, mint, sage, parsley, thyme, fennel, aniseed, etc. These should be of good quality and should be stored in friction-top tins in a cool and dry place.

Water. Only potable water should be used for the preparation of brine. Hard water contains salts of calcium, sodium, magnesium, etc., which interfere with the normal salt-curing of the vegetable. If hard water is to be used, then a small quantity of the vinegar should also be added to the brine to neutralize its alkalinity. Iron should not be present in water in any appreciable quantity since it causes the blackening of the pickles.

Colouring and Hardening Agents

Once it was the practice to heat the vinegar pickle in copper vessels so that the pickle might acquire a green colour. It has now been proved that this colour is due to poisonous copper acetate. The use of copper vessels for making pickles has, therefore, been prohibited in many countries. Colours are not generally used in pickles although they are used to some extent in sauces. Some manufacturers use alum for firmness in pickles, but it is a doubtful expedient since the same results can be obtained with proper pickling methods. The use of alum in pickle-making is not, therefore, recommended as a normal practice.

Equipment

Wide-mouthed stone-jars with straight sides are most suitable for making small quantities of pickle. The advantages of such containers are that they can be easily cleaned and that they absorb undesirable odours and flavours to a lesser extent than wooden containers. For large-scale production, 50 gallon water-tight kegs or barrels are suitable. Before use, the barrels must be washed thoroughly with a strong lye solution to remove all undesirable odours and flavours. To remove all traces of lye, these should be thoroughly cleaned with hot water.

The covers of the kegs should be thick and should be made of such a material that would not impart any colour, taste and flavour of its own. They should be 1-2 inches less in diameter than the inside of the container so that they can be easily placed inside on the top of the vegetable and removed, when desired. The covers should be coated with paraffin wax to fill any pores and thus to facilitate cleaning.

Weighing Scales

For small-scale production, an ordinary country balance would do. A platform balance is, however, essential for work on a large scale.

Measures for Liquids

Water, brine and other liquids can be measured easily and, therefore, need not be weighed. One pound, quarter gallon, half gallon and one gallon measures are most suitable.

Cooking Utensils

Metallic vessels should be non-corrodible. Vessels made of iron and copper are not suitable. Glass-lined vessels and those made of stainless steel (monel metal, inconel (a new alloy) and aluminium should be used. The ladles, spoons and measuring vessels also should be made of non-corrodible materials.

PICKLING PROCESS

Pickling is done in two stages, namely, (i) curing or fermentation with dry salting, or fermentation in brine, or salting without fermentation and (ii) finishing and packing.

Dry Salting

In this method, the vegetable is treated with dry salt. The salt extracts the juice from the vegetable and forms the brine, which is fermented by lactic acid-forming bacteria. The method of dry salting, in general, is as follows:

The vegetable is prepared, washed thoroughly in running cold water, drained and weighed. For every 100 lb. of the prepared vegetable, 3 lb. of salt is used. The vegetable is placed about an inch deep in a keg or barrel and is sprinkled with a small quantity of salt from the weighed amount. Another layer of the vegetable is added and again sprinkled with salt. The salt is added, layer after layer, in the above manner till the container is three-quarters full. Then one or two folds of cheese cloth are spread over the salted vegetable, tucking the cloth at the sides and then placing a piece of wooden board on the top. A clean stone which is not acted upon by salt or organic acids, is placed on the board to press the vegetable so as to form a brine. Generally, a weight of 10 lb. is sufficient for a keg of 5 gallons. If necessary, more weight may be placed, in case brine does not form after the material has stood for a while. Generally brine is formed in about 24 hours.

After packing the vegetable, the container is placed in a warm, dry place and fermentation is allowed to proceed. In a short time, juice from the vegetable forms the brine covering the whole mass. The weight and the board help to keep the vegetable submerged.

As soon as the brine is formed, fermentation starts and bubbles of carbon dioxide begin to rise from the liquid. Fermentation is usually complete in about 8-10 days under favourable conditions which are attained in the temperature range of 80°-90°F. In cold weather, however, it may take about 2-4 weeks to complete the fermentation. When the fermentation is complete, gas bubbles cease. This may be confirmed by tapping the containers gently.

Then the product may be preserved by excluding air. If this is not done, 'pickle scum', a kind of wild yeast, appears on the surface. It soon destroys the lactic acid formed by fermentation with the result that the material is ultimately spoilt.

According to Round and Lang, air can be exhausted in the following manner:

Method I. An air-seal on the surface of the brine can be made by pouring some edible oil like rapeseed or cotton seed oil. The oil being lighter than the brine, floats on the surface and thus prevents the entry of air. A layer of oil about one-quarter inch thick is generally sufficient to keep the pickle indefinitely. The only drawback in this method is that the vegetable cannot be taken out from the container without getting covered with the oil. To avoid this, the oil may be removed from the surface by decanting, syphoning, skimming or by making it overflow by adding more brine.

Method II. After dry-salting and fermentation, the barrel or keg is filled with the vegetable to its maximum capacity and the cover replaced. A half inch hole is bored in the head. Then the barrel is filled with brine to the brim so that no air is left inside. The barrel is allowed to stand for about 48 hours or till such time that bubbles of gas cease to rise. If necessary, more brine is added at intervals to keep the barrel full. When the bubbling has stopped, the vent-hole is closed tightly and the barrel is kept in a cool and dry place. The product packed in this manner will keep indefinitely.

Method III. Hot melted paraffin is used to cover the brine. The containers are kept at a place where they will not be disturbed till the materials are ready for use. Sufficient paraffin is melted and poured over the brine. If it is hot enough to warm up the surface of the brine, a smooth and even layer will be formed before it hardens, and this will give an airtight seal.

The advantages of using hard paraffin wax are: (i) it can be easily separated from the fermented brine before removing the vegetables from the container, and (ii) it can also be remelted, refined and used again. The only disadvantage, however, is that in case any gas is produced in the lower surface, it will break the seal and resealing will be needed. The wax seal, therefore, should not be applied before fermentation is complete and gas formation has ceased.

Fermentation in Brine

Soaking of the vegetable in a salt solution of predetermined concentration for a certain length of time is called brining. This treatment is given only to vegetables like cucumbers, which do not contain sufficient juice to form brine with dry salt.

Brine Preparation

Brine can be made by dissolving common salt in water and filtering it through jelly bags to remove insoluble impurities. The strength of the solution is determined by means of a salometer or salinometer. The amount of brine necessary to cover the vegetable is usually equal to about half the volume of the material to be fermented. To be more precise, if a keg of 10 gallons is to be packed, the amount of brine needed would be 5 gallons. It is preferable to make all the brine needed for the day in one lot.

Brining is the most important step in pickling. Although no set of conditions, ordinarily practicable in pickle-making will destroy or retard the growth of every kind of bacteria, yet the growth of a majority of them is checked in a brine containing 15 per cent. salt. Lactic acid bacteria, which are salt-tolerant, can flourish in a brine of 8-10 per cent. strength only.

Fermentation takes place fairly well in a brine containing approximately

5 per cent. salt (20° salometer). In a brine containing approximately 10 per cent. salt, fermentation proceeds somewhat slowly. To some extent fermentation takes place up to 15 per cent. also, but at 20 per cent. strength all fermentation stops. It is, therefore, customary to place the vegetables initially in 10 per cent. salt solution to allow lactic acid fermentation and then to increase the proportion of salt gradually, so that by the time the pickle is ready, it will have reached the 15 per cent. level. It has to be borne in mind that vegetables contain a certain amount of moisture which exudes from them in the presence of salt and decreases the strength of the brine. The brine strength can, however, be maintained by adding dry salt. The time required for proper fermentation is determined by experience.

Keeping Qualities

Properly brined vegetables will keep in vinegar for a long time. The duration of brining is of great importance. If the vegetables are soaked for a very long time, soft pickles will result. If they are soaked for a short time, say for a night only, the curing of vegetable tissues is incomplete with the result that the pickle will not have proper texture and taste. Brining has, therefore, to be controlled properly. On curing, the vegetables become semi-translucent and their colour changes from green to dark olive green or yellowish green. This is an indication of correct curing. This usually takes about 4-5 weeks. By this method, vegetables can be kept more or less for an indefinite period, provided the right storage conditions are maintained. If the vegetable is to be kept in brine of 10 per cent. salt or less, all air should be excluded from the containers. During curing, the vegetables lose their 'raw' flavour and become firm and crisp.

With Salt

In this method, vegetables are packed with a large quantity of salt to inhibit fermentation. In practice, generally 25 lb. of salt is mixed with every 100 lb. of the prepared vegetable.

The cured vegetables are drained and excess of salt is removed by soaking them in cold or warm water as may be necessary. After removing the salt, the vegetables are stored for several weeks in plain vinegar of 10 per cent. (100 grain) strength. This treatment reduces the tendency of the vegetables to shrivel when packed in sweetened and spiced vinegar and also helps absorption of vinegar by the vegetable tissues.

Spiced Vinegar

Spiced vinegar should always be kept ready so that it is available at the time of pickling. It is made as follows:

Method I. The unground spices are soaked in vinegar and kept for 2-3 months, stirring occasionally. The spices are then squeezed out and the vinegar is allowed to stand. When clear, it is decanted or syphoned.

Method II. The spices are boiled with vinegar till all flavours get extracted. The extract is then filtered.

Another method is to use essential oils, but these do not always impart the original aroma of the spices.

The kind and quantity of spices required depend on the piquancy required in the pickle. There are numerous recipes. A few of these are given below:

Sweet spiced vinegar, according to Poultney, is made as follows:

RECIPE

Sugar	470 lb.
Cloves, whole	11 ,,
Coriander seed	13 ,,
Mustard seed	16 ,,
Cardamom seed	1½ ,,
Celery seed	1¼ ,,
Ginger, whole	3¾ ,,
Caraway seed	½ ,,
Vinegar	50 gal.

The sugar is dissolved in vinegar by heating. The spices, placed in linen bags, are suspended in the vinegar. The batch is simmered gently for 6 hours and is then allowed to cool. The bags are removed after that and the vinegar is filled into casks for storage.

Spiced vinegar with essential oils according to Poultney, is made as follows.

RECIPE

Oil of ginger	12 drams
Oil of cloves	11 ,,
Oil of mace	2¼ ,,
Oil of coriander	3 oz.
Oil of mustard	14 drams
Oil of cardamom	8 oz.
Oil of bay	1 ,,
Vinegar	200 gal.

The essential oils are stirred with the vinegar. For proper emulsification, a little gum may be used. The oils may also be mixed with sugar and then dissolved in the vinegar.

According to Campbell, the following formula gives a good spiced vinegar:

RECIPE

White vinegar (100 grains)	20 gal.
Water	17 gal.
Garlic	11 oz.
Cayenne, finely ground	24 ,,
Cloves, headless, finely ground	48 ,,
Mace, finely ground	8 ,,
Coriander, finely ground	48 ,,
Mustard, finely ground	48 ,,
Cardamom, finely ground	8 ,,
Bay leaves, finely ground	24 ,,
Caraway, finely ground	3¼ ,,
Ginger, finely ground.	32 ,,

The spices should be leached in the vinegar for about a week.

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Packing Methods

Pickled onions and mixed pickles should be packed finally into bottles or jars loosely so as not to damage the shape and appearance of the pieces. Fresh vinegar is then added to fill up the spaces between the pieces. The bottles or jars are then allowed to stand for a while with the lids loosely on, covered again with more vinegar, if necessary, and sealed air-tight. They are stored for a few days, the period of storage depending on the vegetables used for pickling, size of the pieces, condition of the cured vegetable etc., so as to ensure thorough absorption of the vinegar before the pickles are sent to the market.

CAUSES OF SPOILAGE

Different kinds of spoilage occur in pickles. They are described briefly in the following paragraphs.

Shrivelling

Shrivelling occurs when vegetables like cucumber are placed directly in a very strong salt or sugar solution or even in very strong vinegar. To avoid this, weak solutions should be used to start with, increasing their strengths gradually.

Bitter Taste

This results from the use of strong vinegar. It can also be caused by cooking with spices for a long time or over-spicing.

Blackening

This is caused by iron which enters through brine or from the equipment. Sometimes, specific organisms also cause blackening.

Dull and Faded Products

Pickles become dull and faded due to either insufficient curing or use of material of inferior quality.

Softness and Slipperiness

This is due to the action of bacteria and is the most common form of spoilage. It is invariably due to inadequate covering with brine or due to the use of weak brines. By using a brine of proper strength and by keeping the pickle well below the surface of the brine, this kind of spoilage can be eliminated.

Scum Formation

When vegetables are placed in the brine for curing, a white scum is invariably formed on the surface due to the growth of wild yeast. This scum may be thin or thick in appearance, varying from almost an imperceptible film to a thick wrinkled layer. It retards the formation of lactic acid. Since this action may help the growth of putrefactive bacteria which may cause the vegetable to become soft and slippery, it is essential to remove the scum as soon as it is formed. Addition of about 1 per cent. acetic acid helps to prevent the formation of wild yeast on the brine, without hindering in any way with the formation of lactic acid. For this reason some manufacturers add a small amount of vinegar to the brine in the initial stage

Cloudiness

When vegetables are placed in vinegar, it is generally presumed that the product will not spoil. In the case of onions and some other vegetables, however, sometimes the vinegar becomes cloudy and turbid thereby spoiling the appearance of the pack. These materials being of a very solid texture, the acetic acid in the vinegar may not penetrate deep enough to prevent the activity of bacteria or other micro-organisms that may be present in them with the result that fermentation starts from inside rendering the vinegar cloudy. This activity of organisms can only be checked by proper brining. Cloudiness may also be caused by the use of vinegar of an inferior quality or imitation vinegar or, possibly by chemical action between the vinegar and the impurities such as calcium, magnesium and iron compounds that might be present in the salt used, or by action between the vinegar and minerals naturally present in the vegetable itself.

Blemishes on Pickled Onions

Blemishes may sometimes occur in pickles and, especially, in onion pickles made in vinegar. In the case of onions, a whitish blotch is sometimes seen under the first layer of the skin. This appears to be due either to some kind of fermentation or non-removal of all the brine prior to the final pickling.

VARIOUS PICKLES

There are several kinds of pickles sold in the Indian market. Mango pickle ranks first. Then come cauliflower and turnip pickles, followed by those of lime, chilli, bamboo, etc. Pickles are classified according to the method of their preparation.

Vinegar pickles are the most important in foreign countries. There are sour, sweet, spiced and mustard pickles. Picked onions occupy a prominent place among imported products. Then come mixed pickles, followed by piccalilli, dill pickle and walnut, beetroot, cabbage and all other kinds of pickles made from different fruits and vegetables.

Fruit pickles are generally preserved in sweetened and spiced vinegar while vegetable pickles are preserved in salt.

Some recipes for typical pickles are given below:

Apple Pickle

Sarson recommends the following recipe for the pickle:

RECIPE

Sour apples	4 lb.
Spirit or cider vinegar	1½ pints
Sugar	2 lb.
Cinnamon stick	3 inches
Allspice	1 teaspoonful
Cloves, whole	20 (number)

Peel, core and cut the apples and keep them in water to prevent browning. Boil the vinegar, sugar and spices for 5 minutes. Then add the apples and simmer the mass till the pieces are tender. Take out the fruit and pack into jars. Reboil the vinegar and sugar to a syrupy consistency, pour it on the apples while hot and seal the jars. The spices also may be added to the jars, if desired.

Cabbage Pickle

Binstead has given the following recipe:

Take fully mature solid heads. Remove the coarse outer leaves and quarter the heads and shred across the grain. Place the shreds in a non-corrodible vessel and sprinkle them with a thin layer of salt (1 lb. of salt for every 40 lb. of shreds would be sufficient). Place a heavy wooden board over the mass and let it stand for 24 hours, Next day, drain well for about an hour, cover the shreds with the spiced vinegar according to taste, and let it stand for another 24 hours, mixing occasionally so that the absorption of vinegar may be uniform. Then pack, not too tightly, into jars. Cover the shreds with fresh vinegar and seal the jars.

Sauerkraut. This form of cabbage pickle is highly popular in certain parts of Europe and the U.S.A. According to Joslyn and Cruess, the following process is generally adopted for making this product.

Take fully mature solid heads of cabbage. Remove the outer green leaves. Quarter the heads and remove the core. Shred the cabbage into thin strips. Take 1 lb. of salt for every 40 lb. of cabbage and mix them well. Pack the cabbage loosely in a jar or cask and place a false wooden head or plate on top. Then place a heavy stone on it to press out the juice from the cabbage. Allow the jar or cask to remain in a warm place (75°-80°F.) for 8-12 days. Remove any scum that is formed. When fermentation is complete, boil the sauerkraut and pack it hot in sterilized jars. Alternately, the brine may be separated from the cabbage, boiled and poured boiling hot over the cabbage which has been packed in jars. In this case a better flavour will be developed. According to Cruess, sauerkraut can be packed in cans also. The cans are filled with the hot juice, exhausted and processed till the centre of the can reaches 180°F.

Beetroot Pickle

Poultney gives the following recipe for beetroot pickle:

Blanch young beetroots in steam or boiling water, taking care to see that the tops or roots are not cut too close. After blanching, remove the skin by hand and slice or dice the beetroots. Fill the pieces into jars, add vinegar of 10 per cent. strength to the brim and seal the jars. The vinegar may be flavoured suitably with salt and spices.

Cucumber Pickle

According to Cruess, cucumber pickles are made as follows:

With Salt. Select firm cucumbers of small size and fill them into a cask half full of brine of 40° salometer. Add more brine to cover the cucumbers. Place a circular wooden head over the cucumbers and keep it in place so that the cucumbers remain submerged in the brine during fermentation. To prevent the growth of putrefactive organisms, maintain the strength of the brine in the cask at 40° salometer i.e., 10 per cent. salt. The cucumbers will now be of bright green to olive green or yellowish green colour and the flesh will be translucent without any chalky white and opaque appearance. They can be stored in brine for a long time.

With Vinegar. For preparing the vinegar pickle, take out the cucumbers from the brine and soak them in several changes of water at about 100°-130°F. to remove the salt. In case the pickles become soft, add hardening agents like soda alum or calcium chloride at the rate of 1½ ounce per gallon of water. Store the processed cucumbers for a few days in distilled or white vinegar of 4-5 per cent. acidity as acetic acid. Then remove them and pack in fresh 5-6 per cent. vinegar in bottles.

Sweet Variety. For making sweet cucumber pickle, remove the cucumbers from the vinegar and add spiced vinegar, which is prepared according to the following recipe:

RECIPE

Distilled vinegar (8% acidity)	8 gal.
Brown sugar	10 lb.
White sugar	10 ,,
Cloves	1 oz.
Coriander	1 ,,
Mustard seed	1 ,,
Broken ginger root	1 ,,
Mace	1 ,,

Heat the spices in a bag with vinegar at 175°-200°F. for about an hour in a covered vessel. Remove the spice bag and dissolve the sugar in the vinegar. This vinegar will be of about 40° Brix and will contain about 5 per cent. acidity as acetic acid. Store the cucumbers in this spiced vinegar for several weeks. Replace the old with the fresh spiced vinegar raised to 55° Brix by adding sugar.

Other sweet pickles like those of onions, green tomatoes and cauliflowers may also be mixed with sweet cucumber pickles, if desired. Pack in glass jars and seal the latter.

Dill pickles, which are highly popular in some parts of the world, are prepared by fermentation of cucumbers in dilute brine flavoured with the dill herb spices and are marketed in brine rather than in vinegar. These pickles do not keep so well as vinegar cucumber pickles.

According to Cruess, all kinds of cucumber pickles and mixed pickles are now successfully canned in heavily lacquered cans.

Jack Pickle

Tender green jack fruit has been found useful for pickling. The process is as follows:

With Spices. Select tender jack fruits, peel the outer spiny rind with a knife and cut the peeled fruit into ½-¾ inch thick slices. Fill the slices into a glazed jar and cover with 8 per cent. common salt solution. Keep the pieces well immersed in the brine by placing a wooden weight on the top. Raise the strength of the brine by 2 per cent. daily till the final strength reaches 15 per cent. Allow the slices to remain in the brine for 8-10 days to soften them.

Take the following quantities of other ingredients for preparing sweet spiced vinegar pickle:

Sugar	3 lb.
Vinegar (8 per cent.)	4 lb.
Water	1½ lb.
Cloves, headless	1 gm. each
Cinnamon, whole	
Coriander seed	
Ginger root, ground	
Mace, broken	
Mustard seed, broken	

Plain Product. For this, 8 per cent. vinegar only is used without sugar or spices. As the vinegar first added gets diluted, it should be replaced with fresh vinegar of the same strength after 2-3 days. Pack the pickle in bottles or jars.

Onion Pickle

Pickled onions are highly popular in the U.K. According to Eaton, the following method gives good results:

Without Fermentation. Select fully ripe, dry onions which are free from adhering soil and size-grade them. Remove the outer layer of the brown skin, the tops and the tails with a stainless steel knife. For brining without fermentation, pack the onions fairly tight in a cask and fill the cask with a brine of 85° salometer. After 48 hours, run off the brine and replace it with a saturated brine. Two ounces of potassium metabisulphite for a 45 to 50 gallon cask may be added to bleach the onions. The pickle will be ready in about two weeks.

With Fermentation. For adopting the fermentation process Campbell favours the following process:

Soak the onions in water for 2-3 days and then place them for a further period of 4-5 days in 5 per cent. brine. This will leach out the strong taste and give a whiter product. Drain the mass and replace with fresh brine of 60°salometer. Increase this to 80° for longer storage.

Drain the brine from the onions and leach out the salt by soaking in hot water for about 12 hours. Run the water off and pour 4 per cent. acetic acid solution over the onions. Allow the mass to stand for 24 hours. Then remove the onions from the cask. Fill them into wide-mouthed bottles, cover with 5 per cent. acetic acid or white vinegar and seal the bottles airtight.

A few fresh red chillies and a small quantity of white mustard seeds may be added for better appearance. Suitable spiced vinegar also may be used.

The following are quicker methods:

1. Take small onions of about the same size, peel and blanch them in boiling water till they become tender. Then add dry salt at the rate of one lb. for every 8 lb. of the onions and let them stand for 24 hours. Stir the mass occasionally. Drain and pack in cold, spiced vinegar, according to taste.
2. Peel and simmer the onions for about 15 minutes with spiced vinegar containing ½ oz. salt per pint. Drain and pack them in a jar and cover with fresh, hot, spiced vinegar.

Walnut Pickle

Tender walnuts, with their shells still soft, are used for pickling. As they are intensely astringent, they require prolonged curing, say, for 3-4 months. To facilitate this process, they should be pricked with stainless steel needles or bamboo spikes.

Recipe I. To 3 pints of vinegar add 1 oz. salt and ½ oz. each of all-spice, whole pepper, clove and ginger. Puncture the tender walnuts with a fork and store them in this vinegar for 4 months. Cook the walnuts in the vinegar, replacing water lost by evaporation. Drain and fill them into bottles covering with hot fresh spiced vinegar. Seal the bottles. The pickle will be ready for use in about three weeks.

Recipe II. According to Campbell, walnuts can be pickled as follows:

Take green tender walnuts, prick them and cover them in a vessel with a brine containing 4 lb. of salt per gallon of water. Allow the nuts to remain in this brine for 3 days, drain and cover with fresh brine of the same strength. Repeat this process twice. Drain the nuts and dry them in the sun till they turn black. Prepare spiced vinegar by boiling 8 oz. of black pepper, 4 oz. of allspice and 4 oz. of bruised ginger in one gallon of 5 per cent. vinegar. Pack the walnuts in bottles and cover with this vinegar.

For preparing sweet spiced vinegar, sugar may be added at the rate of 3-5 lb. per gallon of vinegar.

OIL PICKLES

In India, oil pickles, that is pickles which contain some edible oil, are highly popular. Cauliflower, lime, mango and turnip pickles prepared in this way are the most important. The preparation of these is described briefly in the following pages.

Bamboo Pickle

Tender bamboo shoots can be used for preparing different types of pickles.

Select tender bamboo shoots and remove their outer leaves. Cut the shoots into small pieces and boil them for half an hour twice with 2-3 changes of water to remove the bitter principle. Drain and rinse. Dry the pieces in the sun for 2-3 hours. Mix them with the usual spices and a small quantity of rapeseed oil or gingelly oil. Fill them into a stone jar. Place the jar in the sun for about a week. To improve its keeping quality, add more oil to cover the pickle.

Cauliflower Pickle

Cauliflower pickle is highly popular in North India. According to Tandon, the following process gives a good pickle.

Take fully developed and compact heads of cauliflower.

Remove the outer leaves and central stalks. Cut the flowers into pieces. Wash, drain and place them in the sun for 2-3 hours to remove surface moisture. Take the following quantities of ingredients:

Take all the spices except mustard and grind them into a fine powder. Fry them in the oil. When the spices turn brown, add the cauliflower pieces and mix the whole mass thoroughly. When the cauliflower pieces turn slightly soft, allow them to cool. When the mass has cooled down to room temperature, add mustard and mix it thoroughly. Place the mixture in the sun for 5-7 days. Then add 5 lb. of vinegar and again place it in the sun for 3 more days.

RECIPE

Prepared cauliflower	40 lb.
Salt	2½ lb.
Chilli powder	1¼ lb.
Cumin	2 oz.
Cloves	2 oz.
Cardamom	1 oz.
Cinnamon	2 oz.
Ginger, green	1¼ lb.
Onions, chopped	1⅓ lb.
Mustard seeds	1½ lb.
Rapeseed oil	5 lb.

For a sweet pickle add 10 lb. of sugar or jaggery along with the vinegar. The pickle will be ready in about a week's time.

The following recipe which requires more mustard, also gives a good pickle:

RECIPE

Prepared cauliflower	82 lb.
Salt	5 lb.
Mustard, finely ground	6 lb.
Red chillies, finely ground	2 lb.
Turmeric, finely ground	½ lb.
Dry ginger, finely ground	½ lb.
Onions, finely ground	2 lb.
Garlic, finely ground	½ lb.
Gur	20 lb.
Rapeseed oil	Sufficient to mix the spices.

Blanch the cauliflower pieces for 5-6 minutes in boiling water. Mix all the ingredients in a jar and place the latter in the sun. In 4-5 days the pickle will be ready. Then add 18 oz. of glacial acid and mix thoroughly.

Jack Fruit Pickle

The pre-pickling treatment of the slices of tender, green jack fruit is the same as for the pickle in vinegar.

Take the following ingredients:

RECIPE

Brined slices	20 lb.
Salt	1¼ lb.
Chilli powder	6 oz.
Cumin (*zira*)	1 oz.
Cloves	1 oz.
Cardamom	½ oz.
Cinnamon	1 oz.
Dry ginger	½ oz.
Onions, chopped	10 oz.
Mustard seed	1 oz.
Gingelly oil	2½ lb.
Garlic	1 oz.
Vinegar	2½ lb.
Sugar	2½ lb.

Fry chopped ginger, onion, garlic and mustard seeds in a little oil till they turn brown. Add these and the rest of the spices to the jack fruit slices and fill the mass into glazed jars. Mix well and place the jar in the sun for 3-4 days, stirring the mass occasionally. Add sugar and vinegar, again mix well and keep the jar in the sun. The pickle will be ready in another 3-4 days. Fill the pickle into glass or glazed earthen jars and pour sufficient oil to cover the pickle well.

Lime Pickle

Wash fully-ripe limes thoroughly. Give two or four slits to each fruit. Take common salt of good quality at the rate of 4 oz. for every pound of the fruit. Fill into the jar about two-third the quantity of the limes and add the salt. Squeeze the remaining portion of the limes partially and put them also into the jar. The juice should now cover the contents of the jar. If necessary, a few more limes may be squeezed and their juice poured into the jar. Place the jar in the sun for about a week. The limes get softened and their skin turns light brown.

For preparing lime and green chilli pickle, these may be taken in proportions ranging from 8:1 to 4:1, in weight. The rest of the process is similar to that for lime pickle. Bamboo shoots also can be used along with limes and chillies.

Mango Pickle

Mango is pickled differently in different parts of India. These are generally oil pickles. The 'Avakai' pickle in the Circars (Andhra State) is a well known oil pickle. These oil pickles are generally highly spiced. In North India, rapeseed oil is commonly used while in the South, gingelly oil is preferred. If handled carefully, the pickles will keep for one to two years. There is a considerable demand in other countries for mango pickles. Since the mango is almost a monopoly of India, it is desirable to standardise its pickling to build up an export trade.

The following recipe gives a good mango pickle.

Take under-ripe, but fully developed, tart variety of mango. Wash them in water. Slice them longitudinally with a stainless steel knife. Discard the stones. Keep the slices in brine of 2-3 per cent. strength to prevent blackening of the cut surfaces. Take the following quantities of spices:

RECIPE

Mango slices	2 lb.
Common salt powdered	8 oz.
Fenugreek (*methe*) coarsely ground	4 oz.
Nigella (*kalaunji*) coarsely ground	1 oz.
Turmeric powder	1 oz.
Red chilli powder	1 oz.
Black pepper	1 oz.
Fennel or aniseed (*saunf*)	1 oz.

Mix the mango slices with the common salt powder. Place the mixture in a glazed jar. Keep it in the sun for 4-5 days, till the slices turn pale yellow. Then mix the other ingredients with the slices and smear them with a little *sarson* (rapeseed) oil. Then pack the pickle in glass or glazed jars and cover with a thin layer of *sarson* oil. The pickle will be ready in 2-3 weeks.

Turnip Pickle

Sweet turnip pickles in oil are highly popular in several parts of North India. The following process gives a good pickle:

Select sound turnips, preferably with a pink skin. Wash them thoroughly. Peel and slice them into pieces of a convenient size, preferably of ¼-½ inch thickness. Take the following ingredients:

RECIPE

Prepared turnip	20 lb.
Red chillies	8 oz.
Black pepper	4 oz.
Mustard	1 lb.
Spices (caraway and cinnamon)	2 oz.
Dried dates (*chhoara*)	8 oz.
Tamarind (*Imli*)	8 oz.
Ginger fresh, chopped	8 oz.
Onions fresh, chopped	2 lb.
Garlic, chopped	4 oz.
Salt	2 lb.
Vinegar	1 bottle (26 oz.)
Gur or jaggery	1½ lb.
Rapeseed oil (*sarson* Oil)	2 lb.

Blanch the turnip pieces for 5-6 minutes in boiling water. Chop the ginger, onions and garlic and fry them in a little oil. Soak tamarind and dates in water overnight. Prepare a thick extract of the tamarind by maceration and pass it through thin muslin cloth to remove seeds. Remove the stones from the dates and slice them into small pieces. Grind black pepper, red chillies and all the other spices. Mix all these ingredients except *gur* and rapeseed oil with the prepared turnip pieces. Fill the mass into jars and keep the latter in the sun for 5-6 days. Then add the *gur* in the form of a thick syrup and again place the jar in the sun for 3-4 days. Add the rapeseed oil and pack the pickle in stone jars.

CHAPTER XV

VINEGAR

Vinegar is perhaps the oldest known fermentation product. It contains about 5 per cent. acetic acid in water, varying amounts of fixed fruit acids, colouring matter, salts and a few other fermentation products which impart a characteristic flavour and aroma to it. In the trade, vinegar is labelled according to the material used in its manufacture. For instance, vinegar made from malt is called malt vinegar and that from apple juice, cider vinegar, and so on.

QUALITY STANDARDS

Vinegar is a liquid derived from various substances containing sugar and starch by alcoholic and subsequent acetic fermentation. It should contain at least 4 grams of acetic acid per 100 c.c. and a corresponding quantity of the mineral salts of the materials from which it is made. It should not contain arsenic in amounts exceeding 0.0143 milligram per 100 c.c., nor any mineral acid, lead, copper, or colouring matter except caramel.

Grain Strength

Vinegar manufacturers and dealers represent the percentage of acetic acid in terms of 'grain strength'. The 'grain strength' of any vinegar is ten times the percentage of the acid present in it. For example, a vinegar containing 5 per cent. acetic acid is spoken of as vinegar of 50 grain strength.

VINEGAR VARIETIES

Vinegar is made from various fruits and also from sugars. Some important types of vinegars are described in the following pages.

Cider Vinegar

Vinegar made from apple juice by fermentation is called 'Apple Cider Vinegar' or 'Cider Vinegar'. It should contain at least (i) 1.6 grams of apple solids per 100 c.c., of which more than 50 per cent. are reducing sugars, and (ii) at least 4 grams of acetic acid per 100 c.c. at 20°C.

Wine or Grape Vinegar

The vinegar made from grapes by acetic fermentation is called 'wine or grape vinegar'. It should contain at least 1 gram of grape solids, 0.13 gram of grape ash and 4 grams of acetic acid per 100 c.c. at 20°C.

Spirit Vinegar

This is made by acetic fermentation of dilute ethyl alcohol. It should contain at least 4 grams of acetic acid per 100 c.c. at 20°C. It may be coloured with caramel. This vinegar is also called 'grain vinegar' or 'distilled vinegar'.

Distilled vinegar is often called white vinegar. The term 'distilled' is misleading, because the vinegar itself is not distilled, but is made from distilled alcohol.

Malt Vinegar

It is derived wholly from malted barley or other cereals, the starch of which has been saccharified by the diastase of malt followed by alcoholic and acetic fermentation without distillation. It contains not less than 4 grams of acetic acid per 100 c.c. at 20°C.

Other Vinegars

Vinegar can be made from oranges, pineapples, ripe bananas, pears, peaches, apricots, etc., and, in fact, from any substance which contains at least 10 per cent. of fermentable sugars and which will give more than the legal minimum of 4 grams of acetic acid per 100 c.c. of vinegar.

METHODS OF PREPARATION

Two distinct processes are involved in the preparation of vinegar, i.e., (*i*) transformation of the sugary substances of fruits, etc., into alcohol by yeast, and (ii) change of the alcohol into vinegar by acetic acid bacteria.

The chemical reactions involved in these two processes are as follows:

i) $$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2\ C_2H_5OH + 2\ CO_2$$

Fermentable sugar	Ethyl Alcohol	Carbon Dioxide
(180)	$(2 \times 46 = 92)$	

ii) $$2\ C_2H_5OH + 2\ O_2 \xrightarrow{\textit{Vinegar bacteria.}} 2\ CH_3COOH + H_2O$$

Ethyl Alcohol	Oxygen	Acetic acid	Water
$(2 \times 46 = 92)$		$(2 \times 60 = 120)$	

1. RAW MATERIAL PROCESSING AND FERMENTATION

Grapes

Grapes are crushed and pressed just as in the case of making white grape juice and are then fermented with a pure starter of yeast. The fermented juice usually contains a much higher percentage of alcohol than that required for vinegar preparation. The liquor is adjusted to 7-8 per cent. alcohol content before acetic fermentation is started. The fermented juice should be diluted only at the time of starting acetic fermentation, otherwise it may spoil due to the formation of 'wine flowers'.

Oranges

In extracting orange juice for fermenting, care should be taken to keep out peel oil.

Apples

Juice is extracted by grating and pressing whole apples in a basket or rack and cloth press. Even after this, the pomace contains a large percentage of juice which is difficult to extract. In order to extract this juice, the pomace is finely ground. For every ton of it about 15 gallons of actively fermenting cider is added in order to promote yeast fermentation. The pomace is allowed to ferment for 2-3 days and then pressed. By this method, a larger yield of juice is obtained than by simple grinding and pressing. The juice extracted by this method being inferior in quality, should be fermented separately.

Dried Fruits

Dried fruits normally contain a much higher percentage of sugar than fresh ones, the percentage varying from 50 to 70. For preparing the solution for making vinegar, 50-60 gallons of water is added to every 100 lb. of the dried fruit, so as to get a juice containing 10-15 per cent. of fermentable sugars. Then a starter of pure wine yeast is added and the mixture allowed to ferment for 2-3 weeks or till the fruit becomes sufficiently soft. During this, the mass is stirred twice a day to prevent the growth of moulds and acetic acid bacteria on the surface. The fermenting material is then pressed in a rack and cloth press and the juice allowed to ferment further till all the sugar present in it changes into alcohol. Alcohol is subsequently fermented into vinegar.

Potatoes

The starch is first extracted and hydrolysed with diastase before further fermentation takes place.

Molasses

The material is diluted to about 16° Brix, neutralised with citric acid and then fermented.

Honey

Low grade honeys are used for fermentation.

Malt Vinegar

For high grade malt vinegar barley is commonly used. The malting of barley is carried out as follows, according to the methods given by Mackenzie, Hopkins and Kraus:

1. **Soaking in Water.** The grain is soaked in water for about 48 hours, during which time it absorbs about 45-47 per cent. of water.

2. Germination. By the older method, the germination of barley is carried out by spreading the grain on the floor of a well-ventilated room till the plumules are about three-fourth the length of the grain. During germination, the grain becomes soft and mealy and diastase is produced. The temperature of the grain rises. To prevent this, the grain is turned over periodically. The temperature of the grain should not be allowed to rise above 77°F. The ideal temperature is 53°-56°F. It usually takes about a week for the grain to germinate.

By a more recent method, the germination is carried out in large revolving perforated drums.

3. Kilning. The sprouted grain is heated in a kiln to stop further growth. The drying should be done slowly so that a temperature of 120°-130°F. is reached in 40-48 hours. On no account the drying temperature should exceed this range, as at higher temperatures the diastatic activity of the malt may be adversely affected or even totally destroyed.

4. Cleaning and Crushing. After drying, the grain is rubbed, sifted to remove broken plumules and crushed between rolls into fine particles or grists.

5. Mashing. The malt alone or mixed with ground barley is suitably thinned with water and heated gradually from 130° to 170°F. The temperature is then raised to about 200°F. and kept at that point for about half an hour to gelatinize the starch. The mixture is then cooled to 150°F., and a fresh portion of malt added to complete the hydrolysis. The progress of the conversion of starch is tested with iodine, which gives a blue colour with starch, but no colour with sugar. The liquid is then run off, cooled and adjusted to about 15° Brix for subsequent alcoholic fermentation.

If cereals other than barley are to be used, the method followed is slightly different. The starch in the cereals is first gelatinised by pressure-processing and a certain amount (10-15 per cent.) of barley malt is added to convert the starch into maltose. The mash is then fermented with a pure yeast like *Saccharomyces cerevisiae* to alcohol and, finally to acetic acid.

Yeasts for Vinegar

The most desirable yeasts for alcoholic fermentation of juices and other sugary materials used in the manufacture of vinegar are, *Saccharomyces Ellipsoideus, Saccharomyces Malei,* and *Saccharomyces Cerevisiae.* These yeasts are very efficient in converting sugar into alcohol. They settle quickly after alcoholic fermentation is complete and produce a clear liquid of good flavour and normal appearance. In practice, only *Saccharomyces Ellipsoideus,* commonly found in grape juice fermentations, is used for fermentation of juices because of its rapid growth and high alcohol-forming power. For the fermentation of mashes made from starchy materials, the yeasts of the *Saccharomyces Cerevisiae* group are the best.

Alcoholic Fermentation

Fruit juices and sugar solutions of low concentration ferment of their own accord due to wild yeast normally present in fruits and in the atmosphere, but this is not desirable because different yeasts produce different kinds of decomposition products. In order, therefore, to get a good vinegar it is essential to destroy all these naturally occurring yeasts and other micro-organisms by pasteurization and to inoculate the sterile juice thus obtained with pure yeast. Pure wine yeast is sold in the market in a compressed form. A 'starter' is prepared from this for adding to the fruit or sugary solution to be fermented.

Yeast Starter

A 'starter' can be prepared as follows: Take one gallon of fruit juice or sugar solution (generally *gur* or molasses is used for the purpose) of about 16° Brix, heat it to about 180°F. for a minute or so and then cool it to 80-85°F. To this, add one cake of yeast after crushing it. Mix the crushed cake thoroughly and place the juice in a clean jug, or a stone or glass jar. Close the mouth of the container with a plug made of cotton or a piece of muslin. Keep it in a dark, warm place at about 80°F.

Yeast requires certain nutrients, such as phosphates, ammonium and potassium salts and sugar. These are normally present in fruit juices and sugar solutions made from *gur* and molasses. When fermentation becomes active in 3-4 days and the juice still shows a Brix of about 8 degrees, it is mixed with fresh juice or sugar solution in the ratio of one to ten. The mixture is stored in a warm place for further fermentation. The fermenters are usually open wooden vats. Sometimes, closed fermenters are used so that the carbon dioxide evolved may be recovered. An addition of about 3-4 ounces of sulphur dioxide (6-8 ounces of potassium metabisulphite) per ton of the crushed fruit or per 200 gallons of juice, helps in getting higher yields of clear alcohol.

Culture Yeast

The growth of 'culture yeast' is favoured by aeration and agitation of the fermenting liquid in the initial stages. Undue aeration should, however, be avoided at the later stages to prevent any oxidation. The best course is to fill a barrel to the brim, leaving only a little space for frothing. The mouth of the container should be plugged loosely with cotton or covered with a piece of cloth to allow the carbon dioxide formed during fermentation to escape.

The most favourable temperature range for the growth of yeast is 77°-80°F. Fermentation becomes abnormal at 100°F. and ceases altogether at 105°F. It also ceases if the temperature of the fermenting liquid falls below 45°F. In order to get good results, the best course is to use a room whose temperature remains within the above mentioned range.

Alcoholic fermentation occurs in two stages. The first is preliminary or vigorous fermentation and the second is slow fermentation. During the first 3-6 days, most of the sugar is converted into alcohol and carbon dioxide. This fermentation is so rapid that foreign micro-organisms have very little chance to develop in the medium.

The secondary fermentation is much slower and usually takes 2-3 weeks. During this fermentation, contamination with vinegar or lactic acid bacteria may take place. 'Stuck tanks' in which alcoholic fermentation has ceased before fermentation is complete, are not uncommon during this stage. This may be due to either unfavourable temperatures or the high sugar content in the solution sufficient to give 14 per cent. or more of alcohol, which is deleterious to the growth of yeast. Under favourable conditions, fermentation is complete in 72-96 hours. Completely fermented juice usually gives a reading of about zero degree Brix or less. On no account more than 0.3 per cent. sugar should remain unconverted. During fermentation, gas bubbles are constantly produced. When fermentation is complete, their evolution ceases.

Clarification and Storage

When the fermentation is complete, the yeast and the fruit pulp settle to form a compact mass at the bottom of the tank. After settling, the fermented liquid is separated from this sediment by syphoning. A filter press also may be used to clarify the liquid. The clear liquid is stored in airtight vessels for later use. In order to prevent loss of alcohol and injury to the quality of the product due to the growth of mycoderma 'wine flowers', the barrel should be filled to the brim and sealed. If, however, the fermented liquid is to be kept exposed, it should either be acidified with strong unpasteurized vinegar so as to increase its acidity to at least 1 per cent. acetic acid or it should be covered with neutral oil (i.e., liquid paraffin) to prevent the growth of 'wine flowers' and evaporation of vinegar.

Acetic acid Fermentation

Acetic acid fermentation is brought about by acetic acid bacteria (acetobacter). These are strongly aerobic and, like other organisms, their activity is greatly reduced or inhibited by direct sun rays. Even diffused day light checks their growth. Acetic fermentation should, therefore, be carried in dark rooms fitted with orange or red glass panes.

Acetic acid bacteria require for their growth, nutrients which are generally present in the alcoholic liquor made from fruit juices or sugary substances. If, however, distilled alcohol is used, addition of a food for the bacteria is essential. Usually malt sprouts, phosphoric acid, potassium carbonate, tri-sodium phosphate and ammonium hydroxide are used. For acetic fermentation, the alcohol content of the fermented liquid is adjusted to 7-8 per cent. alcohol, because acetic acid bacteria do not function pro-

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perly at higher strengths. Mother vinegar containing acetic acid bacteria is then added to it in order to check the growth of undesirable micro-organisms and to hasten the process. It is added at the rate of one gallon to three gallons of fermented juice.

2. PREPARATION OF VINEGAR

Slow Process

This method is generally practised in India. The juice or sugary solution is filled into barrels and allowed to undergo alcoholic and acetic fermentations slowly. To screen off dust and flies, the bung-hole is covered with cloth and the barrels placed in a damp and warm place. In about 5-6 months, the sugary solution turns into vinegar. The main drawbacks of this method are:

(i) Alcoholic fermentation is often incomplete;
(ii) Acetic fermentation is very slow;
(iii) Quality of the vinegar is inferior; and
(iv) Yield is low.

Orleans Slow Process

In this process, about three-quarters of the barrels are filled with the juice, inoculated with mother vinegar and placed lengthwise. Two holes, each about an inch in diameter, are made on either side of the barrel just above the level of the juice, in addition to the bung-hole. These three holes are screened with wire-gauze or cheese cloth to exclude insects, vinegar flies, etc. The barrels are kept in a warm place at 70°-80°F. and fermentation is allowed to proceed till the acid reaches its maximum strength. Under favourable conditions it usually takes about 3 months for the complete conversion of the liquid into vinegar. About three-fourth of the vinegar is then withdrawn and an equal amount of fermented alcoholic juice is added for further vinegar fermentation. The process can be repeated once every 3-4 months. Care should, however, be taken to see that the film of vinegar bacteria on the surface of the fermenting juice is not disturbed; otherwise, the broken film will sink to the bottom, and in the absence of air, exhaust the nutrients without producing any vinegar. In order to avoid the breaking and sinking of the film, a perforated support may be placed in the barrel about an inch below the surface of the fermenting juice to support the film when the vinegar is withdrawn. Vinegar produced by the 'Orleans Slow Process' ages during the process of fermentation, and is clear and of superior quality.

Quick Process

This process is also called the 'Generator' or 'German' process. In this process, additional supply of oxygen is made available for the bacteria by increasing the surface of the bacterial culture. This increases the rate of fermentation. The equipment used in this process is known as 'Upright Generator'. It has a false bottom and head, vent-holes and sparge for discharging the liquor. It consists essentially of three compartments,

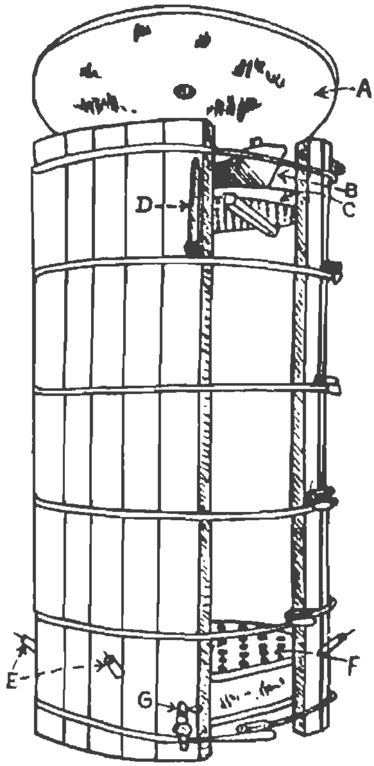

FIG. 54. VINEGAR GENERATOR FOR 'QUICK PROCESS'

namely, central, distribution and receiving compartments (Fig. 57). The generator is in the form of a cylinder 12-14 feet high and 4-5 feet in diameter. The details of the three compartments are as follows:

1. Central Compartment. This is filled with beech-wood shavings, corn cobs, pumice stone, rattan shavings or straw to increase the surface area. This chamber is fitted with an adjustable opening near the bottom for air.

2. Distributing Compartment. This is about one foot above the central compartment and is separated from it by a partition which is perforated with small holes. In this compartment, a revolving sprinkler or a tilting trough is fitted to allow the liquid to trickle slowly over the shavings or other material in the central compartment.

3. Receiving Compartment. This is the bottom chamber of the generator in which vinegar is collected. It is separated from the central compartment by a perforated partition about 5 feet from the bottom of the generator.

The beech-wood shaving or the filling material is wetted with unpasteurized vinegar. A mixture of two parts of the alcoholic juice and one part of the vinegar is fed slowly through the generator to stimulate the growth of vinegar bacteria. Within a few days the growth of the bacteria proceeds sufficiently to permit the normal operation of the generator. When the generator is ready, the alcoholic liquid is mixed with mother vinegar in the ratio of 1:2 to increase its acidity from 3 to 3½ per cent. It is then passed through the generator. A single passage of this mixture through the generator will convert the remaining alcohol into acetic acid. The process can be made a continuous one. The progress of oxidation is determined by finding the increase in acidity of the percolating solution.

The generator and the air passage should be cleaned from time to time to eliminate undesirable micro-organisms. The optimum temperature at which vinegar bacteria are active is 80°-85°F. In the generator, this is controlled by the adjustment of the air intake and by the rate of the flow of liquid. If the temperature increases, the rate of flow of the acidified alcohol is increased and the intake of air is reduced. If on the other hand, the temperature falls, the rate of flow of alcohol is decreased and the passage of the air is increased. For speedy work in all seasons, generators may be fitted with coils in which cold water or steam may be passed to maintain the optimum temperature.

Alcohol, Acetic Acid Yields

Theoretically, 100 parts of sugar (sucrose or maltose) should yield 53.8 parts of alcohol or 70.1 parts of acetic acid. But in actual practice, even under the most favourable conditions, about 45-47 parts of alcohol or about 50-55 parts of acetic acid only are produced. The loss represents the consumption of sugar in solution by the yeast, the loss of alcohol and acetic acid due to evaporation or oxidation and also the loss due to utilization by vinegar bacteria for their growth. Small quantities of alcohol may also remain unconverted. In order to prepare vinegar of about 5 per cent. acetic acid strength, it is, therefore, necessary, to use a juice with at least 10 per cent. sugar (maltose or sucrose) content. After conversion of the whole of alcohol into acetic acid, the vinegar bacteria attack the acid itself. This can be prevented by filling the barrels to the brim and sealing them airtight.

3. POST-PRODUCTION PROCESSES

Ageing

To improve its flavour, vinegar is kept in plain oak barrels for about six months. During this period, its harsh flavour changes to a more pleasing aroma and bouquet. This may be due to the oxidation of vinegar brought about by air entering through the pores in the wood. Acetic acid may also react on alcohol and form ethyl acetate which has a fruity flavour.

Clarification

Before bottling, vinegar must be made sparkling clear. During ageing, most of the suspended material settles down leaving most of the liquid clear. The clear liquid can be syphoned out for further clarification. This can be accomplished either by using finings, such as Spanish clay, bentonite, isinglass, casein, gelatin, or by filtering through pulp filters or aluminium plate and frame presses. If finings are used, the vinegar has to be stored for about a month or so to render it clear.

Pasteurization

The vinegar, after ageing and clarification, is pasteurized to check any spoilage. It is heated in an open vessel to about 150°F. and then cooled to room temperature. It can also be flash-pasteurized by passing it through aluminium pipes surrounded by warm water or steam at 150°F. Bottled vinegar is pasteurized by immersing the bottles in hot water till the vinegar in the bottles attains a temperature of 140°F.

The use of E.K. Seitz filters would ensure the removal of all the micro-organisms present in the vinegar, thus rendering it sterile. Incidentally it also clarifies the vinegar to a sparkling clearness.

Pasteurizing with Silver. In this process the vinegar is either filtered through silver-bearing sand or is electrolyzed with silver electrodes at a very low current. The vinegar picks up a sufficient concentration of silver ions, e.g., about 2 p.p.m., to render it sterile.

Colouring

Caramel colour is used as a colouring material in vinegars.

CHECKING SPOILAGE

Lactic Acid Bacteria

Lactic acid bacteria are generally found in fermented juices. They cause cloudiness and produce disagreeable mousy flavours in the fermented juices, besides producing lactic and other acids. The bacteria interfere in acetic acid fermentation and lower the quality of the vinegar. In alcoholic fermentation, they can be avoided by using a 'starter' of pure yeast and, during acetic fermentation, by adding 20-25 per cent. of unpasteurized vinegar to the fermented alcoholic juice. The acetic acid present in the vinegar checks their growth.

Wine Flowers

This is a kind of film yeast. If the fermented juice is unnecessarily exposed to air, 'wine flowers' grow on the surface of the liquid. They destroy the alcohol and the flavour and also cause cloudiness. Their growth can, however, be checked by (i) spreading a neutral oil like liquid paraffin over the surface of the fermented liquid, (ii) adding 20-25 per cent. of unpasteurized vinegar and, (iii) filling the barrels to the brim.

Vinegar Flies

Known as *Drosophila Cellaris,* vinegar flies are small flies which propagate in piles of fermenting pomace or rotten fruits. Although they do not by themselves in any way affect the quality of the vinegar, they hinder work. They can, however, be kept away by screening the premises and also by ensuring sanitary conditions.

Vinegar Eels

Vinegar eels (*Anguillula,*) are thread-like worms which are sometimes found in vinegar. These are about 1/25-1/16 inch long, and in shape they resemble the letter 'S'. They can be seen in strong light with the naked eye in vinegar in a glass vessel. They destroy the acid of vinegar. They can, however, be destroyed by heating the vinegar to 140°F. or by filtration, using a heavy addition of Filter-Cel. Being strongly aerobic, they do not grow if the container is filled to the brim. If by any chance, the factory using a heavy addition of Filter-cel. Being strongly acrobic, they do not equipment and to pasteurize the vinegar.

Vinegar Louse

These rarely becomes a serious pest. The louse is a small form of aphid and develops only around generators under certain conditions.

Vinegar Mites

These are the enemies of acetic acid bacteria. They multiply rapidly and interfere with the oxidation of alcohol. When dead, their bodies settle to the bottom of the liquid and begin to putrefy. The putrefactive bacteria so produced sooner or later overpower the acetic bacteria.

CHAPTER XVI

DRYING OF FRUITS AND VEGETABLES

Preservation of foods by drying them is perhaps the oldest method known. Large quantities of fruits are dried in the sun in different parts of the world such as Asia Minor, Greece, Spain and other Mediterranean countries, Arabia and Afghanistan. The modern method of dehydration, i.e., drying fruits and vegetables under controlled temperature and humidity conditions is, however, assuming increasing importance. The dehydration industry got an impetus during World War II. Their concentrated form, low cost, and convenient and easy transportability made dried products very popular among the armed forces.

SUN-DRYING

Sun-drying is practised in tropical and sub-tropical regions where there is plenty of sunshine and almost no rain during the drying season. The equipment consists essentially of drying trays and a few other items like knives, lye-bath, etc. Most of the work is done in a drying yard which is kept free from dust, flies, bees, etc.

Fruits are washed, peeled, prepared and placed on flat-bottomed wooden trays inside a shed. They are then treated with sulphur fumes to maintain their colour and also to avoid spoilage by micro-organisms. This is done in a small room by burning a known quantity of sulphur in a receptacle placed on the floor. The trays filled with the fruit are stacked in this room. Wooden trays, $3' \times 2'$, with sides about 2 inches high and with flat bottoms are convenient for handling the fruits. Fruits like thick-skinned grapes, peaches, etc. are lye-treated to 'check' the skin or to remove the peel to facilitate drying. After sulphuring (4-8 lb. of sulphur per ton of fruit) the trays are kept in the sun with occasional turning of the fruit till it is dried. The dried fruit is then stacked in boxes or bins to equalise moisture. This process is known as 'sweating'. After that the lot is boxed and stored in a room which is free from insects and rodents, having been previously fumigated with carbon disulphide.

The methods of sun-drying of some important fruits are given below:

Apricots

The small white apricot, especially the '*Shakarpara*' variety is dried whole in Afghanistan. It is imported into India in fairly large quantities. Apricots are allowed to ripen fully on the tree. These are then picked, cut into halves, the pits removed, and the halves placed on trays with the cups upwards. They are then sulphured for about 3 hours and subsequently dried. The dried fruits are filled into bags for despatch. Apricots are also dried to a large extent in France, Asia Minor and Australia. Royal. Blenheim, Tilton and Moore Park are the principal varieties used for drying.

Bananas

Dried ripe banana is known as 'banana fig'. The fruit is peeled, sliced lengthwise, sulphured and dried in the sun or in dehydrater. Unripe bananas are peeled after blanching in boiling water, and cut into discs which are then dried. The dried slices are either cooked or fried. They can also be converted into banana flour which can be used as such or in combination with other cereal flours. Jain, Das and Siddappa have got a process patented for the preparation of a new fruit product like toffee from banana and other fruits.

Dates

Tunisia, Egypt, Algeria and Arabia are the main date producing countries. Deglet-Nur, Khadrawi and Halawi are the important varieties. In the hard-dried dates (*Chhoara*) sucrose sugar predominates, while in the soft-dried dates invert sugars predominate. In India, dates are picked in the 'dung' stage, that is, when the tip of the fruit has turned a translucent brown. They are spread on mats for 5-8 days for curing. This is expensive as several pickings have to be made. Lal Singh and Bal Singh have found that dates could be picked 3-4 days before the 'dung' stage and then dipped for 30 seconds to 2 minutes in a 0.5-2.5 per cent. caustic soda solution before drying in order to get a good product. Losses due to rain and dust-storms are minimised by this method.

Figs

Smyrna is an important centre for figs. The Smyrna fig which is a large white variety, is used for drying. The Adriatic fig which has pink flesh, is also used. The figs are allowed to ripen on the tree and gathered when they drop. They are then spread thinly on the drying yard for 3-4 days for drying. They are then sorted and packed. According to Cruess, in California, Calimyrna figs are treated with lime and salt (10 lb. of each per 100 gallons) to remove the hair from the skin and also to soften them. They are then dried without sulphuring till there is no exudation of juice on pressing the dried fig between the fingers.

Grapes

Large quantities of seedless grapes known as *Kishmish* grapes are imported into India from Afghanistan. Ripe bunches are hung inside dark rooms known as *Kishmish Khanas* till they acquire a greenish or light amber tint. They are considered far superior to the ordinary sun-dried or

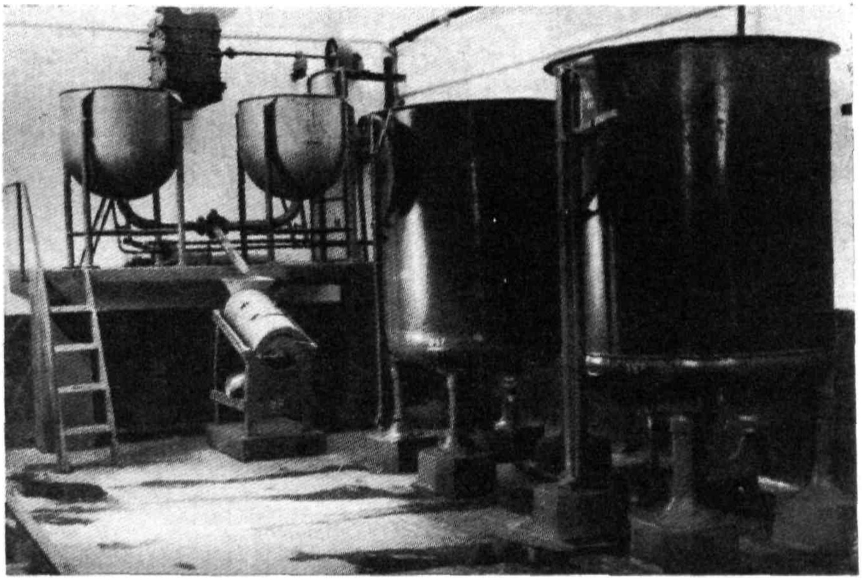

FIG. 55. TOMATO CRUSHER, PRE-HEATING PANS, PULPER AND COOKING PANS

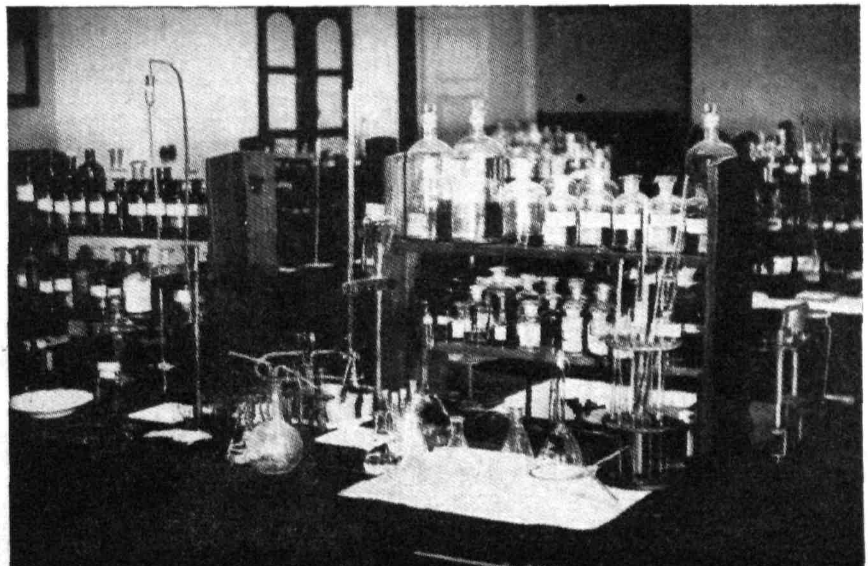

FIG. 56. ANALYTICAL AND RESEARCH LABORATORY, CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE, MYSORE

FIG. 57. A HOME-MADE DRIER

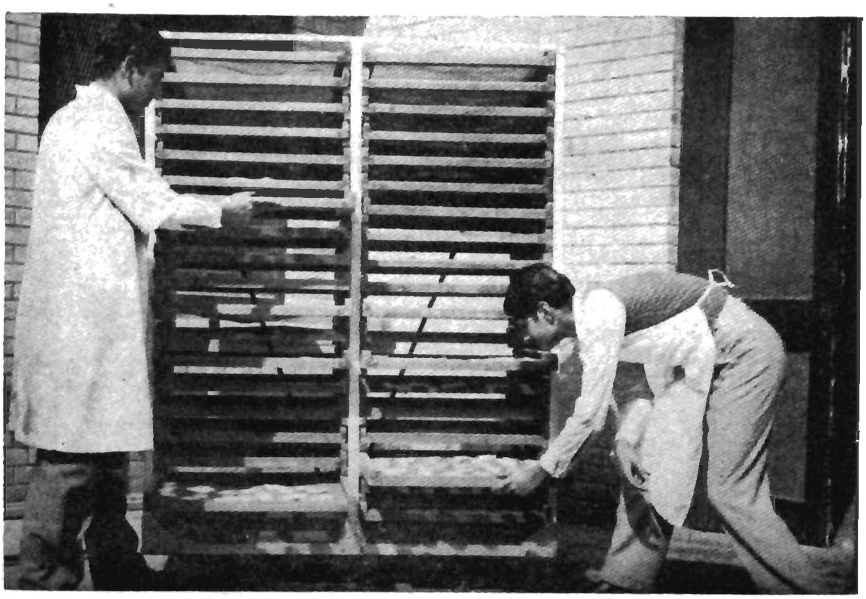

FIG. 58. A DEHYDRATION TROLLEY BEING LOADED

dehydrated products. The other important dried grape called 'Monucca' or 'Raisin' is prepared from the large seeded Haitha grapes which are lye-dipped prior to sun-drying. Siddappa has given complete details of the process for drying grapes in Baluchistan.

For drying, grapes should have a high sugar content of 20-24 degrees Brix. From this point of view some varieties are not suitable. They are then dried without sulphuring till there is no exudation of juice. The yield and quality of the final dried product depend on the Brix of fresh grapes. They are then dried without sulphuring till there is no exudation of juice and quality of the final dried product depends on the Brix of fresh grapes. In California, the Sultanina or Thompson seedless varieties are sun-dried. The grapes are sometimes dipped for 3-6 seconds in caustic soda or a mixed solution of caustic soda and sodium bicarbonate which has a thin layer of olive oil on the surface. This process removes only the wax and the bloom on the grapes without cracking the skin. The dried product has a glossy appearance. Lye-dipped grapes are sometimes treated with sulphur fumes for 3-5 hours for bleaching because certain markets have demand for such variety.

In Australia, potassium carbonate solution with olive oil, sometimes grape seed oil, is used as a dipping solution. The drying is carried out on wire-net racks arranged inside a shed. In this way the grapes are dried without direct exposure to the sun. The drying takes 10-20 days, according to the variety to be dried.

Jack Fruit

The jack bulbs are sliced, the seeds removed and the slices dried with or without sulphuring. The bulbs can be made into a fine pulp which can be dried as sheets or slabs. The dried product prepared by a new method developed in the Central Food Technological Research Institute, Mysore, has excellent texture, taste and aroma. This method has been patented.

Mangoes

In India, unripe, green mangoes are peeled, sliced and dried in the sun. The product is used for making mango powder which is added to dishes as a relish. In the Northern Circars, juicy varieties of mangoes, known as *Rasam* varieties, are processed in the following way: The pulp is squeezed out and spread on bamboo mats and sprinkled with a little sugar. When the first layer has dried, another layer of pulp is spread on it for drying. This process is repeated until a slab ½-1 inch thick is obtained. It has a light yellow amber colour and is very delicious. The product, however, spoils in a few months due to insect attack and discolouration. These defects can be removed by the application of scientific methods. There is great scope for developing this important product. Recently Siddappa and his colleagues at the Central Food Technological Research Institute have developed an improved method which has been patented.

Peaches

Australia, South Africa and California are important peach-drying countries. Freestone peaches like Muir, Lovell, Salway and Elberta are the varieties used for drying. Fruits are picked when they are fully ripe and treated like apricots.

Pears

Bartlett or Williams pear is the important variety used for drying. These fruits are ripened for 8-10 days after picking. They are cut lengthwise into halves without peeling, cored and then sulphured and dried. In California, they are dried in the sun for 1-2 days. The process is completed in the shade to get an attractive product.

Other Fruits

Pomegranate seeds are dried to *'Anardana'*, which is used as a savoury like tamarind. Apple rings are threaded and dried by hanging them out in the sun. Prunes, persimmons, cherries, berries, papaya, guava, tomato, etc., are also dried to some extent in different parts of the world.

MECHANICAL DEHYDRATION

Dehydration by means of mechanical equipment is a process quite distinct from sun-drying. The prepared fruit or vegetable is placed inside a chamber called a 'dehydrater' where the temperature, humidity and rate of air-flow are controlled. Dehydraters have a wide range—from the simple home set to the large commercial machines. Details of their construction and working are given by Morris and also by Von Loesecke.

Home-made Drier

A small cabinet drier has been found useful for small scale dehydration of fruits and vegetables for experimental purposes (Fig. 58 & 59). It consists essentially of a box of galvanized iron sheet, 3′×2′×3′, with a perforated iron sheet below. The sides and the top of the box are fixed in a wooden frame and the whole thing supported on an iron stand about 1¼ ft. high. In order to let off the moisture, there are two slits, 2′×1½′, along the top end of the two long sides, and about 4″ below the top. These slits can be closed or opened as desired by means of metallic shutters. Inside the box seven, 2¾′×2′, trays can be stacked on supports in staggering positions. The perforated plate is heated with a charcoal oven or a stove.

Commercial Dehydraters

These large dehydraters are of several types. They are based either on natural or forced draught circulation. The kiln and stack driers and the Oregon tunnel drier work on natural draught. The modern dehydrater is generally based on forced draught. For drying at low temperatures, vacuum driers are necessary but they are not in general use on account of their high cost. In the forced draught drier, the temperature and humidity can be carefully controlled to get a good dehydrated product.

Kiln Drier. The kiln drier is of the old type and is used for drying apples, hops, etc. It consists of two floors, the top one for spreading the fruit and the bottom one for housing the furnace. The heat for drying is conveyed through pipes. The spent air escapes through a ventilator at the top.

Tower or Stack Type. This consists of a furnace room containing the furnace and the heating pipes, and of a cabinet in which trays of fruit are kept for drying. The heated air from the furnace rises through the trays which are interchanged after some time from top to bottom. The cabinet drier is similar to the stack drier. The heating is done by steam coils placed between the trays.

Oregon Tunnel Unit. According to Cruess, an Oregon tunnel drier consists essentially of several parallel, sloping and narrow chambers above a furnace room. The trays are placed on these sloping floors. Each tunnel is about 20′ long, 5′ high and 3′ wide with a slope of about 2″ per foot. The trays of fruit enter at the cooler upper end on runways and move towards the warmer lower end. The dried fruit is removed from the lower end.

Forced-draught Tunnel. This type normally consists of a long chamber through which the trays of fruit move on trolleys. The heated air is let in at one end and drawn at the other end. The trolleys are pushed into the tunnel through an air-lock door. When one trolley of the dried fruits is taken out at the other end, another trolley of fresh fruit is pushed in at the entrance. The air for drying is recirculated by a fan. Humidity is controlled by letting in air from outside by damper devices.

Heating System

Heating is done direct or by radiation. In the first case, the products of combustion are mixed with hot air and passed over the material. Though this is very efficient, there is the danger of over-heating and deposition of soot and other harmful substances on the material.

In the second method, the air is heated over pipes carrying hot gases from the furnaces. Alternatively, the air is drawn through pipes heated from outside. This system also is as efficient as the first one. In another system, the air is heated by means of steam pipes. Although in this case, heating can be controlled accurately, it is costly and less efficient than the other two methods.

Circulation of Air

Several types of fans are used to force the air through the tunnel by suction or by blowing. According to Cruess, the axial-flow fan is preferable

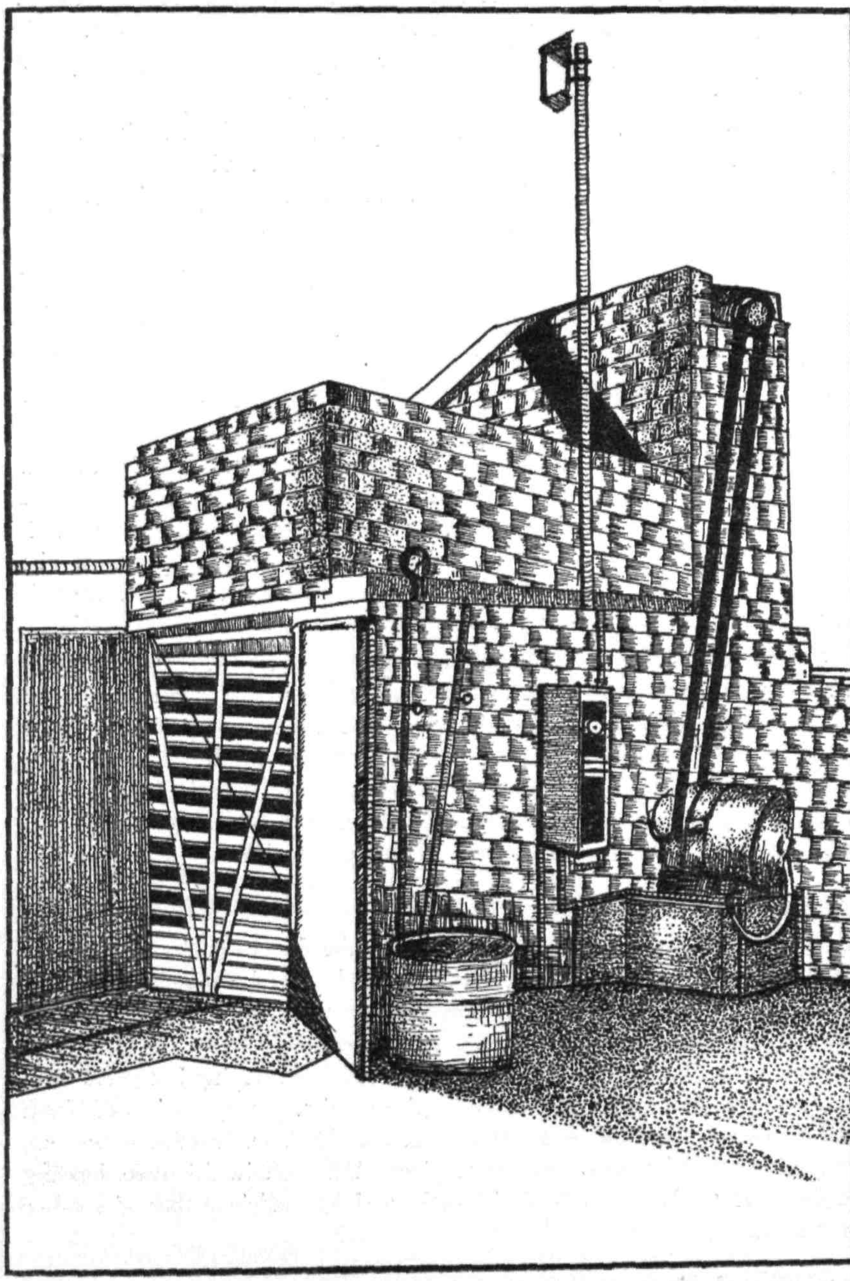

FIG. 59. AN EXPERIMENTAL 3-TROLLEY UNIT TUNNEL DEHYDRATER (RE-CIRCULATING-AIR-BLAST TYPE) FOR DEHYDRATION OF FRUITS AND VEGETABLES

to other types of fans, i.e. propeller type fan, multivane fan, etc. To prevent case-hardening of the material and to increase the thermal efficiency, a portion of the air is recirculated after heating. In general, the temperature of the ingoing air should not exceed 160°-170°F. and the humidity at the exit end should be about 65 per cent. The rate of drying increases with the velocity of the air passing through the tunnel. According to Nichols and his colleagues, an air velocity of 600-800 linear feet per minute gives satisfactory results in tunnel driers. Lower air velocities will be adequate in compartment driers.

Counter-Current and Parallel (Concurrent) Systems

When the air-flow is in the direction opposite to that of the drying material, the system is called counter current system. In the parallel system both flows are in the same direction. In the first case, the material is drawn out from the hottest end. There is, therefore, a likelihood of some scorching of the material. There is also much loss of heat. In the second case, the process starts with dry and hot air and is completed with a moderate temperature in moist air. Moreover, there is less loss of heat. According to Cruess, the parallel system is better for small fruits like grapes, apple slices, etc., to prevent scorching or case-hardening. Sometimes both systems are combined in twin tunnel dehydraters.

General Considerations

On an average, about three lb. of fresh fruit can be spread on each square foot of a tray. On this basis, the capacity of the tunnel can be calculated. The trays are arranged, leaving about 2 inch space between them. The rate of evaporation is deduced from the initial and the final moisture contents, the initial weight of the material and the drying time. In designing dehydraters, allowance has to be made for the losses of heat due to radiation and leakage, and during the removal of the trolleys.

A small tunnel dehydrater of recirculating-air-blast type is described by Lal Singh and Girdhari Lal who used it for experimental work in connection with dehydration of vegetables (Figs. 60 & 62). It is a three-trolley unit with the following parts:

1. (i) **Drying Chamber.** Tunnel measures 13′ long, 5′ wide and 6¼′ high.

   (ii) **Heating Chamber.** 10¼′ long, 5′ wide and 3′ high.

   (iii) **Fan Chamber.** 2½′, long 5′ wide and 3′ high.
   Hot air draft inlet slit in the drying chamber at the hot end 5′ × 1′ (Hot air from the heating chamber passes through this slit into the drying chamber).

2. **Fresh Air Arrangement.** Fresh air damper at the cold end measures 3¼′ × 1½′. This has an adjustable cover for controlling the flow of air.

3. **Side Dampers.** It measures 18″ × 9″. There are two dampers on both sides of the tunnel near the cold end. These have metallic flaps to regulate the flow of the outgoing air in accordance with the humidity in the drying chamber.

4. **Heating System.** This is done by means of steam pipes. Two sets of coil, one 160′ long and of one inch diameter and the other 110′ long and of ½″ diameter are placed in the heating chamber just in front of the blower fan. This can be replaced by a coal furnace with flue pipes inside the heating chamber to reduce the cost without any loss in efficiency.

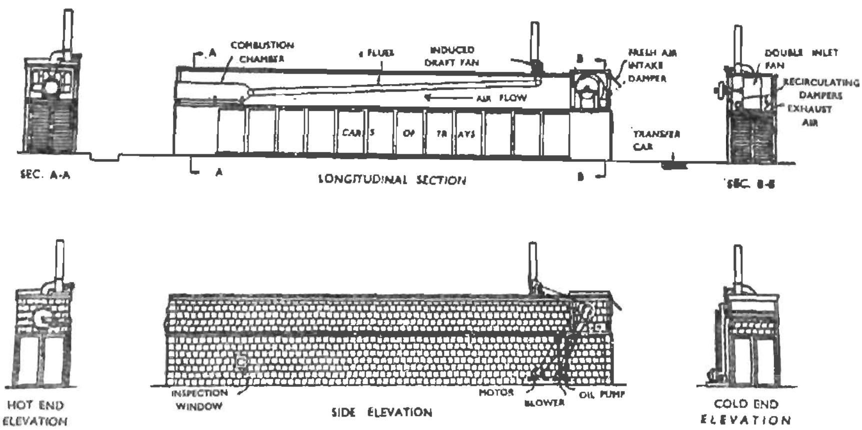

FIG. 60. CIRCULATING-AIR-BLAST TYPE FUNNEL DEHYDRATER

5. **Air-flow System.** One multivane fan, 20″ in diameter, and with 12 blades is placed in the fan chamber. For a 13′ tunnel, the speed of air-flow in the chamber works out to be only about 200 linear feet per minute. The space around the first trolley near the hot end is totally closed to stop the escape of air through the empty spaces without passing over the trolleys.

6. **Trays, and Trolleys.** (i) Trays: $2\frac{1}{4}' \times 2'$ with wire guaze of a 1/8″ mesh fixed on wooden frame. (ii) Trolleys: $2\frac{1}{2}'$ long, $4\frac{2}{3}'$ wide and $5\frac{2}{3}'$ high. There are four trolleys, each accommodating 40 trays in two rows, the distance between the trays in a stack being 2″. The tunnel is worked as a three-trolley unit, one trolley being extra for loading.

7. **Trolley Track and Turn Tables.** To facilitate pushing in and taking out of the trolleys, a tract 2′-4″ wide and 100′ long is built and provided with three turn-tables.

Working Instructions

The prepared material (potato slices in this case) is placed on trays (1-1¼ lb. per square foot) and the trays are loaded (Fig. 58) on one trolley. The trolley is pushed into the tunnel from the cold end and the doors are closed. The temperature is maintained at 140°-145°F. at the cold end and at 175°-180°F. at the hot end. After about 2½ hours, a second loaded trolley is placed in and the tunnel is closed airtight. The process is repeated for the third trolley. The first trolley with the dried potato slices is taken out 2½ hours after the third trolley is pushed in. The process is made continuous in this manner. The temperature and humidity are controlled as follows:

	Temperature	Humidity
Cold end (damper end)	140°145°F.	40-45 per cent.
Hot end	160°165°F.	20-25 per cent.

The humidity is determined at intervals of 30 minutes with the help of a dry and wet bulb thermometer. The drying time varies from 7 to 8 hours per trolley. The capacity of the dehydrater is about 320 lb. of dried potatoes per 24 hours, working continuously. For commercial working, the tunnel length of 13′ is rather small and it should, therefore, at least be double.

PROCESS VARIATIONS

Particulars regarding the preparation, preliminary treatment such as sulphuring, etc., temperature and humidity for the dehydration of various fruits are given briefly in the following paragraphs:

Apples

Apples are peeled, cored and cut into cubes or slices. These are sulphured for 15-30 minutes and dried at 140°-160°F. for 6-10 hours. The yield varies from 10 to 15 per cent.

Apricots

Both white and yellow apricots can be dried whole or in halves. They are sulphured for 15-25 minutes and dried at 135°-155°F. for 10-20 hours. The yield varies from 15 to 19 per cent.

Bananas

Green as well as ripe bananas can be dehydrated. They are peeled, cut into slices, sulphured for 15-30 minutes and dried at 130°-160°F. for 18-20 hours. Several of the well known varieties of South India have been found quite suitable for drying as figs or for preparing banana flour. The yield varies from 14 to 20 per cent.

Grapes

The grapes are lye-dipped, sulphured for about 30 minutes and dried at 150°-180°F. for 20-30 hours. The yield varies from 21 to 27 per cent.

Mango, Guava and Jack Fruit

Methods for drying these are being worked out at the Central Food Technological Research Institute, Mysore. A method for the preparation of sheets or slabs of fruit pulps has been recently patented.

Peaches

The halves are sulphured for 15-20 minutes and dried at 145°-155°F. in 15-24 hours. The yield varies from 14 to 19 per cent.

Pears

The pears which should be ripe, are peeled, cut into halves and cored. They are then sulphured for 15-20 minutes and dried at 140°-145°F. for 15-24 hours. The yield varies from 14 to 19 per cent.

Other Fruits

Berry fruits, prunes, cherries, etc., also can be dehydrated.

Sulphur Dioxide Content

According to Morris, the following are the permitted limits of SO_2 in different countries.

COUNTRY OR STATE	P.P.M. of SO_2
Great Britain	2,000 (750 for raisins)
Canada	2,500
Switzerland	2,000
Germany, Austria	1,250
Czechoslovakia	1,250 (Raisins only)
France	1,000
Japan	1,000 (Apricots only) None allowed in other fruits.
U.S.A. (New York State)	2,000
U.S.A. (New Hampshire)	none

PROCESSES FOR VEGETABLES

Although in India, considerable quantities of different vegetables like cauliflower, cabbage, bitter gourd, carrot, turnip, okra, banana, etc., are dried in the sun, the quality of the dried products is rather poor. The vegetables are not generally given any preliminary treatment such as blanching which is necessary to destroy enzymes that cause discolouration. According to Lal Singh and Girdhari Lal, even after blanching, the sun-dried vegetables after one year's storage were found unsatisfactory. They were poor in colour and remained tough even after long cooking. Earthen Jars, although suitable for sweating of the dried vegetables, are not suitable for storage, as they are highly porous and absorb moisture which spoils the product.

For large scale production of dried vegetables, dehydration is the proper method. To meet the demand of the Armed Forces during World War II, a series of investigations were made by Lal Singh and Girdhari Lal and Girdhari Lal and Jain, to standardize methods for the dehydration of potatoes, onions, garlic, cauliflower, etc. The experimental dehydrater already described was used. Details regarding the dehydration of some of the important vegetables are as follows.

Beans

Tender string beans are used. They are cut into small pieces, blanched in steam for 3-6 minutes and dried until both the pods and the beans inside them are brittle. The drying ratio is 7 : 1.

Bitter Gourd (Karela)

The gourds are scraped and cut into ¼ inch-thick slices. The slices are blanched in boiling water for 7-8 minutes and dried at 150°-160°F. for 7-9 hours. The drying ratio is 26: 1.

Brinjal

The brinjals are cut lengthwise into about ¼ inch thick slices and immersed in a 0.5 per cent. solution of SO_2 for 1½ hours. The slices are then blanched in boiling water for 4-5 minutes and dried at 120°-130°F. for 9-11 hours. The drying ratio is 33: 1. Contact with iron must be avoided.

Cabbage

Outer leaves and the cores are removed and shreds of 3/16 inch thickness are made. The shreds are either blanched in steam for 5-10 minutes or in a boiling 1.0 per cent. sodium bicarbonate solution for 2-3 minutes. According to Cruess, a ½ per cent. solution of sulphite and bisulphite in the blanching water gives a product with better colour. The shreds are dried at 140°-150°F. for 12-14 hours. The drying ratio is 18:1.

Carrot

Yellow carrots are better for drying. They are scraped and the stalks and tips removed. They are then cut into 3/16 inch thick slices and blanched in a boiling common salt solution of 2-4 per cent. strength for 2-4 minutes and dried. The temperature for drying is 155°-165°F. Drying time is 14-16 hours and the drying ratio 18: 1.

Cauliflower

The flowers are removed and cut into pieces, blanched for 4-5 minutes in boiling water, steeped in a 0.5 per cent. SO_2 solution for about an hour and then washed. They are then dried at 140°-145°F. for 10-12 hours. The drying ratio is about 35:1.

Garlic

The individual cloves or buttons are separated by hand and dried at 135°-140°F. as such, without any blanching, etc.

Knol-Khol

These are peeled and cut into 3/16 inch thick slices. The slices can be dried as such or after immersion in a ¼ per cent. SO_2 solution for 30-40 minutes. The drying temperature is 130°-140°F. and the time 11-13 hours. The drying ratio is 19:1.

Okra (Lady's Finger)

They may be dried either whole or as discs or as halves cut lengthwise. The discs should be ¼ inch thick. They are blanched for 4-8 minutes in boiling water or for 2-5 minutes in steam and rinsed in cold water to remove the gelatinous coating. They are then dried at 145°-155°F. for 6-8 hours. The drying ratio is 12:1.

Onions

The outer leaves are removed and the onions cut into 1/10th inch thick slices. The slices are immersed in a 5 per cent. solution of common salt for about 10 minutes and then drained. They are dried at 140°-150°F. for 11-13 hours. It is, however, better to keep the temperature below 135°F. The drying ratio is 10:1. The dried product can be powdered for use in several ways.

Peas

Only tender peas are dehydrated. They are blanched for 1-2 minutes in boiling water and dried at a temperature not exceeding 145°F.

Potatoes

The potatoes should be large, free from disease and fully matured. They should have the minimum number of eyes. They are washed thoroughly in water and peeled either by hand using knives or by means of a potato peeling machine. The peelings are washed away with water. They are then trimmed and placed in water to prevent browning. They are cut into slices 3/16 to 1/4 inch thick, in a slicing machine and the slices again placed in cold water. Whenever there is considerable delay in the subsequent operations of blanching, etc., the slices may be placed in water containing 0.05 per cent.

potassium meta-bisulphite to prevent spoilage. The slices are blanched for 3-5 minutes in boiling water and placed on trays at the rate of 1-1½ lb per square foot of tray surface. The trays are then loaded on the trolleys which are put in the dehydrater. The temperature range is 140°-150°F. (i.e., 140° at the cold end and 150°F. at the hot end.) The drying time is 7-8 hours and the drying ratio is about 7:1 in the case of unprepared potatoes. Dried potatoes reconstitute well in 4-5 times their weight of water It is preferable to pack them in an inert gas like nitrogen.

Pumpkin

Ripe pumpkins are cut into strips to facilitate peeling and then made into 1/4 inch thick slices. The slices are placed in a 2 per cent. common salt solution for 10 minutes. They are then blanched for 3-4 minutes in 2.0 per cent. boiling common salt solution and dried at 150°-160°F. for 9-11 hours. The drying ratio is 19:1.

Spinach

The leaves are washed thoroughly and dried as such or after steaming them for 4-5 minutes. The drying temperature is 145°-155°F. and the drying time 7-8 hours. The drying ratio is 22:1

Tomatoes

The tomatoes are peeled after scalding in boiling water for 30-60 seconds and cut into 1/4—3/8 inch thick slices. The slices are then dried at 140°-150°F. for 9-10 hours. The drying ratio is 27:1. Tomatoes need not be peeled for making tomato powder.

Turnip

The turnips are peeled and cut into 3/16 inch thick slices. The slices are immersed in a 0.5 per cent. SO_2 solution for 1-2 hours and blanched for 2-4 minutes in boiling water. They are then dried at 125°-135°F. for 11-13 hours. The drying ratio is 28:1.

PACKING AND STORAGE

Dried fruits and vegetables are subject to insect attack even when they have been properly dried and stored. Insects not only consume the material but also leave much debris which spoils the appearance of the product. To avoid insect attack, great care is necessary in the construction of packing sheds and godowns. Beetles and moths are the most troublesome pests. The best way to avoid the infestation is to prevent their entry into the product instead of adopting curative measures. The two important curative methods are heat treatment and fumigation.

Heat Treatment

Dried fruits like raisins, figs, peaches, etc., are dipped in boiling water or a dilute solution of sodium chloride or bicarbonate and then redried at 130°-150°F. to destroy all insects. Dried vegetables may be heated as such without any preliminary dipping. The heat-sterilized materials should be packed in sterile containers without delay to avoid chances of any reinfestation.

Fumigation

There are several fumigants available in the market, but all of them are not useful in the case of dried fruits and vegetables. Fumigation kills insects including their eggs. Great care is necessary in using fumigation as some of these substances (like carbon disulphide and hydrocyanic acid gas) are highly inflammable or highly poisonous. It is also possible that the fruit may absorb a small amount of hydrocyanic acid rendering the product poisonous. These two fumigants are not, however, in general use now. Methyl bromide is becoming popular, as it is very effective. This gas which is heavier than air, is poured on the stored material from the top. The normal dosage is prescribed by the suppliers. It is non-explosive, but is toxic to human beings also. Mixtures of ethylene dichloride and carbon tetra chloride, ethylene oxide and ethylene dichloride have also been used for fumigation. Ethylene oxide, though highly explosive and inflammable, is an ideal fumigant for food-stuffs in general. It is supplied in cylinders. It is vaporized inside airtight stores. According to Cruess, in the case of materials like walnuts and almonds, rather than dried fruits, fumigation can be carried out very effectively in a vacuum.

Packing is perhaps the most vital step for the success of the dehydration industry. Dried fruits and vegetables should be quite dry and should be packed in moisture-proof tins. If care is not taken to guard against excessive moisture, the contents will become mouldy in the container. Boxes of wood or cardboard are not generally moisture-proof and insect-proof unless special methods are adopted to line them with waxed paper and seal them properly. Dried vegetables can be packed in large tin containers in an inert gas like nitrogen to prolong their keeping quality.

CHAPTER XVII

BY-PRODUCTS

During the canning of fruits and vegetables and the preparation of juices, squashes, jams, jellies, dried products, etc. large quantities of waste materials are left over. A producer has to dispose of the peel, rags and seeds of citrus fruits, the peels and stones of mangoes, the rind and seed of jack fruit, the core and peel of guavas and seed, skin and trimmings from tomatoes and the like. Then there is the problem of utilization of overripe and blemished fruits and vegetables. It is necessary to find out a profitable outlet for these waste products in order to make the industry paying. In India, a considerable amount of work has already been done on this important aspect of the industry.

UTILIZING WASTE MATERIAL

Below are given suggestions to utilise waste materials from various sources:

Apple

The pomace left after the extraction of juice can be dried and utilized for the preparation of pectin. Further details are given in the next chapter.

Apricot

According to Siddappa and Mustafa, kernels of white apricots are sweet and can be added, after removing their outer coat, to apricot jam to improve its appearance and consumer appeal. They can also be used in confectionery. According to Cruess, an oil can be extracted from the kernels by pressure or with a suitable solvent. This oil can be refined and used just like almond oil. It can also be used in cosmetics and pharmaceutical preparations. Apricot kernels are sometimes used for making macaroon paste which is usually made from almonds. The oil cake is rich in protein and is used as a cattle feed.

Grape

In the preparation of grape juice and wines, stems and pomace are the main waste products. The stems can yield cream of tartar. From the pomace the seeds can be separated and pressed to extract an oil which is edible in its refined state. It can also be used to dip grapes prior to drying so that they acquire a lustrous appearance. The oil cake can be used as a cattle feed. The pomace may be treated with water, and calcium tartrate precipitated by the addition of a mixture of calcium hydroxide and calcium chloride. The calcium tartrate precipitate is treated with dilute sulphuric acid to precipitate the calcium as sulphate. From the filtrate, tartaric acid is recovered by crystallization. Tannin extracts can be prepared from the hulls of the decorticated grape seeds. The pomace can be used for the preparation of jelly. According to Elwell and Dehn, grape marc can be a suitable source of commercial pectin under certain conditions.

Guava

The core with the seed and also the peelings can be utilized for making guava cheese. Guava cheese is a fruit confection of the type of Indian *Halwa* and has a potential home as well as foreign market. Recently Jain, Das and Girdhari Lal have standardized an improved method for its preparation. According to these authors, the cold process of pulping is more convenient and better in various other respects than the hot process. The pulp surrounding the seeds as well as the seed is not as useful for the preparation of the cheese as the peelings and the fleshy portion of the fruit. The fruit is minced and passed through a screw type juice extractor having a sieve of 40-50 mesh.

Guava Cheese

RECIPE

Pulp	= X lb.
Sugar	= 67% of the amount indicated by the jelmeter, for jelly; *i.e.*, 0.67×XY lb. (where Y = lb. of sugar required for 1 lb. pulp for jelly)
Citric Acid	= 4.5 oz. per 100 lb. sugar
Common salt	= 14.0 oz. " " " "
Butter or	= 33.5 oz. " " " "
Vegetable fat, *i.e.*, hydrogenated vegetable oil	= 25 oz. " " " "

All the ingredients except the citric acid are heated together in a pan. When the temperature reaches 221°F., the citric acid is added to bring about 36 per cent. inverted sugar in the finished product. The boiling is finished at 239°F. at sea level. The cooked mass is then spread over the smooth surface of a tray smeared with butter or hydrogenated oil or glycerine and allowed to cool and set. The cheese is of good set. It is light brown in colour and has good flavour.

Using this recipe, it has been observed that the peelings, seed and pulp in the seed core can be utilized for making cheese. The peelings give a cheese of good set with a deep brown colour and satisfactory flavour. The cheese made from seeds is rather soft, sticky and dark brown in colour but possesses good flavour. The cheese from the pulp in the seed core has a soft texture and fairly good flavour.

Jack Fruit

The waste material, i.e. the thick rind with inner perigones, has been found by Siddappa and Bhatia to be a good raw material for a high class jelly. Pectin can also be prepared from it. The starchy seeds can be roasted or cooked and eaten as a delicacy. They can also be ground into flour for use with other cereals.

Mango

The mango peeling can be extracted with water and fermented into vinegar. The kernel in the stone can be dried, powdered and utilized for edible purposes. The possibility of utilizing mango stones for food is of considerable importance due to scarcity of cereals in the country.

Passion Fruit

The rind can be used for recovering pectin and the seed for oil.

Peach

Just as in the case of apricot, the peach kernels can also yield oil.

Pear

The peelings and cores can be fermented into perry or vinegar. They can also be dried and used as an animal feed.

Pineapple

According to Cruess, the shells, trimmings and other waste materials are shredded and pressed in a continuous press to recover the juice which is refined by de-acidifying and decolourizing, and mixed with cane sugar syrup for use in canning pineapples. At one time, this juice was fermented into alcohol for use in automobiles. Citric acid was also recovered from the juice by neutralizing it with $CaCO_3$ and treating the calcium citrate formed to get citric acid as from lemon juice. The cores can either be candied or converted into juice. The press cake from the juice can be dried and used as an animal feed. The pomace left after extracting the juice from the peeled fruits or cores or trimmings, is not quite suitable for making jam.

Peas

The vines and pods can be used as stock feed either as such or after drying.

Tomatoes

An edible oil can be extracted from the seeds after separating them from the skins. The trimmings can be used for the preparation of juice or ketchup. When tomato juice is prepared by the cold method, the seeds are still good for sowing.

Other Vegetables

The wastes left over in the drying of vegetables like potatoes, cabbage, cauliflower, sweet potatoes, beans, etc., can be used for making cattle feed. It may also be possible to utilize the leafy wastes of vegetables for the preparation of some useful food products.

Citrus By-products

The most important waste materials are peelings from oranges, the rags and seeds and the sludge which is deposited when lime juice is stored for making cordial. The peelings can be used for candying or for the extraction or distillation of essential oil which finds a ready market in confectionery and perfumery trades. The rags can be utilized for making pectin, marmalade or toffee. They can also be dried and used as a cattle feed. According to Jain, Das and Girdhari Lal, lime oil can be recovered from the lime juice sludge by distillation. Citric acid can also be prepared from it. Orange residues can also be fermented into vinegar.

Citric Acid

According to Lal Singh and Girdhari Lal, citric acid can be made from cull limes, *galgal, khatti,* etc. The juice is first fermented naturally to remove gums, pectins and sugars which hinder its filtration. The fermented juice is then treated with a filter-aid like Kieselguhr at about 140°-150°F. and then filtered. Hydrated lime and calcium carbonate are added to precipitate the calcium citrate. This is separated and dried quickly to avoid discolouration. For conversion into citric acid directly, the wet calcium citrate precipitate itself is used in the form of a thin paste. It is treated with the calculated amount of concentrated sulphuric acid to decompose the citrate into citric acid. The calcium sulphate precipitate is removed and the liquor concentrated to crystallize the citric acid. From the unfermented juice calcium citrate may be prepared and decomposed with a strong solution of sodium carbonate to form sodium citrate. The precipitate of calcium carbonate may be filtered off and the solution concentrated to crystallize sodium citrate.

The manufacture of citric acid on a large scale is not profitable on account of the high cost of fruits. Imported citric acid which sells at about Rs. 2/- to Rs. 3/- per lb., is much cheaper. Further, citric acid is being produced cheaply in other countries from sugars by the fermentation process.

Pectin

Pectin can be prepared from the juice residues of *galgal* or oranges. The method is described in chapter XVIII.

Citrus Oils

According to Lal Singh and Girdhari Lal, fresh orange peels yield 0.54 per cent. of oil by the cold press method. Citrus peel oil extracted by the

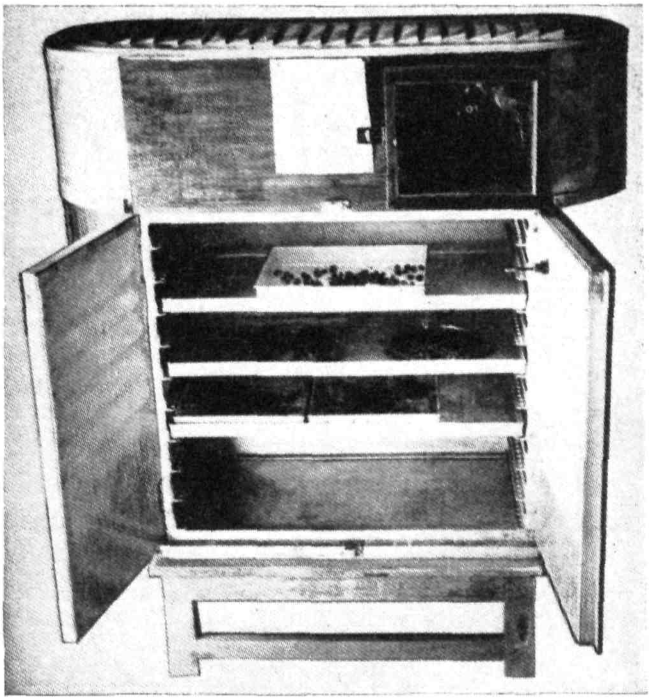

FIG. 61. AN ELECTRICALLY OPERATED CABINET DRIER

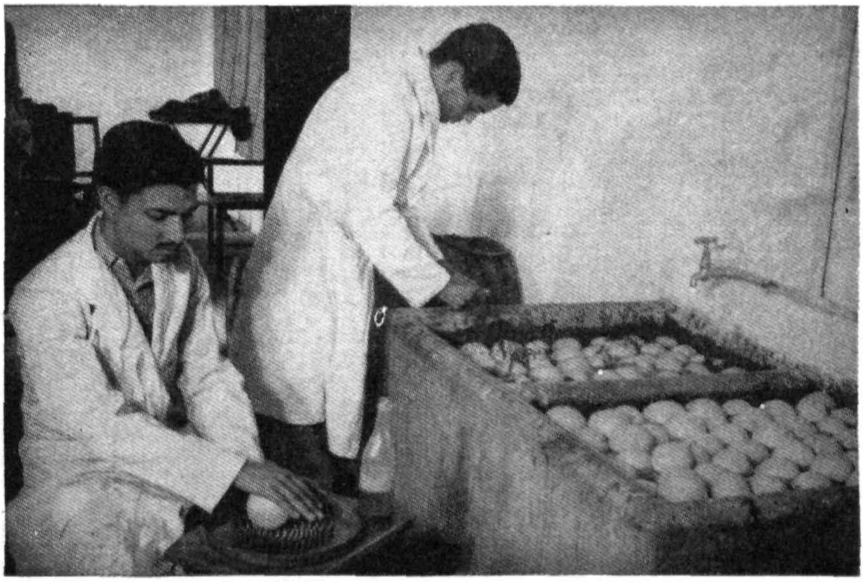

FIG. 62. EXTRACTION OF OIL FROM ORANGES BY USING A PLATE WITH SPIKES

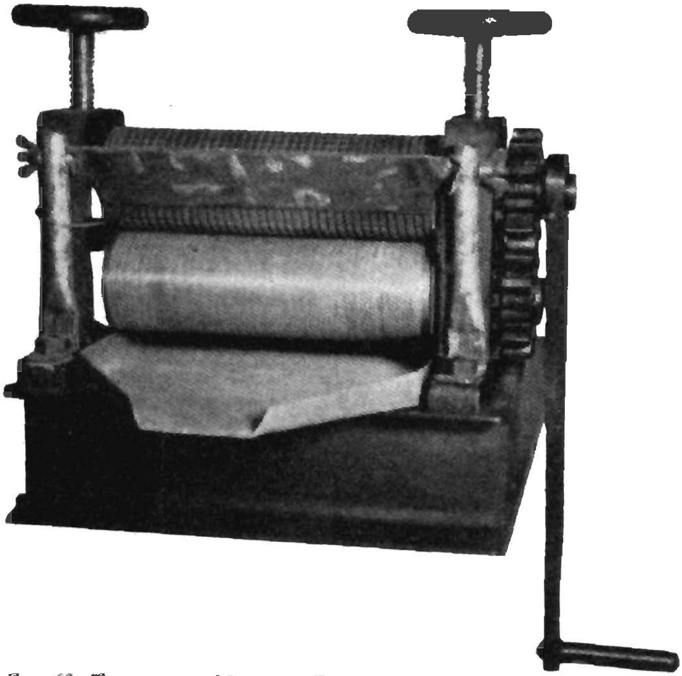

FIG. 63. TWO-ROLLER MILL FOR EXTRACTION OF OIL FROM CITRUS PEELS

FIG. 64. EXTRACTION OF OIL FROM ORANGES IN A FRUIT JUICE FACTORY

cold process fetches a better price than distilled oil which is of inferior quality. Peel oil is extracted in several ways. In Italy, the lemon peels are pressed by hand over a bowl and the juice and oil caught on a sponge. The oil and juice are squeezed from the sponge periodically and the oil decanted from the mixture. After the mixture has stood for a night, it is filtered through paper and packed in copper cans.

In the case of oranges, they are scraped by revolving abrasive discs and the scraped fruit is wiped with a sponge to recover the oil.

In another type of machine, oranges or lemons are made to roll on numerous pointed spikes (Figs. 63 and 64) which puncture the oil cells and release the oil. The oil is washed off with sprays of water and recovered in centrifugal separators.

In the case of fresh peels from loose jacket oranges, oil of good quality can be obtained by bending the peel between the fingers and scraping the exuded oil and juice across the sharp edge of a funnel placed over a bottle. The peel juice and the oil collect in the bottle. The oil, which is at the top, can be decanted or separated by means of a separating funnel. Other simple methods for the cold extraction of peel oil are being worked out at the Central Food Technological Research Institute, Mysore (Fig. 65). The preliminary treatment of the peel with lime or $CaCl_2$ facilitates the extraction of oil.

TABLE 22. SOME PHYSICO-CHEMICAL CHARACTERISTICS OF NAGPUR MANDARIN PEEL OIL (COLD PRESSED)

S. No.	Particulars	Sample I	Sample II
1.	Sp. gravity 25°/25°C	0.8462	0.8472
2.	Optical rotation (in 1:25 alcohol solution at 30°C)	+100.7	+100.0
3.	Refractive index	1.4745	1.4758
4.	Evaporation residue %	2.99	3.60
5.	Acid number	1.77	1.59
6.	Aldehyde value (as decylaldehyde) % (Hydroxylamine hydrochloride method)	0.37	0.32
7.	Ester number	4.64	4.12
8.	Flavour	Pleasant normal	Pleasant, but slightly inferior to I
9.	Solubility in 95% alcohol (in one volume)	Soluble	Soluble
10.	Solubility in 90% alcohol (5-9 volumes	Soluble with slight haziness	Soluble with slight haziness
11.	Colour		
	Optical density		
	at 650 mμ	0.097	0.119
	at 420 mμ	1.30	1.40
	Lovibond units	3.0 R	3.0 R
		20.0 Y	20.1 Y

Fresh peels can be steamed or water-distilled to recover the oil. They can also be sun-dried and the oil distilled subsequently after a preliminary soaking. Experiments at the Central Food Technological Research Institute, Mysore have shown that the mincing of the peel helps in quickening the liberation of the oil by distillation. Recently, Pruthi and Girdhari Lal have analysed two samples of cold pressed Nagpur Mandarin peel oil, and have reported the following data:

The ester content of Nagpur orange oil is somewhat lower than that of the Italian product, but is higher than that of the Florida oil. The constants for Nagpur orange oil resemble closely the specifications for tangerine oil as laid down by the U.S. Department of Agriculture.

CHAPTER XVIII

MANUFACTURE OF PECTIN

Pectin, which is used for thickening jams, etc., is present chiefly in fruit and vegetable pulps. Cheap and important sources are: (i) Apple pomace from cider presses, apple skins and cores from canning and dehydration plants and cull apples; and (ii) citrus residues such as inner rind and pulp from citrus products factories.

Pea hulls, grape marc and beets also can be used as raw materials for pectin.

Wilson gives the following data regarding the percentages of pectin in some raw materials:

Material	Per cent. pectin in fresh material	Per cent. pectin on dry weight basis
Apple pomace	1.5-2.5	15-18
Lemon pulp	2.5-4.0	30-35
Orange pulp	3.5-5.5	30-40
Beet pulp	1.0	25-30
Carrots	0.62	7-14

PECTIN FROM APPLES

According to Rooker, the different stages in the manufacture of apple pectin are as follows:

1. Washing, crushing and pressing the apples for extraction of juice.
2. Drying of the pomace.
3. Leaching.
4. Extraction of pectin.
5. Pressing the treated mass to obtain a pectin solution.
6. Removing the sediment from the pectin solution by settling or centrifugal treatment.
7. Treating the pectin solution with proper enzymes to remove starch and proteins.
8. Treating the pectin solution with decolourizing carbon to get a pure product.
9. Filtration of the pectin solution to the required degree of brilliancy.
10. Concentration of the pectin solution.

11. Standardisation of the pectin solution for jelly strength.
12. Bottling and canning of the standard solution.
13. Preparation of powdered pectin.

Apples are washed with dilute hydrochloric acid to remove any spray residues. They are then crushed and pressed. The pomace is dried quickly to avoid fermentation. It is dried in revolving drums at 150°-180°F. to 6-8 per cent. moisture. About 100 lb. of dry pomace are obtained from a ton of apples. The dried pomace is leached with cold water to remove colouring and flavouring materials and sugar, if any. The leaching can be carried out conveniently in a tank fitted with a perforated false bottom and an outlet.

Composition

Pectin has not got any definite composition. Its compounds have different jelly-making powers. Pectins with a high jellying power are intermediate bodies and are easily converted into less useful substances like pectic acid and methyl alcohol. The time, temperature and the *p*H of the medium are important factors in the extraction of pectin. The pomace is heated at a *p*H of 3.5 for 1-1½ hours at about 190°F. or for 30-40 minutes at 212°F. Addition of 0.2 per cent citric, tartaric or lactic acid gives better results. After boiling, the pomace is pressed and the solution clarified by settling or by centrifugal treatment. The starch and proteins present are removed by adding enzymes, and the liquid is then heated to kill the enzymes and decolourized with activated carbon. After that, it is filtered in a filter press. It contains 0.7-1 per cent. pectin. It is concentrated under reduced pressure to 4.5 per cent. strength. The concentrate is standardized by carrying out jelly tests. It is packed in cans of 1 or 5 gallons capacity and of extra char tinplate or in dark brown bottles. No 10 cans are processed for 30 minutes at 170°F., while 5 gallon tins are filled hot at 168°-170°F., inverted and allowed to cool in air for 35 minutes. They are then cooled quickly in water down to 120°-130°F. Eight-ounce bottles are filled at 115°F.-120°F., pasteurized for 30 minutes at 170°F. and then cooled.

Pectin Powder

Pectin powder can be prepared from the extract by spray-drying or by precipitation with acetone or alcohol. The pectin liquor is concentrated to a thick paste of 25-30 per cent. solids and treated with 2-3 volumes of 95 per cent. alcohol to precipitate the pectin. The precipitated pectin is washed with alcohol, dried and powdered. Aluminium sulphate and ammonia have also been used for precipitating pectin. These methods are, however, covered by patents. The principle of these methods is that pectin particles are negatively charged and can, therefore, be precipitated by adding a positive charge carried on colloidal particles. The aluminium in the precipitated pectin is removed by treating the mass with alcoholic hydrochloric acid.

PECTIN FROM CITRUS FRUITS

Citrus skins and residues contain 2.5-5.5 per cent. of pectin. After the extraction of essential oils and juice from the fruit, the residue is dried. The peels, however, require slicing and grinding. The residue is washed with cold water on sieves and then boiled with 0.015-0.02 normal hydrochloric or sulphuric acid or with 0.025 molar citric acid for 40-45 minutes. The liquor is pressed and filtered. The subsequent processes are similar to those used for apple pectin.

PECTIN FROM OTHER MATERIALS

Pectin of good quality can also be prepared from green papaya, jack fruit rind, wood apple, guava, etc. Useful research on this subject is being conducted at the Central Food Technological Research Institure, Mysore. Recently, Jain and Girdhari Lal have standardized the methods for the preparation of good pectin from green and tender jack fruit rind and wood apple. Lewis, Dwarkanath and Johar have reported that good pectin can be prepared from tamarind pulp. The yield on dry basis is 2.31-3.70 per cent.

TESTING JELLY GRADE

Pectin is standardized for jelly grade either by chemical methods or by actual jelly boiling trials. The Carré and Haynes method is widely used for the chemical determination of pectin as calcium pectate. This alone does not always give a true value for the jelly strength of pectin as purified pectins may vary greatly in composition. Actually jelly-making tests are, therefore, more reliable.

Grade evaluation of high ester pectins which are used for making jellies containing 65 per cent. soluble solids, is carried out by standard methods. Besides these pectins, there are the more recently developed low-ester (low-methoxyl) pectins which can form good jellies with much less soluble solids.

Grading Methods

In these methods, attempts have been made to establish a relation between viscosity of the pectin solution and the strength of the jelly prepared from it. These tests are generally useful in the case of a series of preparations of similar history. By means of calibration curves, the jelly grade of the pectin can be deduced fairly accurately. There are various devices for measuring the viscosity. Of these mention may be made of the falling hall viscometer of Ogg and the simple capillary pipette of Baker generally known as a jelmeter. The latter has already been described in an earlier chapter. In this device, viscosity measurements are made with 0.5 and 1.0 per cent. pectin solutions and a curve showing the relation between the grade and relative viscosity of the pectin is drawn. From these standard curves the approximate grade of any pectin sample can be derived.

Actual Tests

The following problems arise in this method:

1. variations in the method of preparation of the jelly;
2. variations in the property measured and in the method of measuring; and
3. desirable characteristic of the jelly.

The method of preparation also has much influence on the properties of the jelly. In the method evolved by the U.S. Department of Agriculture, standard 100 grade pectin is used to prepare standard jelly. Jellies are made with the sample to be tested and compared with the standard jelly made under the same conditions.

TABLE 23. AMOUNTS OF PECTIN USED IN JELLY TESTS TO DETERMINE PECTIN GRADE BY C.P.P.F. METHOD

Grade	Weight (gm.)	Grade	Weight (gm.)
10	50.00	120	4.17
20	25.00	130	3.85
30	16.66	140	3.57
40	15.50	150	3.33
50	10.00	160	3.12
60	8.33	170	2.94
70	7.14	180	2,78
80	6.25	190	2.63
90	5.55	200	2.50
100	5.00	210	2.38
110	4.55	220	2.27

Kertez gives the following method of testing jelly grades:

General conditions for making compositions are (i) 65 per cent. sugar in jelly, (ii) *p*H of jelly 3.00 ± 0.05 and (iii) jelly strength to be measured 18 hours after making.

A glass vessel with a glass rod is weighed and 320 ml. of cold distilled water, 500 gm. of sugar and the requisite quantity of Commercial Pectin Preparation Food (C.P.P.F.) as shown in Table 23 are put in it. The pectin is mixed with a portion of the sugar (about five times its weight). About 0.5 ml. of citric acid solution (50 gm. of citric acid in 100 ml. of solution) and 1 ml. of sodium citrate (25 gm. of sodium citrate in 100 ml. solution) are added to the water. Three 8-fluid-ounce jelly glasses are taken and to each are added 2 ml. of the citric acid solution and 0.5 ml. of the sodium citrate solution. The pectin-sugar mixture is put into the water and stirred. The mixture is heated rapidly to a boil, stirring it constantly. It is boiled for 30 seconds, after which the rest of the sugar is added. The solution is again heated to a boil and brought down to a net weight of 770 grams. The vessel is removed from the fire occasionally to check the weight. When the correct weight is reached, boiling is stopped. The jelly is allowed to cool for about 30 seconds and any scum that may be formed is removed. It is then poured into the jelly glasses and stirred with the glass rod. The jellies are allowed to set for 18 hours at 26°C. They are then taken out of the glasses on to a flat surface and their firmness compared with that of a standard jelly made at the same time under similar conditions. Generally, a piece of the jelly is sliced off and squeezed between the thumb and the forefinger until the jelly breaks. Differences of 5 per cent. can be detected in this way after some experience.

Jain and Girdhari Lal have standardized methods for the preparation of pectin from green papaya, wood apple and jack fruit wastes. Siddappa and Bhatia have reported a pectin content of 2 per cent. in ripe jack fruit wastes. They have shown that a good jelly can be made from this waste. Das, Siddappa and Girdhari Lal have shown that in the case of green papaya there is practically no loss of pectin due to the extraction of papain from it. They have also pointed out that it might be a workable proposition to collect the tapped fruits, dehydrate them and store the dried material for extraction of pectin.

The methods that have been standardized for the preparation of pectin from indigenous sources are described briefly as follows:

PECTIN PREPARATION

Processing of Raw Material

After washing, green papayas are grated or minced in a mincing machine. Wood apple pulp is removed with a sharp spoon-shaped stainless steel knife and broken into smaller pieces. The rind and core of jack fruit including the perigones which are left over as waste in the canning of the fruit, are minced into small pieces or cut into thin slices.

Washing and Leaching

Papaya and wood apple are washed thoroughly in water to remove sugars, etc. Jack fruit is washed and treated with a solution containing 0.1 per cent. potassium metabisulphite and 0.05 per cent. HCl. Washing is continued till the Brix of the wash water is practically zero. In the case of wood apple, an extract suitable for the preparation of wood apple syrup can be obtained by carefully controlling the washing process. In the case of jack fruit rind also, much of the 5-7 per cent. of the sugars present can be recovered by controlled washing.

Extraction

After washing and leaching, the material is extracted with $\frac{N}{60}$—$\frac{N}{50}$ HCl in the case of papaya and jack fruit and 0.5 per cent. potassium metabisulphite in the case of wood apple pulp. Three extractions are taken at 97°-100°C. by heating the material for half an hour each time and separating the extract by straining through a sieve of a suitable mesh. The extract should be cooled at once to minimize depolymerization of the pectin. The amount of water to be added for extraction in each case is 1½-2 times the weight of the fresh material for the first extraction and 1-1¼ times for the second and third extractions. For each extraction, the water containing the added acid or potassium metabisulphite is brought to a boil and then the material is added. The boiled mass is strained through 8-10 mesh sieves to separate the extract from the residue. The latter is gently pressed in a basket press and a second extraction is taken without much delay. The extract is finally passed through a sieve of 80-90 mesh or a piece of muslin to separate all the coarse pulp.

Clarification and Decolourization

The sieved extract is passed through a Sharples Super Centrifuge for further clarification. There is no need to use any clarifying agent. In case a Super Centrifuge is not available, the extract may be allowed to settle and then filtered through a piece of drill cloth using a filter press for the purpose. Sedimentation and filtering are particularly important in the case of jack fruit and wood apple extracts. Decolourization of the extract is not essential in the case of the jack fruit and papaya extracts. In the case of extract of wood apple pulp, it should, however, be decolourized with 1.0 per cent. activated carbon. Subsequent filtration of the extract, however, presents difficulties. A Sharples Super Centrifuge is useful for clarification. Both the treatments, i.e., clarification and decolourization, can be conveniently combined into one process.

Concentration and Precipitation

The clarified and decolourized pectin extract is concentrated to 30°-40° Brix at about 50°C. and 26-28 inches vacuum. For the precipitation of pectin from this concentrated extract, two volumes of 95 per cent. alcohol are used. A calculated amount of HCl is added to the alcohol before mixing so that its concentration in the final mixture is 0.1 N. Addition of 0.5 per cent. potassium metabisulphite to the concentrated extract, prior to the addition of alcohol, improves the colour of the precipitated pectin. The pectin is allowed to remain overnight in contact with HCl and SO_2 and is separated next morning by centrifuging or squeezing the material in a piece of thick cloth. It is then washed twice with 80 per cent. alcohol and finally with 95 per cent. alcohol.

Drying and Powdering

The pectin precipitate is dried preferably in a vacuum drier at about 40°C. It can also be dried at room temperature or in the sun or in an ordinary oven. The dried product is powdered and passed through a 100-120 mesh sieve to get commercial pectin powder.

Standardization

A series of jellies are prepared using varying amounts such as 20.0, 22.5, 25.0, 27.5, 30.0 c.c. of 1.0 per cent. pectin solution, (50-x) gm. of sugar and a sufficient amount of a 10 per cent. citric acid solution to obtain a *p*H of 2.9-3.1 in the mixture. The value of x is equal to the amount of pectin and citric acid solids collectively added to each individual sample. The ingredients are placed in clean dry glass beakers provided with glass rods. The total weight of all the ingredients in each beaker is made up to 90 gm. by adding distilled water. The mixture is heated on an electric hot plate to a weight of 77.0 gm. and poured into a clean dry 4 oz. jelly glass. The final weight of the jelly for 65 per cent. soluble solids should be 76.9 gm. Cooking is, however, finished at 77.0 gm. to allow for any evaporation that may occur after pouring the jelly into the glass. The strength of the different jellies is compared after 20 hours with a standard jelly prepared under similar conditions using a standard pectin sample such as the 150 grade citrus pectin powder of the California Citrus Growers' Exchange.

From the above tests, quantities of the pectin solution giving jellies which are just weaker or just stronger than the standard jelly are determined. A second series of jellies is then prepared with quantities of pectin solution ranging between these two quantities with increments of 0.5 c.c. only. The quantity of pectin solution and the amount of pectin required to yield a jelly comparable with the standard jelly is determined and the grade calculated.

If a pectin sample has a grade of over 250, a 0.5 per cent. solution may be used instead of a 1.0 per cent. solution. If the grade is less than 150, it is preferable to use a 2.0 per cent. solution instead of using larger quantities of the weaker solution.

USES OF PECTIN

Pectin is used as a thickening agent in the preparation of ketchups, sauces, jams, etc. It is also used as an emulsifying agent in the preparation of products like cod liver oil, ice-cream, mayonnaise, etc. It can be used to increase the foaming power of gases in water and also to glacé candied fruit. Pectin is also used in the manufacture of explosives, lacquers, sizes for textile, lotions and as an agglutinant in blood therapy.

Powder pectin does not go into solution easily. It has a tendency to form lumps. In jam-making, it is, therefore, mixed with 5-6 times its weight of sugar, stirred in water at 60°-70°C. for a short time and then brought to a boil. It can also be mixed with sugar and sprinkled over the boiling jam mixture.

Apple pectin in liquid form and citrus pectin in powder form are important commercial products in the U.K. and the U.S.A. There is ample scope for manufacturing similar products in India from indigenous materials.

CHAPTER XIX

WATER FOR A CANNERY

On an average 1,000 gallons of water are required for handling a ton of fruit. The quantity varies from fruit to fruit and product to product. It is used for preparing syrups and brines, and in several other processes such as washing, blanching, sterilizing, and cooling of fruits and vegetables.

A cannery must have plenty of good water. It should be absolutely free from contamination and be perfectly potable. Its mineral content should be low, and it should be specially free from sulphates and iron salts.

The water used in a cannery should not be hard as this toughens the product. In pickling, the carbonates and bicarbonates of lime and magnesia combine with the lactic acid and thereby lower the acidity and thus affect the flavour. If the water used is very hard, scales are formed in the boiler and also a white crust is formed on the cans. Hence such water will have to be softened suitably before use. Iron in the water combines with the tannins in fruits and vegetables and leads to their darkening. The water used should be colourless, odourless, tasteless, and bacteriologically pure. It should not show the presence of any faecal organism like *Bacillus Coli.* It should not ordinarily have more than 20 parts hardness per 100 litres i.e., 0.096 grain per ounce. The upper limit is 50 parts hardness. Water containing 5-10 parts hardness per 100 litres is moderately soft, 10 to 15 parts slightly hard and 15 to 25 parts, moderately hard, and 25 to 30 parts and above exceedingly hard. Organic Carbon should not exceed 0.2 parts nor organic nitrogen 0.02 parts per 100,000. Free ammonia should not exceed 0.05 parts per million. Water consuming 0.05 grain or less of oxygen per gallon is very pure while that consuming between 0.05 and 0.15 grain is of medium purity. [07 grain/gallon = 10 p.p.m.]

The natural sources of water are river, spring or deep well, and sea. Rain water, although pure to start with, picks up oxygen, nitrogen, carbon dioxide, nitric acid, sulphur dioxide, etc., present in the atmosphere. It can be collected from clean roof-tops, stored and filtered before use. River water contains several kinds of impurities of uncertain nature and should, therefore, be filtered and purified before use. Surface or pond water usually contains much organic matter and should not be used in a cannery. Deep well water is normally pure on account of its percolation through the earth for some considerable distance and thus becoming aerated, oxidised, and filtered. In some cases, however, these waters may be very hard depending upon the locality. Besides, there may also be external contamination. They should, therefore, be tested before use.

QUALITIES OF WATER

Hard and Soft Waters

Soft water readily produces a lather with soap whereas hard water does not form a lather easily with it. The hardness of water is of two kinds, namely, temporary and permanent hardness. Temporary hardness is due to the presence of bicarbonates of calcium and magnesium. These are removed by boiling the water, when carbon dioxide is driven out, leaving the insoluble carbonates.

$Ca(HCO_3)_2$	$\rightleftharpoons$	$CaCO_3 + H_2O + CO_2$
Calcium bicarbonate (soluble)		Calcium carbonate (insoluble)

Permanent hardness is due to the soluble sulphates or chlorides of lime and magnesium. This type of hardness cannot be removed by boiling.

Softening Processes

This is done by boiling the water or by Clark's process. In the latter process, the amount of bicarbonate present is determined and the requisite amount of quick lime is added to remove the excess of carbon dioxide. The bicarbonates are converted into insoluble carbonates and the carbon dioxide which holds them in solution, combines with quick lime, which is added, to form a second portion of the insoluble carbonate. Quick lime forms $Ca(OH)_2$ when added to water.

(I)	$Ca(OH)_2 + CO_2$	=	$CaCO_3 + H_2O$
	Quick lime (soluble)		Calcium Carbonate (insoluble)

(II)	$Ca(HCO_3)_2$	+	$Ca(OH)_2$	=	$2CaCO_3 + 2H_2O$
	Soluble		Soluble		Insoluble

Commercially, hardness is expressed as carbonate of lime. For every 1,000 gallons of water with hardness of one grain per gallon, about one ounce of quick lime is required. If magnesium bicarbonate is present, then double the amount of quick lime is added, when the sparingly soluble magnesium hydroxide is formed.

$Mg(HCO_3)_2$	+	$2Ca(OH)_2$	=	$Mg(OH)_2$	+	$2CaCO_3$	+	$2H_2O$
Magnesium Bicarbonate (soluble)		Calcium hydroxide (soluble)		Magnesium Hydroxide (insoluble)		Calcium Carbonate (insoluble)		

Permanent Hardness

By adding sodium carbonate, the chlorides and sulphates are converted into insoluble carbonates.

$CaSO_4$	+	Na_2CO_3	=	$CaCO_3$	+	Na_2SO_4
Calcium Sulphate		Sodium carbonate		Calcium carbonate (insoluble)		

$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$

Magnesium Sulphate (soluble) → Magnesium carbonate (insoluble)

$$MgCl_2 + Na_2CO_3 = MgCO_3 + 2NaCl$$

Magnesium Chloride (soluble) → Magnesium carbonate (insoluble)

If both temporary and permanent hardness are present, they may be removed by the addition of commercial caustic soda and sodium carbonate. Caustic soda neutralizes the bicarbonates of calcium and magnesium, precipitating the carbonate and forming sodium carbonate which further reacts with the sulphates and decomposes them into insoluble carbonates.

(i) $Ca(HCO_3)_2 + 2NaOH = CaCO_3 + Na_2CO_3 + 2H_2O$

Soluble, Soluble, Insoluble

(ii) $CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$

Calcium Sulphate, Sodium Carbonate, Calcium Carbonate insoluble

$$H_2CO_3, CaCO_3 + Na_2CO_3 = CaCO_3 + 2NaHCO_3$$

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

Calcium carbonate and magnesium carbonate are soluble in water to the extent of 1.3 and 0.93 parts respectively per 100,000 parts. It is, therefore, not possible to produce water of zero hardness. Since 4-5 parts per 100,000 has no harmful effect upon any material, water of zero hardness is seldom required in a canning factory. Water for canning fruits and vegetables should not have both temporary and permanent hardness in excess of 10-12 parts per 100,000. Salts of calcium and magnesium combine with pectins and thus make the skins of fruits and vegetables tough. If the water is of temporary hardness, calcium and magnesium carbonates settle down during sterilization thereby making the liquid cloudy and spoiling the appearance of the canned product.

Permutit Process

By this process in which an artificial zeolite is used, both types of hard water can be softened. Permutit is a silicate of sodium and alumina ($2SiO_2$, Al_2O_3, Na_2O, $6H_2O$) which is practically insoluble in water. It is ground coarsely and packed in a tube. When water is percolated through the column, double decomposition of salts present in water and zeolite takes place.

$$CaSO_4 + 2NaP = CaP_2 + Na_2SO_4$$

The change is reversible. When the permutit is exhausted, it is reactivated by percolating a strong solution of sodium chloride for 8-10 hours.

$$CaP + 2NaCl = CaCl_2 + 2NaP$$

Permutit units are commercially available.

PURIFICATION OF WATER

Filtration

When water is stored, insoluble impurities present in it settle down leaving the clear water above. The water is then filtered through beds of sand and gravel where it is freely exposed to air and can absorb oxygen. In another method, alum is used to coagulate the suspended matter including bacteria. This water is then allowed to settle down before filtration.

Sterilization

Sterilization of water is effected by adding chlorine or bleaching powder. Normally 1.5—4.0 lb. of liquid chlorine is mixed with ammonia and used for one million gallons of water. This corresponds to 0.15—0.40 P.P.M. of chlorine. Water treated with chlorine is not harmful in canning processes. Water can also be sterilized with potassium permanganate, ozone gas, ionic silver, ultra-violet rays, etc. The silver-ion process, known as the Katadyn process, can also be applied for sterilizing fruit juices such as lime juice, apple juice, grape juice, etc.

ANALYSIS OF WATER

In addition to its chemical analysis, it is also necessary to have an idea of the bacterial flora in the water. Pure waters, such as purified water or water from a deep well, do not ordinarily contain *B. Coli* in a 100 c.c. sample. This should be the state of purity that one should attain in water used in a cannery. Samples of water should be carefully collected and got analysed without much delay. The complete analysis is generally carried out in Public Health laboratories.

1. Colour

A yellow or brown tint observed when the water is placed in a tall glass jar indicates the presence of organic matter.

2. Smell

This can be detected by shaking the water in a stoppered bottle and then smelling.

3. Total Solids

This is determined by evaporating 100 cc. of water in a platinum, nickel or porcelain dish and weighing the residue.

4. Organic Matter

This is indicated by charring when the evaporated residue is heated over a flame.

5. Free chlorine

This is estimated colorimetrically.

6. Chlorides

This is determined by titration against N/50 silver nitrate solution using potassium chromate as indicator.

Temporary Hardness

100 cc. of water is titrated with N/50 sulphuric acid using methyl orange as indicator to a faint red colour (1 c.c. N/50 sulphuric acid=0.001 gram of calcium carbonate in 100 c.c. of water). The amount of calcium carbonate (or magnesium carbonate) is expressed as parts per 100,000 parts. One part per 100,000 is equivalent to 0.7 grains per gallon. One grain of calcium carbonate per gallon is known as one degree of hardness, Clark.

$$Ca(HCO_3)_2 + H_2SO_4 = CaSO_4 + 2CO_2 + 2H_2O$$
$$Mg(HCO_3)_2 + H_2SO_4 = MgSO_4 + 2CO_2 + 2H_2O$$

Take 100 cc. of water in a conical flask and add one drop of methyl orange as an indicator. Deliver N/50 H_2SO_4 solution from a burette until the solution becomes faint red.

One c.c. of N/50 H_2SO_4 represents 0.001 gram of $CaCO_3$ in 100 c.c. of water. Hence, the number of c.c. of N/50 H_2SO_4 multiplied by 0.001 would give the amount of $CaCO_3$ (or equivalent $MgCO_3$) in grams per 100 c.c. of water.

Suppose, in a specific instance, 15 c.c. of N/50 H_2SO_4 were required to exactly neutralize the bicarbonate present in 100 c.c. of water. It means that $15 \times 0.001 = 0.015$ grams of $CaCO_3$ or its equivalent $MgCO_3$ was present in 100 c.c. of water. Therefore, in 100,000 grams (1 c.c. of water is equivalent to 1 gram) of water, the amount of calcium carbonate present would be $100{,}000 \times 0.015$ divided by 100 i.e., 15 parts per 100 litres. Since one part of calcium per 100,000 parts of water is termed as one degree of hardness, the water in the above case has a temporary hardness of 15 degrees.

Permanent Hardness

Permanent hardness is assumed to be always due to $CaSO_4$, although sulphates and chlorides of calcium and magnesium may be present.

Take 100 c.c. of water and boil thoroughly to expel CO_2. Then add 10 c.c. each of N/10 NaOH and Na_2CO_3 and evaporate to reduce the volume to about 40 c.c. Cool the solution and filter. Wash the residue on the filter paper with CO_2-free distilled water, till it is free from NaOH as tested with phenolphthalein. Make the filtrate to 100 c.c. and find out the alkalies left over unreacted, by means of N/10 H_2SO_4, using methyl orange as an indicator.

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$
$$MgSO_4 + 2NaOH = Mg(OH)_2 + Na_2SO_4$$

The difference between the amount of N/10 H_2SO_4 used to neutralize the alkali (10 c.c. each of N/10 NaOH and Na_2CO_3) and the amount of N/10 H_2SO_4 used to neutralize the excess of alkali in the water, gives the amount of acid equivalent to alkalies used for throwing out the permanent hardness of water. In this case, 20 c.c. of acid is equivalent to 10 c.c. of each N/10 NaOH and Na_2CO_3. Suppose that 16 c.c. of N/10 H_2SO_4 neutralizes the excess of alkali. Therefore, $20 - 16 = 4$ c.c. of N/10 H_2SO_4 is equivalent to the amount of alkali used up in throwing down the salts responsible for permanent hardness.

1 c.c. of N/10 $H_2SO_4 = 0.005$ gram of $CaCO_3$

Therefore, 4 c.c. of N/10 $H_2SO_4 = 0.005 \times 4 = 0.020$ gram $CaCO_3$ in 100 c.c. of water

Hence, permanent hardness, per 100,000 parts is equal to

$$\frac{0.020 \times 100{,}000}{100} = 20$$

Total hardness of water = Temporary hardness plus permanent hardness of water

Determination of Hardness

Hardness of water is sometimes determined by noting lather formation with standard soap solution. The chemical method is, however, more accurate.

Alkalinity in water is due to the presence of bicarbonates and carbonates. The presence of carbonates is indicated by a pink colour when phenolphthalein is added. 100 c.c. of water is first titrated with N/50 HCl or H_2SO_4 using phenolphthalein as indicator. The carbonates will be changed into bicarbonates.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + HCl = \underset{\text{Sodium bicarbonate}}{Na_2HCO_3} + NaCl$$

In another flask 100 c.c. of water is titrated with N/50 HCl or H_2SO_4 using methyl orange till the yellow colour changes to faint red. In this case the bicarbonates are titrated.

$$\underset{\text{Sodium Bicarbonate}}{NaHCO_3} + HCl = \underset{\text{Sodium chloride}}{NaCl} + H_2O + CO_2$$

1. Volume of the acid used with phenolphthalein as indicator × 2 = Volume of the acid used for neutralization of carbonates
2. Volume of acid used with methyl orange as an indicator Minus Volume of acid used for neutralization of carbonates = acid used for the neutralization of the bicarbonates.

Suppose, in a specific instance, 5 c.c. of N/50 HCl were required to discharge the pink colour produced by phenolphthalein in 100 c.c. of water and 18 cc. of N/50 cc. HCl were required to change the yellow colour of methyl orange to faint red in 100 c.c. of water. It means that:

1. Volume of acid required to neutralize carbonates in 100 c.c. of water $= 5 \times 2 = 10$ c.c. of N/50 HCl

2. Volume of acid required to neutralize bicarbonates in 100 c.c. water $= 18 - 10 = 8$ c.c. of N/50 HCl

1 c.c. of N/50 HCl $= 0.00106$ gram Na_2CO_3
1 c.c. of N/50 HCl $= 0.00168$ gram $NaHCO_3$

Hence, the amount of Na_2CO_3 Present in 100 c.c. of water $= 10 \times 0.00106 = 0.0106$ grams

Therefore, Na_2CO_3 in 100 litres $= \frac{100,000 \times 0.0106}{100} = 10.6$ grams

The amount of bicarbonate present in 100 c.c. of water $= 8 \times 0.00168 = 0.01344$ grams

Therefore, $NaHCO_3$ in 100 litres of water $= \frac{100,000 \times 0.01344}{100} = 13.44$ grams

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Slica

This is estimated in one litre of water by evaporation, ignition, etc., and is expressed as SiO_2.

Iron

In the filtrate from silica, iron is determined as Fe_2O_3.

Calcium

From the filtrate from iron, calcium is estimated volumetrically or gravimetrically as CaO.

Magnesium

From the filtrate from calcium estimation, magnesium is precipitated as magnesium phosphate and estimated as MgO.

Alkali Metals

Sulphates, iron, magnesium, calcium and barium are removed by special treatments, and finally the chlorides of alkali metals are ignited and weighed.

Free and saline ammonia, albuminoid ammonia, nitrites, nitrates, oxygen absorption in 15 minutes and 4 hours, etc., are determined by standard methods for water analysis.

BACTERIOLOGICAL EXAMINATION

500 c.c. sample of water should be collected in sterile 600 c.c. bottles and transported packed in ice for analysis without undue delay. Quantities of 50, 20, 10 and 5 c.c. of the sample are drawn and placed in tubes of culture medium. The bottles are incubated at 37°C for 48 hours and examined for

the production of acid, gas and any turbidity. A positive test here may be regarded as presumptive for the presence of *B. Coli.* Bile salt-litmus-lactose broth is used. Some use glucose instead of lactose to get a better knowledge of the fermentative flora present in the water. When the sample of water has given a positive presumptive test, the next step is to determine whether the organism present is faecal *B. Coli* or one of the other members of the group. Of these, *B. Aerogenes* sub-group is the one most likely to occur as it is predominantly present in soil and plants. These are distinguished from *B. Coli* which are present in faeces only by plating on special media like neutral red-lactose-bile salt medium. The two organisms produce different types of colonies and are thus distinguished.

Classification of Water

	Presumptive Coliform Count per 100 c.c.
Highly satisfactory	Less than 1
Satisfactory	1-2
Suspicious	3-10
Unsatisfactory	Greater than 10

Chlorinated water is highly satisfactory.

Interpretation of Analysis

Albuminoid Ammonia. In water of high purity, albuminoid ammonia does not exceed 0.004 parts per 100,000. In waters of average purity, it does not exceed 0.008 parts.

Free and Saline Ammonia. This varies considerably with the source of water, from 0.005 to 0.1 part per 100,000. In deep-well water even as high as 0.1 part should not be considered as suspicious.

Nitrites. Even traces are generally suspicious as they indicate recent pollution.

Nitrates. The presence of nitrate indicates the past history of the water, especially contamination with manure or sewage. The amount of nitric nitrogen varies greatly from zero to 1.5 parts per 100,000 parts in upland, surface and spring waters. In shallow well water, it may be nil or as high as 20 parts.

Oxygen Absorption

Water of great purity	0.0-0.05 parts per 100,000
Water of average quality	0.1-0.3 parts per 100,000
Impure water	above 0.4 parts per 100,000

Chlorine. It should not exceed 2.5 parts per 100,000.

Hardness. Water for canning purposes should not exceed 10-12 degrees of hardness.

Silica. The amount of silica in 250 c.c. of water should be either nil or too small to determine, in the case of water used for canning purposes.

CHAPTER XX

FOOD COLOURS

Artificial colours are sometimes added to improve the appearance of preserved products. Of the colours available, some are soluble in water, some in oil and some others in acids and alkalies. They should be harmless and stable and should be characteristic of the colour of the product to which they are added. They should, therefore, be chosen carefully.

The colours employed are mostly the permitted coal tar dyes. Different countries have specific laws regarding the use of colours in food stuffs. The prospective exporter should, therefore, study these regulations before manufacturing his product. The important shades of colours used are red, orange, yellow, green and blue. Among the red colours, Ponceau 3 R, Ponceau XS and Erythrosin are edible colours. Orange I and orange SS are important orange colours. Tartrazine and sunset yellow FCF are well-known yellow colours. Light Green SF and Pea Green H are the important green colours.

CERTIFIED COLOURS

According to Loesecke the following Table gives the list of certified colours for foods up to 1949, of the Federal Food and Drug Administration, U.S.A.

TABLE 24. LIST OF CERTIFIED FOOD COLOURS

New names	Former names
Red Shades.	
F D & C Red No. 1	Ponceau 3 R
F D & C Red No. 2	Amaranth
F D & C Red No. 3	Erythrosin
F D & C Red No. 4	Ponceau XS
F D & C Red No. 32	Oil Red XO
Orange Shades.	
F D & C Orange No. 1	Orange I
F D & C Orange No. 2	Orange SS
Yellow Shades.	
F D & C Yellow No. 1	Naphthol Yellow S
F D & C Yellow No. 2	Naphthol Yellow S Potassium Salt
F D & C Yellow No. 3	Yellow A B
F D & C Yellow No. 4	Yellow OB
F D & C Yellow No. 5	Tartrazine
F D & C Yellow No. 6	Sunset Yellow FCF
Green Shades.	
F D & C Green No. 1	Guinea Green B
F D & C Green No. 2	Light Green SF Yellowish
F D & C Green No. 3	Fast Green FCF
Blue Shades.	
F D & C Blue No. 1	Brilliant Blue FCF
F D & C Blue No. 2	Indigotine

In the U.K., the Imperial Chemical Industries supply a large number of food colours which are termed Edicol Colours. The following list includes the most important of these. Some of these are generally employed in the fruit and vegetable preservation industry while others are used in confectionery, meat and fish products, etc.

No.	Name of colour	Uses in fruit and vegetable products
1.	Naphthol yellow FYS	
2.	Tartrazine N N S	Lemon jelly, lime juice cordial
3.	Egg yellow N	
4.	Egg yellow A	
5.	Sunset yellow FCF	Apricot jam, orange squash
6.	Orange AG	Orange jelly, orange squash
7.	Orange INS	
8.	Ponceau RNS	Canned strawberries, red currants, cherries, strawberry jam and jelly, red plum jam.
9.	Raspberry A	Canned raspberries, raspberry jam, and jelly raspberry syrup.
10.	Carmoisine WNS	Raspberry jelly.
11.	Amaranth ANS	
12.	Amaranth YS	
13.	Geranine 2 GNS	Blackcurrant Jam
14.	Rose BS	
15.	Brown OHNS	
16.	Caramel W	Vinegar, Sauces
17.	Chocolate NS	Chocolate Syrup
18.	Chocolate M	Chocolate Syrup
19.	Indigo Carmine XNS	
20.	Blue EGS	
21.	Green SFS	
22.	Blackcurrant A	Canned blackcurrant, blackcurrant jam and jelly.
23.	Erythrosin AS	Canned cherries, victoria plums
24.	Pea Green H	Canned fresh and processed peas.
25.	Red BR	Canned beetroot
26.	Greengage A	Greengage jelly

BANNED COLOURS

According to the Public Health (Preservatives, etc., in Food) Regulations, 1925, (amended 1926 and 1927) of the Ministry of Health, U.K., Part II, the following colouring matters should not be added to articles of food.

1. Metallic

Compounds of any of the following metals:

Antimony, arsenic, cadmium, chromium, copper, mercury, lead, zinc.

2. Vegetable colouring matter : Gamboge

3. Coal tar colours

Name	Synonyms
Picric acid	Carbazotic acid.
Victoria yellow	Saffron substitute, dinitro-cresol
Manchester yellow	Naphthol yellow, Martius yellow
Aurantia	Imperial Yellow
Aurine	Rosolic acid, yellow coralline

According to the proposed revised specification of the Fruit Products Order, India (1955), only certain food colours are permitted in fruit and vegetable products (See Appendix II).

Detection

According to Cox, the general method to detect the presence of prohibited colours is as follows: About 100 ml. of liquid or watery mixture of the food stuff are acidified with 1 ml. of HCl and boiled for 5 minutes with a strip of thin wool cloth. The coloured wool is rinsed in cold water and the colour stripped from the fibre by boiling it for a few minutes in 2 per cent. ammonia. The wool is removed and a fresh piece put in. The solution is now acidified and again boiled to transfer the dye to the fresh piece of wool. In the case of fruit juices or jams, a third transference of the colour to fresh wool is desirable. The dyed wool is then tested for identifying the dye according to a comprehensive scheme worked out by Nicholls. Recently, chromatographic methods are being employed for the identification of colours.

Spot Tests

For the identification of food colours, the dyed wool is tested with concentrated HCl, H_2SO_4 10 per cent. NaOH Solution and strong ammonia and the resulting colour change noted. The colours can be identified by making use of the following table.

The detection of single colours is fairly easy, but there will be much difficulty in identifying these colours when they are used in different combinations in foodstuffs. In such cases, in order to confirm the findings, it is desirable to repeat the tests using known colours.

TABLE 25. SPOT OF COLOURING MATTER (COAL-TAR DYES)
(after Jacob—1951)

Sl. No.	Test Reaction with	1 FD & C Red No. 1 Ponceau 3 R on Dyed Wool	2 FD & C Red No. 2 Amaranath on Dyed Wool	3 FD & C Red No. 3 Erythrosin B on Dyed Wool	4 FD & C Red No. 4 Ponceau SX on Dyed Wool	5 FD & C Red No. 32 Oil Red XO on Dyed Silk	6 FD & C Orange No. 1 on Dyed Wool	7 FD & C Orange No. 2 Orange SS on Dyed Silk	8 FD & C Yellow No. 1 Naphthol Yellow S on Dyed Wool	9 FD & C Yellow No. 2 Naphthol Yellow S (Potassium Salt) on Dyed Wool
1.	Concentrated Hydrochloric Acid	Rose-Red	Darker	Orange Yellow	Trifle Deeper Red	Bright Red	Bluish Red	Redder	Nearly de-colourised	Nearly de-colourised
2.	Concentrated Sulphuric Acid	Scarlet	Violet	Orange Yellow	Deeper Red	Bright Red	Purple	Redder	Paler	Paler
3.	Ten per cent. Sodium Hydroxide	Orange	Dull Brownish	No change	Orange Yellow	Orange	Red	Orange Yellow	No change	No change
4.	Concentrated Ammonium Hydroxide	No change	No change	No change	Orange Yellow	Orange	Red	No change	No change	No change

TABLE 25.—*Continued*
(1951)

Sl. No.	Test Reaction with	10 FD & C Yellow No. 3 Yellow Yellow AB on Dyed Silk	11 FD & C Yellow No. 4 Yellow OB on Dyed Silk	12 FD & C Yellow No. 5 Tartrazine on Dyed Wool	13 FD & C Yellow No. 6 Sunset Yellow FCF on Dyed Wool	14 FD & C Green No. 1 Guinea Green B on Dyed Wool	15 FD & C Green No. 2 Light Green SF Yellowish on Dyed Wool	16 FD & C Green No. 3 Fast Green FCF on Dyed Wool	17 FD & C Blue No. 1 Brilliant Blue FCF on Dyed Wool	18 FD & C Blue No. 2 Indigo Carmine on Dyed Wool
1.	Concentrated Hydrochloric Acid	Orange	Orange Red	Slightly Darker	Trifle redder	Yellow	Yellow	Orange Yellow	Yellow	Darker
2.	Concentrated Sulphuric Acid	Bluish red	Bluish red	Darker	Trifle redder	Orange	Orange	Greenish Yellow	Yellow	Darker
3.	Ten per cent. Sodium Hydroxide	No change	No change	No change	Browner	Greenish Yellow	Almost colourless	Blue	No change	Greenish Yellow
4.	Concentrated Ammonium Hydroxide	No change	No change	No change	No change	No change	Almost colourless	Blue	No change	Greenish Blue

Selection

In the selection of colours, it is desirable to choose those which have high solubility in order to get a concentrated solution of the colour. Acid colours are generally more stable in solution than alkaline ones. Since colouring matters are liable to fade and change in shade, special care is necessary to select proper colours to suit the product. Strong sunlight, oxidation and reduction by metals like tin and zinc, action of micro-organisms, etc., affect the colours. Azo dyes like Amaranath, Ponceau, Sunset Yellow, etc., easily fade in the presence of tin. Triphenyl methane dyes like fast green, light green, etc., are less susceptible to the action of tin. The yellow azo-dyes that are generally employed for colouring fruit squashes are not ordinarily decolourised by sulphur dioxide which is added as a preservative. Ponceau 2 R and Erythrosin also are stable towards SO_2. In the case of orange squash, however, Sunset Yellow and a mixture of tartrazine and Ponceau and orange fade during prolonged storage in spite of all precautions. Since almost all colouring matters are affected by prolonged heating, it is advisable to add them to the product towards the last stage of boiling. The laws that govern the use of artificial colours in foods are different in different countries. It is, therefore, necessary that the manufacturer should make sure that the colour he adds to his products is permitted in the country to which he intends to export them.

Preparation of Solutions

Generally colours are purchased in powder form but the manufacturer can obtain them in the form of solution ready to use. The powder colour should be made into a paste with cold water and then the requisite quantity should be added to nearly boiling water with constant stirring, and the mixture allowed to stand until cold and any sediment formed removed by filtration. When the concentration of colour in solution is high, sometimes a precipitate is formed at the bottom of the container, thereby lowering the concentration of the colour in the supernatant liquid. This often leads to colour variation in the factory and should, therefore, be guarded against. To prevent sedimentation, glycerine is usually added to increase the density of the solution. In about 10 per cent glycerine solution the sedimentation of colour will be negligible. Isopropyl alcohol also helps in increasing the solubility of the powdered colours.

Liquid colours should be suitably preserved to prevent spoilage. The addition of about 10 per cent., by volume, of alcohol helps in prolonging the keeping quality of the solution. Glycerine also is a good preservative when added in sufficiently large quantities. According to Morgan, addition of 25 per cent. glycerine will be sufficient for preserving the solution for comparatively short periods. For prolonged storage, however, the concentration of glycerine will have to be increased to about 50 per cent. Citric and tartaric acids when used at the rate of 2-2½ ounces per gallon of liquid colour, also act as preservatives. These acids cannot, however, be used in the case of colours like Erythrosin, Orange I, Light Green, Guinea Green, etc., as they are precipitated by these acids. Spoilage in the liquid colours can also be prevented by the addition of 0.1. per cent. of sodium benzoate. The quantity of benzoate introduced into the food product to which the colour is added should, however, be taken into consideration in connection with the legal limit for this chemical as a preservative.

The colour solutions should be stored in a cool and dry place and preferably in the dark. The required quantity of the solution should be drawn for use. Only small quantities of colours are required to produce the desired effect in the product. The following are some typical examples.

Colour	*Product*	*Quantity*
Ponceau 2R	Canned strawberries	2 gm. per gallon of syrup
	,, Longanberries	1 -do-
	,, raspberries	½ -do-
	,, Victoria plums	1/5 -do-
Pea Green colour 5% solution	Canned fresh peas	10 c.c. per gallon of brine
	,, green beans	7-8 c.c. -do-
	,, dried peas	7-8 c.c. -do-
Sunset Yellow	Orange squash	2½-3 gm. per 100 lb. of squash
Supra Rose BS 20 parts, Tartrazine yellow 80 parts	Tomato ketchup	0.85 gram per 100 lb.
	Tomato juice	0.9 gram per 100 lb.

Recently, Das, Siddappa and Girdhari Lal have done a considerable amount of work on the suitability of different colours, singly or in combination for use in orange squash. The stability of these colours under different conditions of preparation and storage of the product is being investigated with a view to evolve a satisfactory combination of colours for use in orange squash.

Although colours add to the attractiveness of food products, it is better to avoid their use as far as possible. This is because colours can often be misused to cover defects in the natural product. In course of time, the consumer will gradually learn to appreciate the value of products with natural colours.

CHAPTER XXI

VITAMINS

Fruits and vegetables are natural sources of important vitamins like vitamin C, vitamin A, Carotene, the precursor of vitamin A, and vitamin B_2. Mango, tomato, peach and papaya are rich in carotene. Amla (*Phyllanthus Emblica*), citrus fruits, guava, mango and tomato are rich in vitamin C. Tomatoes contain vitamin B_2 also. Modern methods of preservation are conducted so as to minimise the destruction of vitamins during processing.

In the U.S.A., the nutritive aspect of canned foods has been studied extensively by Kohman. The Nutrition Laboratory of the American Can Company has also published a bibliography of scientific reports and helpful tables of food data regarding the nutritive aspects of canned foods. Mention may also be made of some other publications of this type, such as: (i) The composition of Foods Used in Far Eastern Countries by Woot Tsuen Wu-Leung, Pecot and Watt of the Bureau of Human Nutrition and Home Economics of the Agricultural Research Administration of the U.S. Department of Agriculture and (ii) Chemical Composition of Foods by McCance and Widdowson. Recently, King, of the Nutrition Foundation of the U.S.A. and Clifcorn of the Continental Can Company of the U.S.A. have reviewed the work on the nutritional quality of the canned foods and pointed out the importance of work in this field especially with reference to preserved fruits and vegetables. A few other publications of similar nature are based on data which have been collected systematically. In India, however, we do not at present have complete data of this type for even our major fruits like canned mangoes, pineapples, oranges, etc. Whatever little data is available is mostly of a fragmentary nature, and there are several gaps to be filled up. The research work in India on this aspect has been mostly of a specific nature as for instance, study of changes in vitamin C in preserved juices and squashes, stability of carotene and ascorbic acid in some canned fruits, etc. There is scope, therefore, for systematic investigation on vitamins in Indian preserved fruits and vegetables.

PROCESSING AND VITAMINS

The method of preparation and preservation of fruits and vegetables has an important bearing on their vitamin content. For instance, in the case of citrus squashes, very little heat is applied and sulphur dioxide is used as a preservative. These two factors help in the maximum retention of ascorbic acid. Fruit juice concentrates, like orange juice concentrate, black currant syrup, rose-hip syrup, etc., are rich sources of vitamin C for the feeding of infants. In the case of pure fruit juices, the loss of vitamin C is minimised by deaerating the juice and bottling it by flash pasteurization or over-flow pasteurization. In the canning of fruits, the air is exhausted from inside the can before sealing it. This naturally helps the retention of vitamin C, unlike in the case of ordinary open cooking with the fruit or vegetable exposed to the action of heat and air simultaneously. Further, in the canned product, traces of oxygen left inside the can are acted upon by the tin so that destruction of vitamin C by oxidation is lessened. Adam, using the chemical method of assay, found very little loss of vitamin C in canned fruits stored for six months. He also noticed that plain cans afforded some protection to this vitamin. In the case of canned oranges, Siddappa and Bhatia have reported that during canning of *Coorg* (loose-skinned mandarin) and *Sathgudi* (tight-skinned) oranges, as such and after lye peeling, the loss of ascorbic acid ranges between 14.0 and 17.0 per cent. and that subsequent loss during a storage period of about one year at room temperature of 24°-30°C is of the order of about 5 per cent. only. Jain and Das have reported 80 per cent. retention of ascorbic acid in canned guavas after 12 months' storage at room temperature. Siddappa and Bhatia have recently studied the ascorbic acid content of important varieties of mangoes canned alone or in combination with other fruits and observed that the retention of ascorbic acid in the can after comparatively long periods of storage is quite high and of the order of 60-65 per cent. They have also studied the distribution of true ascorbic acid as well as 'apparent' ascorbic acid between the fruit and the syrup in the canned products making use of the formaldehyde condensation and xylem extraction technique of Robinson and Stotz. Recently, Pruthi, Girdhari Lal, Dhopeshwarkar and Magar have studied the effect of processing operations on the nutritive value of canned *Badami* and *Raspuri* mangoes and reported that the per cent. retention of carotene and ascorbic acid immediately after processing was very high and of the order of about 98 and 90 per cent. respectively. Siddappa and Bhatia have reported that the carotene content of four important commercial varieties of mangoes namely, *Badami*, *Raspuri*, *Neelum* and *Mulgoa* is 8212, 4727, 2365 and 1685 mcg/100 gm. respectively, and that the retention of B-Carotene in canned mangoes is of the order of about 65.0 per cent. after 6 months storage at 24°-30°C. Studies are in progress at the Central Food Technological Research Institute, Mysore, to evaluate the retention of vitamin C and carotene in several other canned fruits and other fruit products.

Girdhari Lal has studied the changes in the vitamin C content of citrus squashes during storage using the direct method of titration with 2:6 dichlorophenol-indophenol dye, after eliminating the interference of sulphur dioxide used as a preservative. He has reported that during one year's storage, the total loss of ascorbic acid was 38-62 per cent. in the case of orange squash and 30-45 per cent. in the case of lemon squash preserved by different methods. In the case of orange squash, irrespective of preliminary treatment, sugar concentration and the method of preservation, the product prepared from pre-heated juice showed less deterioration in its vitamin C content than that prepared from unheated juice. In lemon squash, however, the reverse effect was observed.

In the case of tomato juice, Lal Singh and Girdhari Lal noticed that carotene is fairly stable to the action of heat and oxidation by air during the various processes of manufacture, while there is a considerable loss of vitamin C during the screening of the juice through a sieve. They attributed this loss to the incorporation of much air during screening. They also observed in the pasteurized juice, a comparatively higher ascorbic acid content than in the same juice just prior to filling into bottles for subsequent pasteurization. This has since been explained as due to the formation of reductone-like bodies which are formed during heating and which have a reducing action on the indophenol dye. The recent formaldehyde condensation technique in the method of estimation of ascorbic acid eliminates the interference of these substances so that it is possible to estimate true ascorbic acid only in the products. Pruthi has studied the role of ascorbic acid in the discolouration of citrus juices during storage and has reported that during a storage period of 1½-3 months at room temperature the losses in ascorbic acid were 10-15 per cent only.

Siddappa has studied the changes in true ascorbic acid content during the concentration of orange juice from 10°Brix to 72°Brix under reduced pressure and reported a loss of 10-15 per cent. He has also observed that added ascorbic acid in orange juice powders is highly stable during storage, the loss being only 25-30 per cent. during a storage period of 12 months at room temperature of 24°-30°C. According to Siddappa and Girdhari Lal, packing the powder under nitrogen gas did not prove superior to ordinary packing in air. According to Pruthi, passion fruit juice is a fairly rich source of ascorbic acid (30-50 mg./100 gm.) and carotene (0.3-0.5 mg./100 gm.).

Jain and Girdhari Lal have studied the preparation of *amla* (*Phyllanthus emblica*) syrup and reported a value of 122 mg. of ascorbic acid per 100 gm. of squash (42.5 mg. per fluid oz.). The overall losses of ascorbic acid in *amla* extract during one year's storage were normal and in the range of 35-45 per cent., and the extracts could be used with advantage for the fortification of other fruit products with vitamin C. Siddappa and Bhatia have observed that canned *Badami* mango pulp has a comparatively high value of 60 mg. of ascorbic acid per 100 gm. of pulp and is thus a good source of vitamin C for feeding children.

Olliver found very little destruction of vitamin C in the case of jams from black currant, strawberry, red currant, gooseberry, raspberry, golden plum and orange marmalade. It is necessary to make a detailed study of the ascorbic acid content of some typical Indian jams and jellies, especially those made from fruits like mango, guava, papaya, etc., which are rich in vitamin C and also to investigate the degree of its retention during storage. This type of investigation is to be extended to other typical Indian products like pickles and chutneys also. Recently, Siddappa and Bhatia have taken up a detailed investigation of the changes in added ascorbic acid in tomato ketchup and other similar products. Das and Jain who have made a detailed study of the changes in ascorbic acid and carotene contents during drying of mango and papaya pulps have observed that while ascorbic acid is lost almost completely during drying, there is only 35-40 per cent. loss in carotene. During storage for about a year at ordinary room temperature of 24°-30°C, the subsequent loss in carotene is about 25-30 per cent.

Under a comprehensive scheme of investigation on the nutritive value of canned fruits and vegetables, systematic work has been taken up recently at the Central Food Technological Research Institute, Mysore, to study the vitamin contents in important preserved fruits and vegetables and the changes they undergo during processing and storage. This is an investigation of great importance to the rapidly growing fruit and vegetable preservation industry in the country.

CHAPTER XXII

LIMITS FOR USE OF PRESERVATIVES

Not all articles of food can contain preservatives. Even in the case of those where it is permitted to add preservatives, proportions have been fixed. According to the British Ministry of 'Health' the articles of food specified in the first column of the following table may contain the preservative specified in the second column in proportions not exceeding the number of parts (estimated by weight) per million specified in the third column:

Food	Preservative	Parts per million
1. FRUIT and fruit pulp (not dried) for conversion into jam or crystallized glacé or cured fruit.		
(a) Cherries	Sulphur Dioxide	3,000
(b) Strawberries and raspberries	-do-	2,000
(c) Other fruits	-do-	1,500
2. Dried fruit:		
(a) Apricots, peaches, nectarines, apples and pears	Sulphur Dioxide	2,000
(b) Raisins and sultanas	-do-	750
3. Unfermented grape juice and non-alcoholic wine made from such grape juice if labelled in accordance with the rules contained in the Second Schedule to these regulations.	Benzoic Acid	2,000
4. Other non-alcoholic wines, cordials and fruit juices, sweetened or unsweetened.	Either Sulphur Dioxide or Benzoic Acid	350 600
5. Jams (including marmalade and fruit jelly prepared in the way in which jam is prepared, but not including marmalade made from citrus fruits).	Sulphur Dioxide	40
6. Crystallized, glacé or cured fruit, including candied peel	-do-	100
(a) Fruit and fruit pulp not otherwise specified in this schedule	-do-	350
7. Sugar (including solid glucose and cane syrups).	-do-	70
8. Corn syrup (liquid glucose)'	-do-	450
9. Cider	-do-	200
10. Alcoholic wines	-do-	450
11. Sweetened mineral waters	Either Sulphur Dioxide or Benzoic Acid	70 120
12. Brewed Ginger beer	Benzoic Acid	120
13. Pickles and sauces made from fruits or vegetables	-do-	250

N.B. Similar points have been specified in Fruit Products Order 1955, Appendix II.

MISCELLANEOUS

1 gallon	4.5459 litres = 10 pounds (1 British Gallon: 1.2 U.S. Gallon)
1 cubic foot water	6.228 gallons = 62.3 pounds
1 cubic metre	35.3 cubic feet = 220 gallons
1 pint	20 fluid ounces
1 gallon	8 pints
1 hundred weight (cwt)	112 lbs.
1 ton	2240 lbs.
1 cusec	0.539 million gallons per day
1 ounce	437.5 grains
7000 grains	1 lb.
60 minims	1 fluid drachm
8 fluid drachms	1 fluid ounce

Hardness of Water

Hardness (parts per million as $CaCo_3$) of 1.0 is equal to 0.07 grains per gallon
-do- -do- 100 is equal to 7.0 grains per gallon
This is equal to 7 degrees hardness. Clark
i.e. one degree of hardness is equal to 14.3 p.p.m. of $CaCo_3$

Boiling Point

Number of atmospheres	Boiling point of water	
	Degree C.	Degree F.
1	100	212
1½	112.2	234
2	120.6	249
3	134	273

Some Useful Data

Length

1 inch = 2.54 centimetres
1 foot = 0.305 metre

Area

1 Square inch : 6.451 square centimetres
1 Acre : 4840 square yards

Volume

1 Cubic inch : 16.39 cubic centimetres

Weight

1 Ounce	: 28.35	grams
1 Pound	: 453.6	grams
1 Grain	: 0.0648	grams
1 Gram	: 15.432	grains

Some Constants

		Area of surface	Volume
Square (side a)	=	a^2	
Triangle (base a, altitude h)	=	$\frac{1}{2}ah$	....
Circle (radius r)	=	πr^2	....
Rectangular solid (edges a, b, c,)	=	$2(ab+bc+ca)$	abc
Cylinder (radius r, height h)	=	$2\pi r(h+r)$	$\pi r^2 h$
Cone (radius r, height h, slant height l)	=	$\pi r(l+r)$	$1/3\pi r^2 h$
Sphere (radius r)	=	$4\pi r^2$	$4/3\pi r^3$

(π : 3.1416 or approximately 22/7)

Thermometers	Freezing Point	Boiling Point
Centigrade	0 Degree	100 Degree
Fahrenheit	32 „	212 „
Reaumer	0 „	80 „

[4 Reaumer scale divisions = 5 centigrade divisions ;
= 9 Fahrenheit divisions]

$$\frac{F-32}{9} = \frac{C}{5}$$

Therefore, to convert degrees Centigrade into degrees Fahrenheit, multiply by 9, divide by 5 and add 32.

To convert degrees F. into degrees C. subtract 32, multiply by 5 and divide by 9.

Domestic measures

Liquids		Solids
1 tea spoonful	$\frac{1}{8}$ fluid ounce	1 level table spoonful $= \frac{1}{2}$ Ounce
1 dessert spoonful	$\frac{1}{4}$ fluid ounce	
1 table spoonful	$\frac{1}{2}$ fluid ounce	
1 tumblerful	10 fluid ounces	

APPENDIX I

REFERENCE TABLES

TABLE 1. TOMATO PULP

Total solids in vacuo at 70°C.	Specific gravity at 20°C.	Refractometer reading at 20°C.		Specific gravity of filtrate at 20°C.
		Refractive index	Brix scale	
4.0	1.0162	1.3384	3.7	1.0150
4.1	1.0166	1.3386	3.8	1.0154
4.2	1.0171	1.3387	3.9	1.0158
4.3	1.0175	1.3388	4.0	1.0162
4.4	1.0179	1.3390	4.1	1.0166
4.5	1.0183	1.3391	4.2	1.0170
4.6	1.0188	1.3393	4.3	1.0174
4.7	1.0192	1.3394	4.4	1.0178
4.8	1.0196	1.3396	4.5	1.0182
4.9	1.0200	1.3397	4.6	1.0186
5.0	1.0205	1.3398	4.7	1.0190
5.1	1.0209	1.3400	4.8	1.0194
5.2	1.0213	1.3401	4.9	1.0198
5.3	1.0217	1.3402	5.0	1.0202
5.4	1.0222	1.3404	5.1	1.0207
5.5	1.0226	1.3405	5.2	1.0211
5.6	1.0230	1.3407	5.2	1.0215
5.7	1.0234	1.3408	5.3	1.0219
5.8	1.0239	1.3409	5.4	1.0223
5.9	1.0243	1.3411	5.5	1.0227
6.0	1.0247	1.3412	5.6	1.0231
6.1	1.0251	1.3414	5.7	1.0235
6.2	1.0256	1.3415	5.8	1.0239
6.3	1.0260	1.3416	5.9	1.0243
6.4	1.0264	1.3418	6.0	1.0247
6.5	1.0268	1.3419	6.1	1.0251
6.6	1.0273	1.3420	6.2	1.0255
6.7	1.0277	1.3422	6.3	1.0259
6.8	1.0281	1.3423	6.4	1.0263
6.9	1.0285	1.3425	6.5	1.0267
7.0	1.0290	1.3426	6.6	1.0271
7.1	1.0294	1.3427	6.6	1.0275
7.2	1.0298	1.3429	6.7	1.0279
7.3	1.0302	1.3430	6.8	1.0283
7.4	1.0307	1.3432	6.9	1.0287
7.5	1.0311	1.3433	7.0	1.0291
7.6	1.0315	1.3434	7.1	1.0295
7.7	1.0319	1.3436	7.2	1.0299
7.8	1.0324	1.3437	7.3	1.0303
7.9	1.0328	1.3439	7.4	1.0307
8.0	1.0332	1.3440	7.5	1.0311
8.1	1.0336	1.3441	7.6	1.0315
8.2	1.0341	1.3443	7.7	1.0319
8.3	1.0345	1.3444	7.8	1.0323
8.4	1.0349	1.3445	7.9	1.0327
8.5	1.0353	1.3447	7.9	1.0331
8.6	1.0358	1.3448	8.0	1.0335

Thermometers	Freezing Point	Boiling Point
Centigrade	0 Degree	100 Degree
Fahrenheit	32 „	212 „
Reaumer	0 „	80 „

[4 Reaumer scale divisions = 5 centigrade divisions;
= 9 Fahrenheit divisions]

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Therefore, to convert degrees Centigrade into degrees Fahrenheit, multiply by 9, divide by 5 and add 32.

To convert degrees F. into degrees C. subtract 32, multiply by 5 and divide by 9.

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4.3	1.0175	1.3388	4.0	1.0162
4.4	1.0179	1.3390	4.1	1.0166
4.5	1.0183	1.3391	4.2	1.0170
4.6	1.0188	1.3393	4.3	1.0174
4.7	1.0192	1.3394	4.4	1.0178
4.8	1.0196	1.3396	4.5	1.0182
4.9	1.0200	1.3397	4.6	1.0186
5.0	1.0205	1.3398	4.7	1.0190
5.1	1.0209	1.3400	4.8	1.0194
5.2	1.0213	1.3401	4.9	1.0198
5.3	1.0217	1.3402	5.0	1.0202
5.4	1.0222	1.3404	5.1	1.0207
5.5	1.0226	1.3405	5.2	1.0211
5.6	1.0230	1.3407	5.2	1.0215
5.7	1.0234	1.3408	5.3	1.0219
5.8	1.0239	1.3409	5.4	1.0223
5.9	1.0243	1.3411	5.5	1.0227
6.0	1.0247	1.3412	5.6	1.0231
6.1	1.0251	1.3414	5.7	1.0235
6.2	1.0256	1.3415	5.8	1.0239
6.3	1.0260	1.3416	5.9	1.0243
6.4	1.0264	1.3418	6.0	1.0247
6.5	1.0268	1.3419	6.1	1.0251
6.6	1.0273	1.3420	6.2	1.0255
6.7	1.0277	1.3422	6.3	1.0259
6.8	1.0281	1.3423	6.4	1.0263
6.9	1.0285	1.3425	6.5	1.0267
7.0	1.0290	1.3426	6.6	1.0271
7.1	1.0294	1.3427	6.6	1.0275
7.2	1.0298	1.3429	6.7	1.0279
7.3	1.0302	1.3430	6.8	1.0283
7.4	1.0307	1.3432	6.9	1.0287
7.5	1.0311	1.3433	7.0	1.0291
7.6	1.0315	1.3434	7.1	1.0295
7.7	1.0319	1.3436	7.2	1.0299
7.8	1.0324	1.3437	7.3	1.0303
7.9	1.0328	1.3439	7.4	1.0307
8.0	1.0332	1.3440	7.5	1.0311
8.1	1.0336	1.3441	7.6	1.0315
8.2	1.0341	1.3443	7.7	1.0319
8.3	1.0345	1.3444	7.8	1.0323
8.4	1.0349	1.3445	7.9	1.0327
8.5	1.0353	1.3447	7.9	1.0331
8.6	1.0358	1.3448	8.0	1.0335

TABLE 1.—*Continued*

Total solids in vacuo at 70°C.	Specific gravity at 20°C.	Refractometer reading at 20°C.		Specific gravity of filtrate at 20°C.
		Refractive index	Brix scale	
8.7	1.0362	1.3450	8.1	1.0339
8.8	1.0366	1.3451	8.2	1.0343
8.9	1.0370	1.3452	8.3	1.0347
9.0	1.0375	1.3454	8.4	1.0351
9.1	1.0379	1.3455	8.5	1.0355
9.2	1.0383	1.3456	8.6	1.0359
9.3	1.0387	1.3458	8.7	1.0363
9.4	1.0392	1.3459	8.8	1.0367
9.5	1.0396	1.3461	8.8	1.0371
9.6	1.0400	1.3462	8.9	1.0375
9.7	1.0404	1.3463	9.0	1.0379
9.8	1.0409	1.3465	9.1	1.0383
9.9	1.0413	1.3466	9.2	1.0387
10.0	1.0417	1.3468	9.3	1.0391
10.1	1.0421	1.3469	9.4	1.0395
10.2	1.0426	1.3470	9.5	1.0399
10.3	1.0430	1.3472	9.6	1.0403
10.4	1.0434	1.3473	9.7	1.0407
10.5	1.0438	1.3475	9.7	1.0411
10.6	1.0443	1.3476	9.8	1.0415
10.7	1.0447	1.3477	9.9	1.0419
10.8	1.0451	1.3479	10.0	1.0423
10.9	1.0455	1.3480	10.1	1.0428
11.0	1.0460	1.3481	10.2	1.0432
11.1	1.0464	1.3483	10.3	1.0436
11.2	1.0468	1.3484	10.4	1.0440
11.3	1.0472	1.3486	10.5	1.0444
11.4	1.0477	1.3487	10.6	1.0448
11.5	1.0481	1.3488	10.6	1.0452
11.6	1.0485	1.3490	10.7	1.0456
11.7	1.0489	1,3491	10.8	1.0460
11.8	1.0494	1.3493	10.9	1.0464
11.9	1.0498	1.3494	11.0	1.0468
12.0	1.0502	1.3495	11.1	1.0472
12.1	1.0506	1.3497	11.2	...
12.2	1.0511	1.3498	11.3	...
12.3	1.0515	1.3500	11.4	...
12.4	1.0520	1.3501	11.5	...
12.5	1.0524	1.3502	11.6	...
12.6	1.0529	1.3504	11.6	...
12.7	1.0533	1.3505	11.7	...
12.8	1.0537	1.3506	11.8	...
12.9	1.0542	1.3508	11.9	...
13.0	1.0546	1.3509	12.0	...
13.1	1.0551	1.3511	12.1	...
13.2	1.0555	1.3512	12.2	...
13.3	1.0559	1.3514	12.3	...
13.4	1.0564	1.3515	12.4	...
13.5	1.0568	1.3516	12.5	...
13.6	1.0573	1.3518	12.5	...
13.7	1.0577	1.3519	12.6	...
13.8	1.0582	1.3520	12.7	...
13.9	1.0586	1.3522	12.8	...

TABLE 1.—*Continued*

Total solids in vacuo at 70°C.	Specific gravity at 20°C.	Refractometer reading at 20°C.		Specific gravity of filtrate at 20°C.
		Refractive index	Brix scale	
14.0	1.0591	1.3523	12.9	...
14.1	1.0595	1.3525	13.0	...
14.2	1.0599	1.3526	13.1	...
14.3	1.0604	1.3528	13.2	...
14.4	1.0608	1.3529	13.3	...
14.5	1.0613	1.3531	13.4	...
14.6	1.0617	1.3532	13.5	...
14.7	1.0621	1.3534	13.5	...
14.8	1.0626	1.3535	13.6	...
14.9	1.0630	1.3537	13.7	...
15.0	1.0635	1.3538	13.8	...
15.1	1.0639	1.3540	13.9	...
15.2	1.0644	1.3541	14.0	...
15.3	1.0648	1.3543	14.1	...
15.4	1.0652	1.3544	14.2	...
15.5	1.0657	1.3545	14.3	...
15.6	1.0661	1.3547	14.4	...
15.7	1.0666	1.3548	14.4	...
15.8	1.0670	1.3550	14.5	...
15.9	1.0675	1.3551	14.6	...
16.0	1.0679	1.3553	14.7	...
16.1	1.0683	1.3554	14.8	...
16.2	1.0688	1.3556	14.9	...
16.3	1.0692	1.3557	15.0	...
16.4	1.0697	1.3559	15.1	...
16.5	1.0701	1.3560	15.2	...
16.6	1.0706	1.3562	15.3	...
16.7	1.0710	1.3563	15.4	...
16.8	1.0714	1.3565	15.5	...
16.9	1.0719	1.3566	15.5	...
17.0	1.0723	1.3567	15.6	...
17.1	1.0728	1.3569	15.7	...
17.2	1.0732	1.3570	15.8	...
17.3	1.0737	1.3572	15.9	...
17.4	1.0741	1.3573	16.0	...
17.5	1.0745	1.3575	16.1	...
17.6	1.0750	1.3576	16.2	...
17.7	1.0754	1.3578	16.3	...
17.8	1.0759	1.3579	16.4	...
17.9	1.0763	1.3581	16.5	...
18.0	1.0768	1.3582	16.5	...
18.1	1.0772	1.3584	16.6	...
18.2	1.0776	1,3585	16.7	...
18.3	1.0781	1.3587	16.8	...
18.4	1.0785	1.3588	16.9	...
18.5	1.0790	1.3589	17.0	...
18.6	1.0794	1.3591	17.1	...
18.7	1.0798	1.3592	17.2	...
18.8	1.0803	1,3594	17.3	...
18.9	1.0807	1.3595	17.4	...

TABLE 1.—*Concluded*

Total solids in vacuo at 70°C.	Specific gravity at 20°C.	Refractometer reading at 20°C.		Specific gravity of filtrate at 20°C.
		Refractive index	Brix scale	
19.0	1.0812	1.3597	17.5	...
19.1	1.0816	1.3598	17.5	...
19.2	1.0821	1.3600	17.6	...
19.3	1.0825	1.3601	17.7	...
19.4	1.0829	1.3603	17.8	...
19.5	1.0834	1.3604	17.9	...
19.6	1.0838	1.3606	18.0	...
19.7	1.0843	1.3607	18.1	...
19.8	1.0847	1.3608	18.2	...
19.9	1.0852	1.3610	18.3	...
20.0	1.0856	1.3611	18.4	...

TABLE 2. TOMATO PASTE

Total solids in vacuo at 70°C.	Refractometer reading at 20°C.		Specific gravity at 20°C.
	Refractive index	Brix scale	
20.0	1.3611	18.4	1.0856
20.1	1.3613	18.5	1.0860
20.2	1.3614	18.6	1.0865
20.3	1.3616	18.7	1.0869
20.4	1.3617	18.7	1.0873
20.5	1.3619	18.8	1.0878
20.6	1.3620	18.9	1.0882
20.7	1.3622	19.0	1.0886
20.8	1.3624	19.1	1.0891
20.9	1.3625	19.2	1.0895
21.0	1.3627	19.3	1.0899
21.1	1.3628	19.4	1.0904
21.2	1.3630	19.5	1.0908
21.3	1.3632	19.6	1.0912
21.4	1.3633	19.7	1.0916
21.5	1.3635	19.8	1.0921
21.6	1.3636	19.9	1.0925
21.7	1.3638	20.0	1.0930
21.8	1.3639	20.1	1.0934
21.9	1.3641	20.2	1.0938
22.0	1.3643	20.2	1.0943
22.1	1.3644	20.3	1.0947
22.2	1.3646	20.4	1.0951
22.3	1.3647	20.5	1.0956
22.4	1.3649	20.6	1.0960
22.5	1.3651	20.7	1.0965
22.6	1.3652	20.8	1.0969
22.7	1.3654	20.9	1.0973
22.8	1.3655	21.0	1.0978
22.9	1.3657	21.1	1.0982
23.0	1.3658	21.2	1.0986
23.1	1.3660	21.3	1.0991
23.2	1.3662	21.4	1.0995
23.3	1.3663	21.5	1.0999
23.4	1.3665	21.6	1.1004
23.5	1.3666	21.7	1.1008
23.6	1.3668	21.7	1.1012
23.7	1.3669	21.8	1.1017
23.8	1.3671	21.9	1.1021
23.9	1.3673	22.0	1.1025
24.0	1.3674	22.1	1.1030
24.1	1.3676	22.2	1.1034
24.2	1.3677	22.3	1.1038
24.3	1.3679	22.4	1.1043
24.4	1.3681	22.5	1.1047
24.5	1.3682	22.6	1.1051
24.6	1.3684	22.7	1.1056
24.7	1.3685	22.8	1.1060
24.8	1.3687	22.9	1.1064
24.9	1.3688	23.0	1.1069

TABLE 2.—*Continued*

Total solids in vacuo at 70°C.	Refractometer reading at 20°C.		Specific gravity at 20°C.
	Refractive index	Brix scale	
25.0	1.3690	23.1	1.1073
25.1	1.3692	23.2	1.1077
25.2	1.3693	23.2	1.1082
25.3	1.3695	23.3	1.1086
25.4	1.3697	23.4	1.1090
25.5	1.3698	23.5	1.1095
25.6	1.3700	23.6	1.1099
25.7	1.3701	23.7	1.1103
25.8	1.3703	23.8	1.1108
25.9	1.3705	23.9	1.1112
26.0	1.3706	24.0	1.1116
26.1	1.3708	24.1	1.1121
26.2	1.3710	24.2	1.1125
26.3	1.3711	24.3	1.1129
26.4	1.3713	24.4	1.1134
26.5	1.3715	24.5	1.1138
26.6	1.3716	24.6	1.1142
26.7	1.3718	24.7	1.1147
26.8	1.3720	24.8	1.1151
26.9	1.3721	24.9	1.1155
27.0	1.3723	25.0	1.1160
27.1	1.3724	25.1	1.1164
27.2	1.3726	25.1	1.1168
27.3	1.3728	25.2	1.1173
27.4	1.3729	25.3	1.1177
27.5	1.3731	25.4	1.1182
27.6	1.3733	25.5	1.1186
27.7	1.3734	25.6	1.1190
27.8	1.3736	25.7	1.1195
27.9	1.3738	25.8	1.1199
28.0	1.3739	25.9	1.1203
28.1	1.3741	26.0	1.1208
28.2	1.3742	26.1	1.1212
28.3	1.3744	26.2	1.1216
28.4	1.3746	26.3	1.1221
28.5	1.3747	26.4	1.1225
28.6	1.3749	26.5	1.1229
28.7	1.3751	26.6	1.1234
28.8	1.3752	26.7	1.1238
28.9	1.3754	26.8	1.1242
29.0	1.3756	26.9	1.1247
29.1	1.3757	26.9	1.1251
29.2	1.3759	27.0	1.1255
29.3	1.3761	27.1	1.1260
29.4	1.3762	27.2	1.1264
29.5	1.3764	27.3	1.1268
29.6	1.3765	27.4	1.1273
29.7	1.3767	27.5	1.1277
29.8	1.3769	27.6	1.1281
29.9	1.3770	27.7	1.1286

TABLE 2.—*Concluded*

Total solids in vacuo at 70°C.	Refractometer reading at 20°C.		Specific gravity at 20°C.
	Refractive index	Brix scale	
30.0	1.3772	27.8	1.1290
30.1	1.3774	27.9	1.1294
30.2	1.3776	28.0	1.1299
30.3	1.3777	28.1	1.1303
30.4	1.3779	28.2	1.1308
30.5	1.3781	28.3	1.1312
30.6	1.3783	28.4	1.1316
30.7	1.3784	28.5	1.1321
30.8	1.3786	28.6	1.1325
30.9	1.3788	28.7	1.1330
31.0	1.3790	28.8	1.1334
31.1	1.3791	28.9	1.1338
31.2	1.3793	29.0	1.1343
31.3	1.3795	29.1	1.1347
31.4	1.3797	29.2	1.1352
31.5	1.3798	29.3	1.1356
31.6	1.3800	29.4	1.1360
31.7	1.3802	29.5	1.1365
31.8	1.3804	29.6	1.1369
31.9	1.3805	29.7	1.1374
32.0	1.3807	29.8	1.1378
32.1	1.3809	29.9	1.1382
32.2	1.3811	30.0	1.1387
32.3	1.3812	30.1	1.1391
32.4	1.3814	30.2	1.1396
32.5	1.3816	30.3	1.1400
32.6	1.3818	30.4	1.1404
32.7	1.3820	30.5	1.1409
32.8	1.3821	30.6	1.1413
32.9	1.3823	30.7	1.1418
33.0	1.3825	30.8	1.1422
33.1	1.3827	30.9	1.1426
33.2	1.3828	31.0	1.1431
33.3	1.3830	31.1	1.1435
33.4	1.3832	31.2	1.1440
33.5	1.3834	31.3	1.1444
33.6	1.3835	31.3	1.1448
33.7	1.3837	31.4	1.1453
33.8	1.3839	31.5	1.1457
33.9	1.3841	31.6	1.1461
34.0	1.3842	31.7	1.1466
34.1	1.3844	31.8	1.1470
34.2	1.3846	31.9	1.1475
34.3	1.3848	32.0	1.1479
34.4	1.3849	32.1	1.1484
34.5	1.3851	32.2	1.1488
34.6	1.3853	32.3	1.1492
34.7	1.3855	32.4	1.1497
34.8	1.3856	32.5	1.1501
34.9	1.3858	32.6	1.1506
35.0	1.3860	32.7	1.1510

TABLE 3. TOMATO KETCHUP

Per cent. total solids	Specific gravity at 68°F. (20°C.)	Abbé refractometer reading at 68°F. (20°C.)
16.0	1.067	1.3557
16.5	1.069	1.3565
17.0	1.072	1.3573
17.5	1.074	1.3582
18.0	1.077	1.3590
18.5	1.079	1.3598
19.0	1.082	1.3606
19.5	1.084	1.3614
20.0	1.087	1.3622
20.5	1.089	1.3631
21.0	1.091	1.3639
21.5	1.094	1.3647
22.0	1.096	1.3655
22.5	1.099	1.3664
23.0	1.101	1.3672
23.5	1.104	1.3681
24.0	1.106	1.3689
24.5	1.109	1.3698
25.0	1.111	1.3706
25.5	1.113	1.3715
26.0	1.116	1.3723
26.5	1.118	1.3732
27.0	1.121	1.3740
27.5	1.123	1.3749
28.0	1.126	1.3758
28.5	1.128	1.3767
29.0	1.131	1.3775
29.5	1.133	1.3784
30.0	1.136	1.3793
30.5	1.138	1.3802
31.0	1.140	1.3811
31.5	1.143	1.3820
32.0	1.145	1.3829
32.5	1.148	1.3838
33.0	1.150	1.3847
33.5	1.153	1.3856
34.0	1.155	1.3865
34.5	1.158	1.3874
35.0	1.160	1.3883
35.5	1.162	1.3893
36.0	1.165	1.3902
36.5	1.167	1.3911
37.0	1.170	1.3920
37.5	1.172	1.3930
38.0	1.175	1.3939
38.5	1.177	1.3949
39.0	1.180	1.3958
39.5	1.182	1.3968
40.0	1.185	1.3978

TABLE 4. CORRECTIONS FOR SPECIFIC GRAVITY AND BRIX* READINGS AT DIFFERENT TEMPERATURES TO 68°F. (20°C.)

Temperature		Corrections		Temperature		Corrections	
Deg. F.	Deg. C.	Sp. Gr.	Brix	Deg. F.	Deg. C.	Sp. Gr.	Brix
50	10.0	.0017	.38	59	15.0	.0010	.22
51	10.6	.0016	.36	60	15.6	.0009	.20
52	11.1	.0016	.35	61	16.1	.0009	.18
53	11.7	.0015	.33	62	16.7	.0008	.16
54	12.2	.0014	.31	63	17.2	.0007	.13
55	12.8	.0014	.30	64	17.8	.0006	.11
56	13.3	.0013	.28	65	18.3	.0004	.08
57	13.9	.0012	.26	66	18.9	.0003	.05
58	14.4	.0011	.24	67	19.4	.0002	.03

Corrections to be subtracted from specific gravity or degrees Brix

TABLE 5. CORRECTIONS TO BE ADDED TO SPECIFIC GRAVITY OR DEGRESS BRIX

Temperature		Corrections		Temperature		Corrections	
Deg. F.	Deg. C.	Sp. Gr.	Brix	Deg. F.	Deg. C.	Sp. Gr.	Brix
69	20.6	.0002	.03	79	26.1	.0017	.35
70	21.1	.0003	.05	80	26.7	.0018	.39
71	21.7	.0004	.08	81	27.2	.0019	.42
72	22.2	.0006	.11	82	27.8	.0021	.46
73	22.8	.0007	.15	83	28.3	.0023	.49
74	23.3	.0009	.18	84	28.9	.0024	.54
75	23.9	.0011	.21	85	29.4	.0026	.58
76	24.4	.0012	.24	86	30.0	.0027	.62
77	25.0	.0013	.28	87	30.6	.0029	.66
78	25.6	.0015	.32	88	31.1	.0031	.70

* These temperature corrections are for a Brix instrument standardized for 20°C.

TABLE 5a. CORRECTIONS FOR REFRACTOMETER BRIX READING WHEN DETERMINED AT TEMPERATURES OTHER THAN 68°F. (20°C.)

Temperature		Refractive index reading						
°C.	°F.	1.3400	1.3500	1.3600	1.3700	1.3800	1.3900	1.4000
		To be subtracted from reading						
15	59.0	.0004	.0005	.0005	.0006	.0006	.0007	.0007
16	60.8	.0004	.0004	.0004	.0005	.0005	.0005	.0005
17	62.6	.0003	.0003	.0003	.0003	.0004	.0004	.0004
18	64.4	.0002	.0002	.0002	.0002	.0002	.0003	.0003
19	66.2	.0001	.0001	.0001	.0001	.0001	.0001	.0001
		To be added to reading						
21	69.8	.0001	.0001	.0001	.0001	.0001	.0001	.0001
22	71.6	.0002	.0002	.0002	.0002	.0003	.0003	.0003
23	73.4	.0003	.0003	.0003	.0004	.0004	.0004	.0004
24	75.2	.0004	.0004	.0005	.0005	.0005	.0006	.0006
25	77.0	.0005	.0005	.0006	.0006	.0007	.0007	.0007
26	78.8	.0006	.0006	.0007	.0008	.0008	.0008	.0009
27	80.6	.0007	.0008	.0008	.0009	.0010	.0010	.0010
28	82.4	.0008	.0009	.0010	.0010	.0011	.0011	.0012
29	84.5	.0010	.0010	.0011	.0012	.0012	.0013	.0013
30	86.0	.0011	.0012	.0012	.0013	.0014	.0014	.0015

TABLE 5b. CORRECTIONS FOR REFRACTOMETER BRIX READING WHEN DETERMINED AT TEMPERATURES OTHER THAN 68°F. (20°C.)

Temperature		Refractometer Brix reading						
°C.	°F.	5	10	15	20	25	30	35
		To be subtracted from reading						
15	59.0	0.29	0.31	0.33	0.34	0.34	0.35	0.36
16	60.8	.24	.25	.26	.27	.28	.28	.29
17	62.6	.18	.19	.20	.21	.21	.21	.22
18	64.4	.13	.13	.14	.14	.14	.14	.15
19	66.2	.06	.06	.07	.07	.07	.07	.08
		To be added to reading						
21	69.8	0.07	0.07	0.07	0.07	0.08	0.08	0.08
22	71.6	.13	.14	.14	.15	.15	.15	.15
23	73.4	.20	.21	.22	.22	.23	.23	.23
24	75.2	.27	.28	.29	.30	.30	.31	.31
25	77.0	.35	.36	.37	.38	.38	.39	.40
26	78.8	.42	.43	.44	.45	.46	.47	.48
27	80.6	.50	.52	.53	.54	.55	.55	.56
28	82.4	.57	.60	.61	.62	.63	.63	.64
29	84.2	.66	.68	.69	.71	.72	.72	.73
30	86.0	.74	.77	.78	.79	.80	.80	.81

TABLE 6. EQUIVALENT VOLUMES OF TOMATO PULP OF DIFFERENT DEGREES OF CONCENTRATION.

Whole tomato pulp		Examination of filtrate			Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of			
Specific gravity at 68°F. (20°C.)	Per cent. total solids	Refractometer reading at 68°F. (20°C.)		Specific gravity of filtrate at 68°F. (20°C.)	1.035	1.040	1.045	1.050
		Refractive index	Brix scale					
1.015	3.7	1.3381	3.5	1.0139	.433	.378	.335	.301
1.016	4.0	1.3384	3.7	1.0148	.460	.402	.357	.320
1.017	4.2	1.3387	3.9	1.0158	.489	.427	.378	.339
1.018	4.4	1.3390	4.1	1.0167	.516	.451	.400	.359
1.019	4.7	1.3394	4.4	1.0177	.545	.476	.422	.378
1.020	4.9	1.3397	4.6	1.0186	.573	.500	.443	.397
1.021	5.1	1.3400	4.8	1.0196	.601	.525	.465	.417
1.022	5.4	1.3403	5.0	1.0205	.629	.549	.487	.437
1.023	5.6	1.3407	5.2	1.0215	.658	.574	.509	.456
1.024	5.8	1.3410	5.5	1.0224	.685	.598	.531	.476
1.025	6.1	1.3413	5.7	1.0233	.714	.623	.553	.496
1.026	6.3	1.3416	5.9	1.0243	.741	.647	.575	.516
1.027	6.5	1.3420	6.1	1.0252	.771	.673	.597	.536
1.028	6.8	1.3423	6.3	1.0262	.800	.698	.619	.555
1.029	7.0	1.3426	6.6	1.0271	.827	.722	.641	.575
1.030	7.3	1.3429	6.8	1.0281	.857	.748	.663	.595
1.031	7.5	1.3433	7.0	1.0290	.885	.772	.685	.615
1.032	7.7	1.3436	7.2	1.0300	.915	.798	.707	.635
1.033	8.0	1.3439	7.4	1.0309	.942	.822	.730	.654
1.034	8.2	1.3442	7.6	1.0318	.972	.848	.752	.674

TABLE 6.—*Continued*

Whole tomato pulp		Examination of filtrate			Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of			
Specific gravity at 68°F. (20°C.)	Per cent. total solids	Refractometer reading at 68°F. (20°C.)		Specific gravity of filtrate at 68°F. (20°C.)	1.035	1.040	1.045	1.050
		Refractive index	Brix scale					
1.035	8.4	1.3446	7.9	1.0328	1.000	.873	.774	.694
1.036	8.7	1.3449	8.1	1.0337	1.029	.899	.797	.714
1.037	8.9	1.3452	8.3	1.0347	1.058	.924	.819	.735
1.038	9.1	1.3455	8.5	1.0356	1.088	.949	.842	.755
1.039	9.4	1.3459	8.7	1.0366	1.116	.975	.864	.776
1.040	9.6	1.3462	8.9	1.0375	1.145	1.000	.887	.796
1.041	9.8	1.3465	9.1	1.0385	1.174	1.025	.909	.816
1.042	10.1	1.3468	9.4	1.0394	1.204	1.051	.932	.836
1.043	10.3	1.3472	9.6	1.0404	1.232	1.076	.955	.857
1.044	10.5	1.3475	9.8	1.0413	1.262	1.102	.977	.877
1.045	10.8	1.3478	10.0	1.0422	1.292	1.128	1.000	.897
1.046	11.0	1.3481	10.2	1.0432	1.320	1.154	1.023	.918
1.047	11.2	1.3485	10.4	1.0441	1.351	1.179	1.045	.938
1.048	11.5	1.3488	10.6	1.0451	1.380	1.205	1.068	.959
1.049	11.7	1.3491	10.8	1.0460	1.409	1.231	1.091	.979
1.050	12.0	1.3494	11.0	1.0470	1.440	1.257	1.114	1.000
1.051	12.2	1.3498	11.3	...	1.469	1.282	1.136	1.020
1.052	12.4	1.3501	11.5	...	1.499	1.308	1.159	1.040
1.053	12.6	1.3504	11.7	...	1.526	1.333	1.182	1.060
1.054	12.9	1.3508	11.9	...	1.555	1.358	1.204	1.081

TABLE 6.—*Continued*

Whole tomato pulp		Examination of filtrate			Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of			
Specific gravity at 68°F. (20°C.)	Per cent. total solids	Refractometer reading at 68°F. (20°C.)		Specific gravity of filtrate at 68°F. (20°C.)	1.035	1.040	1.045	1.050
		Refractive index	Brix scale					
1.055	13.1	1.3511	12.1	...	1.585	1.383	1.227	1.101
1.056	13.3	1.3514	12.3	...	1.613	1.408	1.250	1.121
1.057	13.5	1.3518	12.5	...	1.642	1.434	1.272	1.141
1.058	13.8	1.3521	12.7	...	1.671	1.459	1.295	1.161
1.059	14.0	1.3524	12.9	...	1.700	1.484	1.317	1.181
1.060	14.2	1.3527	13.2	...	1.730	1.510	1.340	1.201
1.061	14.4	1.3531	13.4	...	1.758	1.535	1.363	1.221
1.062	14.7	1.3534	13.6	...	1.788	1.560	1.385	1.242
1.063	14.9	1.3537	13.8	...	1.816	1.586	1.407	1.263
1.064	15.1	1.3541	14.0	...	1.846	1.611	1.430	1.283
1.065	15.4	1.3544	14.2	...	1.876	1.637	1.453	1.303
1.066	15.6	1.3547	14.4	...	1.905	1.662	1.476	1.323
1.067	15.8	1.3550	14.6	...	1.935	1.689	1.499	1.344
1.068	16.0	1.3554	14.8	...	1.963	1.714	1.522	1.364
1.069	16.3	1.3557	15.0	...	1.993	1.740	1.545	1.385
1.070	16.5	1.3560	15.2	...	2.024	1.766	1.568	1.405
1.071	16.7	1.3564	15.4	...	2.052	1.791	1.590	1.426
1.072	16.9	1.3567	15.6	...	2.083	1.818	1.613	1.447
1.073	17.2	1.3570	15.8	...	2.113	1.844	1.636	1.467
1.074	17.4	1.3574	16.0	...	2.142	1.870	1.659	1.488

TABLE 6.—*Concluded*

Whole tomato pulp		Examination of filtrate			Factor by which to multiply volume of pulp of given specific gravity to ascertain volume of pulp with equivalent solid content and with specific gravity of			
Specific gravity at 68°F. (20°C.)	Per cent. total solids	Refractometer reading at 68°F. (20°C.)		Specific gravity of filtrate at 68°F. (20°C.)	1.035	1.040	1.045	1.050
		Refractive index	scale Brix					
1.075	17.6	1.3577	16.2	...	2.172	1.896	1.682	1.509
1.076	17.8	1.3580	16.4	...	2.201	1.922	1.705	1.530
1.077	18.1	1.3583	16.7	...	2.232	1.948	1.729	1.551
1.078	18.3	1.3587	16.9	...	2.263	1.975	1.752	1.571
1.079	18.5	1.3590	17.1	...	2.292	2.000	1.776	1.592
1.080	18.7	1.3593	17.3	...	2.322	2.027	1.799	1.613
1.081	19.0	1.3597	17.5	...	2.352	2.053	1.822	1.634
1.082	19.2	1.3600	17.7	...	2.383	2.080	1.846	1.655
1.083	19.4	1.3603	17.9	...	2.413	2.107	1.869	1.676
1.084	19.6	1.3606	18.1	...	2.443	2.132	1.893	1.697
1.085	19.9	1.3610	18.3	...	2.474	2.159	1.916	1.718
1.086	20.1	1.3613	18.5	...	2.504	2.185	1.938	1.739
1.087	20.3	1.3616	18.7	...	2.535	2.212	1.963	1.760
1.088	20.6	1.3620	18.9	...	2.566	2.239	1.987	1.782
1.089	20.8	1.3623	19.1	...	2.596	2.266	2.010	1.803

APPENDIX II

FRUIT PRODUCTS ORDER 1955

(AS AMENDED UPTO 18-2-1958)

Government of India, Ministry of Food and Agriculture

New Delhi, the 3rd May 1955

S.R.O. 1052.—In exercise of the powers conferred by Section 3 of the Essential Commodities Act, 1955 (10 of 1955), the Central Government hereby makes the following order, namely:—

1. (1) This Order may be called the Fruit Products Order, 1955.
(2) It extends to the whole of India except the State of Jammu and Kashmir.

2. In this Order, unless the context otherwise requires,—

(a) "the Act" means the Essential Commodities Act, 1955 (10 of 1955);

(b) "Committee" means the Central Fruit Products Advisory Committee constituted by the Central Government under Clause 3;

(c) "Form" means a Form set forth in the First Schedule;

(d) "fruit product" means any of the following articles, namely:—

(i) synthetic beverages, syrups and sharbats;
(ii) vinegar, whether brewed or synthetic;
(iii) pickles;
(iv) dehydrated fruits and vegetables;
(v) squashes, crushes, cordials, barley waters, barrelled juice and ready-to-serve beverages or any other beverages containing fruit juices or fruit pulp;
(vi) jams, jellies and marmalades;
(vii) tomato products, ketchup and sauces;
(viii) preserves, candied and crystallized fruits and peels;
(ix) chutneys;
(x) canned and bottled fruits, juices and pulps;
(xi) canned and bottled vegetables;
(xii) frozen fruits and vegetables;
(xiii) aerated waters containing fruit juices or pulp;
(xiv) any other unspecified items relating to fruits or vegetables;

(e) "Licensee" means a manufacturer to whom a licence is granted under this Order;

(f) "Licence number" means the number of a licence granted to a manu facturer under this Order ;

(g) "Licensing Officer" means the Agricultural Marketing Adviser to the Government of India and includes any other officer empowered in this behalf by him with the approval of the Central Government ;

(h) "manufacturer" means a licensee engaged in the business of manufacturing any fruit products for sale and includes a person purchasing such fruit products in bulk and repacking them for sale, either by himself or through some one else ;

(i) "Schedule" means a Schedule annexed to this Order ;

(j) "sharbat" means any non-alcoholic sweetened beverage or syrup containing non-fruit juice or flavoured with non-fruit flavours, such as rose. khus, kewra, etc. ;

(k) "synthetic beverage" means any non-alcoholic beverage or syrup, other than aerated waters, containing no fruit juice but having an artificial flavour or colour resembling any fruit ; and

(l) "term" means a period of twelve months ending on the 31st day of December of any year.

3. (1) As soon as may be after the commencement of this Order, and thereafter at the interval of every two years, the Central Government shall, by order published in the Official Gazette, constitute a Committee, to be called the Central Fruit Products Advisory Committee, which shall consist of the licensing officer who shall be the Chairman of the Committee, and the following other members, namely:—

Members

(a) five persons, one each to be elected by the licensees in the northern, central, western, eastern and southern zones, respectively in such manner as the licensing officer may, from time to time, by order direct ;

(b) two persons possessing, in the opinion of the licensing officer, suitable technical qualifications with regard to the manufacture of fruit products, to be nominated by the licensing officer ;

(c) the Director, Central Food Technological Research Institute, Mysore or any other officer of the Institute nominated by him in this behalf ;

(d) the Agricultural Commissioner of the Government of India, or any other officer nominated by him in this behalf ;

(e) the Technical Adviser in the Ministry of Food and Agriculture or any other officer nominated by him in this behalf ; and

(ee) two persons representing fruit and vegetable growers in India to be nominated by the Licensing Officer ;

Member Secretary

(f) the Senior Marketing Development Officer (Fruit Products) in the Directorate of Marketing and Inspection.

(2) A member of the Committee shall hold office for the period for which the Committee has been constituted:

Provided that a member may resign his office by notice in writing given to the licensing officer.

(3) If a vacancy occurs by death, resignation, efflux of time, or otherwise in the office of any elected or nominated members of the Committee, the vacancy so caused shall be filled by election or nomination by the body or authority which elected or nominated him, as the case may be, under sub-clause (1), and any person appointed to fill a casual vacancy shall hold office so long only as the member in whose place he is elected or nominated, would have held office.

(4) The quorum of the Committee shall be five but subject thereto, the Committee may act notwithstanding any vacancy in its number.

(5) The Committee may regulate its proceedings in such manner as it thinks fit, but on any matter on which the votes of the Committee are equally divided the Chairman or the person presiding at the Committee shall have a second or casting vote.

(6) The functions of the Committee shall be to advise the Directorate of Marketing and Inspection in the Ministry of Food and Agriculture on any matter appertaining to the fruit preservation industry.

(7) The Central Government may, at any time, if it so deems expedient in the public interest, by order, dissolve the Committee and thereupon the Committee shall stand dissolved and all persons elected or nominated to the Committee shall cease to be members thereof with effect from the date of the order:

Provided that the Central Government shall take steps to reconstitute the Committee as soon as possible in the manner provided in sub-clause (1).

4. No person shall carry on the business of a manufacturer except under and in accordance with the terms of an effective licence granted to him under this Order in Form 'B'.

5. (1) Every application for the grant of a licence under clause 4 shall be made in duplicate to the licensing officer in Form 'A' and shall be accompanied by a fee of such amount as is appropriate to each of the class of licence for which such application is made under the provision of sub-clause (2).

(2) The following fees being appropriate fees shall be payable for one form or part thereof under sub-clause (1), namely:—

(a) in the case of manufacturer using no power or using up to one Horse Power, Rs. 25 for all types of fruit products:

(b) in the case of a manufacturer using more than one Horse Power but up to ten Horse Power, Rs. 100 for all types of products:

(c) in the case of a manufacturer using more than ten Horse power—

(i) Rs. 40 for synthetic beverages, syrups and sharbats;

(ii) Rs. 40 for vinegar, whether brewed or synthetic;

(iii) Rs. 40 for pickles;

(iv) Rs. 40 for dehydrated fruits and vegetables;

(v) Rs. 80 for squashes, crushes, cordials, barley waters, barrelled juice and ready to serve beverages or any other beverages containing fruit juices or fruit pulps;

(vi) Rs. 80 for jams, jellies and marmalades;

(vii) Rs. 80 for tomato ketchup, tomato sauce and any other sauce;

(viii) Rs. 160 for preserves, candied and crystallized fruits and peels;

(ix) Rs. 200 for chutneys;

(x) Rs. 250 for canned and bottled fruits, juices and pulps, including tomato juice;

(xi) Rs. 250 for canned and bottled vegetables:

(xii) Rs. 250 for frozen fruits and vegetables:

(xiii) Rs. 250 for aerated waters containing fruit juices or pulps;

(xiv) Rs. 250 for any other unspecified items relating to fruits and vegetables.

(3) Any fee paid by any applicant for a licence under this clause shall not be refundable.

(4) The licensing officer may, by order for reasons to be recorded in writing, refuse to grant a licence to any applicant and shall furnish him as soon as possible with a copy of the order so passed.

6. (1) The licensing officer may, after giving the manufacturer an opportunity to show cause and after giving him three months' notice, cancel any license granted to him under this Order for any breach of the terms of the licence or for any contravention of the provisions of this Order or for any failure to comply with any order, direction or requisition made under this Order.

(2) The manufacturer may appeal to the Central Government against any order passed by the licensing officer under sub-clause (1) cancelling the licence within a period of thirty days after the receipt of the order by such manufacturer and the decision of the Central Government shall be final.

7. Every manufacturer shall manufacture fruit products in conformity with the sanitary requirements and the appropriate standard of quality and composition specified in the Second Schedule to this Order. Every other fruit and vegetable product not so specified shall be manufactured in accordance

with the standard of quality and composition laid down in this behalf by the Licensing Officer.

8. (1) Every manufacturer shall, in regard to the packing, marking and labelling of containers of fruit products, comply with the following requirements, that is to say—

(a) every container in which any fruit product is packed shall bear such label as may, from time to time, be approved by the licensing officer and different labels may be approved for different fruit products and a manufacturer in packing such container shall use a label which is for the time being approved by the licensing Officer ;

(*b*) when a bottle is used in packing any fruit products, it shall be so sealed that it cannot be opened without destroying the licence number and the special identification mark of the manufacturer to be displayed on the top or neck of the bottle. The licence number of the manufacturer shall also be exhibited prominently on the side label on such bottle ;

(c) when a tin, barrel or other container is used in packing any fruit product, the licence number of the manufacturer shall either be exhibited prominently on the side label of such tin or be embossed prominently thereon ;

(d) each container in which any fruit product is packed shall specify a code number indicating the lot or the date of manufacture of such fruit product ;

(e) the labels should not contain any statement, claim, design or device which is false or misleading in any particular concerning the fruit products contained in the package or concerning the quantity or the nutritive value or in relation to the place of origin of the said fruit products.

(2) Without prejudice to the generality of the provision contained in sub-clause (1), the licensing officer may, by order published in the Official Gazette, specify the requirements in regard to the packing, marking and labelling of containers of fruit products of any specified type or description, whether such fruit products are manufactured in India or not and every manufacturer or any person for the time being acting on his behalf shall be bound to comply with the provision of such order.

9. Every manufacturer shall, as soon as possible after the end of every term or on or before such date as the licensing officer may in any case, by order, specify in this behalf, submit to the licensing officer a return in

duplicate in respect of each class of fruit products manufactured by him during that term.

10. No person shall sell, or expose for sale, or despatch or deliver to any agent or broker for the purpose of sale, any fruit products which do not conform to the standards of quality and composition specified in the Second Schedule or which are not packed, marked and labelled in the manner laid down in this Order.

Provided that nothing in this clause shall apply to any fruit products imported into India, except when such fruit products are repacked by any licensee for retail sale; but notwithstanding anything in the foregoing provision, no fruit products imported into India may be sold in the original containers unless the name of the country of manufacture of such fruit products is mentioned and unless the said fruit products conform either to the standards of quality laid down in the Second Schedule or to the specifications of the country of their origin, as may be determined by the licensing officer.

11. (1) Any beverage which does not contain at least twenty-five *per centum* of fruit juice in its composition shall not be described as a fruit syrup, fruit juice, squash or cordial or crush and shall be described as a synthetic syrup.

(2) Every synthetic syrup shall be clearly and conspicuously marked on the label as a 'SYNTHETIC' product, and no container containing such product shall have a label, whether attached thereto or printed on the wrapper of such container or, otherwise, which may lead the consumer into believing that it is a fruit product. Neither the word "FRUIT" shall be used in describing such a product, nor shall it be sold under the cover of a label, which carries the picture of any fruit. Aerated water containing no fruit juice or pulp shall not have a label which leads the consumer into believing that it is a fruit product.

12. Every manufacturer to whom any direction or order is issued in pursuance of any provision of this Order shall be bound to comply with such direction or order and any failure on the part of the manufacturer to comply with such direction or order shall be deemed to be a contravention of the provision of this Order.

13. The licensing officer or any officer authorised by him in this behalf may with a view to securing a compliance with this Order:

(a) require any person to give any information in his possession with respect to the manufacture and disposal of any fruit products manufactured by him;

(b) enter upon and inspect, the premises of any licensee or manufacturer at any time during the business hours with a view to satisfying himself that the requirements of this Order are being complied with, and—

(i) on giving a proper receipt, seize or detain any fruit products manufactured, marked, packed or labelled otherwise than in accordance with the provisions of this Order or suspected to be manufactured, marked, packed or labelled in contravention of the provisions of this Order;

(ii) seize or detain, on giving a proper receipt, raw materials, documents, account books or other relevant evidence connected with manufacture of fruit products in respect of which he has reason to believe that a contravention of the Order has taken place;

(iii) dispose of all fruit products or raw materials so seized or detained in such manner as he deems fit:

(c) Not more than twice during one term, inspect any books or other documents of a licensee relating to the manufacture and disposal of fruit products;

(d) Collect, on payment, samples of fruit products intended or exposed for sale, or sold, or under despatch or delivery to any dealer, agent or broker for the purpose of sale, and have such samples analysed at a laboratory selected for the purpose by the licensing officer;

(e) Collect, from the licensee or manufacturer, free of charge, on giving a proper receipt, samples of any fruit products or any chemical, dye or any other ingredients used in the preparation of such fruit products from the premises of such licensee or manufacturer; in respect of which he has reason to believe that a contravention of the Order has taken place;

(f) By an order in writing prohibit the sale or manufacture of any fruit products in respect of which he has reason to believe that a contravention of this Order has taken place.

14. No person shall refuse to furnish any information which he is legally bound to furnish and which may be lawfully demanded of him under the provisions of this Order, or cancel, destroy, mutilate or deface any book or other document with a view to evading the provisions of this Order.

15. No prosecution for contravention of any of the provisions of this Order shall be instituted without the previous sanction of the licensing officer.

16. Nothing in this Order shall be deemed to apply:—

(i) to any syrups which—

(a) contain fruit juices for medicinal use,

(b) are prepared in accordance with the allopathic, homoeopathic, Ayurvedic, Unani or any other system of medicine, and

(c) are sold in bottles bearing a label containing the words 'For medicinal use only' which does not exhibit any picture of fruits, and

(ii) To any fruit products manufactured by a person in any non-municipal areas in quantities not exceeding two hundred pounds during a term.

(iii) To any fruit products produced by institutions, colleges and training centres for demonstration and training purposes and not for sale on commercial basis.

THE FIRST SCHEDULE

FORM 'A'

[*See* clause 5 (I)]

Application for licence under the Fruit Products Order, 1955.

1. Name and address of the applicant.

2. Address of the factory.

3. Description of the fruit products which the applicant wishes to manufacture.

4. Period for which the licence is required.

5. Plan of the factory and list of equipments.

6. Whether any power is used in the manufacture of fruit products. If so, state the exact Horse Power used.

7. Licence fee paid during the previous year.

8. Total value of fruit products manufactured during the previous year.

9. I/We hereby undertake to comply with all the provisions of the Fruit Products Order, 1955.

10. I/We have forwarded a sum of Rs. in respect of the licence fee due according to the provisions of Fruit Products Order, 1955.

[Signature (s) of the applicant (s).]

FORM 'B'

(*See* clause 4)

Government of India
Ministry of Food and Agriculture
Directorate of Marketing and Inspection.

Government of India
Emblem
Licence under Fruit Products Order, 1955

LICENCE NO FPO————————

1. Name and address of licensee.

2. Address of authorised premises for manufacture.

3. Change of premises, if any.

This licence is granted under and is subject to the provisions of F.P.O., 1955 all of which must be complied with by the licensee.

Place.

Date.

Licensing Officer,
Agricultural Marketing Adviser to the Govt. of India.

Validation and Renewal

Period of validity	Categories of fruit products authorised to manufacture	Rate of licence fee per category	Licence fee paid	Signature of Licensing Officer

THE SECOND SCHEDULE

(*See* clauses 7 and 10)

PART I A

Sanitary Requirements of a factory manufacturing fruit products.

The place where any fruit products are manufactured, (hereinafter referred to as the factory), shall comply with the following requirements and in the opinion of the licensing officer shall be fit for manufacturing the item or items for which the licence is granted to the manufacturer.

1. The premises shall be clean, adequately lighted and ventilated and shall be cleaned, if required, by lime-washing or colour washing or painting or disinfecting or deodourising.

2. Windows, doors and other openings suited to screening shall be fly-proof. The doors should have springs so that they may close automatically. The ceiling or roof shall be of permanent nature. The floor should be cemented, tiled or laid in stone.

3. The premises may be used to manufacture any product not repugnant to the manufacture of food and other allied products like Gulkand, Ark, herbaceous products, the like.

4. The premises shall be located in a sanitary place and free from filthy surroundings.

5. All yards, outhouses, stores and all approaches of the premises shall be kept clean and sanitary.

6. The authorised premises shall be so constructed or maintained as to permit hygienic production and all operations, in connection with preparing or packing of product shall be carried out carefully under strict sanitary conditions laid down in the Factories Act, 1934, as amended and modified from time to time.

7. Equipment and machinery when employed shall be of such design which will permit easy cleaning. Adequate arrangements for cleaning of containers, tables, working parts of machinery etc., shall be provided.

8. No vessel, container or other equipment, the use of which is likely to cause metallic contamination injurious to health shall be employed in the preparation, packing or storage of fruit. (Copper or brass vessels shall be always kept tinned. No iron or galvanised iron shall come in contact with fruit products).

9. The water used in the manufacture shall be potable and if required by the Licensing Officer shall be got examined chemically and bacteriologically by any recognised laboratory. The manufacturer will bear the cost of such analysis.

10. There should be efficient drainage system and there shall be adequate provisions for disposal of refuse.

11. Wherever five or more employees of either sex are employed, a sufficient number of latrines for each sex as under shall be provided:—

Number of workers	Number of latrines
5 to 24	1
25 to 49	2
50 to 100	3

Adequate facilities for cleanliness shall be provided by providing clean towels, soaps, hand-scrubbing brushes and wash basins.

12. Wherever cooking is done on open fire, proper arrangements will be made for outlet of smoke and soot.

13. No workers suffering from infectious or contagious disease shall be allowed to work in the factory. Arrangements shall be made for examination of workers and such staff once a year to check that they are free from any infectious, contagious or other diseases and they will be inoculated and vaccinated against the enteric group of diseases once a year and against small-pox once in two years and certificate whereof will be kept for inspection. In case of epidemic, all workers should be inoculated.

14. The workers working in processing and preparation shall be provided with proper aprons and headwears, which shall be clean.

PART I B

1. All the factories licensed under the Fruit Products Order, 1955 will comply with the requirements under Part 1(A) the factories will be further categorised under the following categories:—

(a) Cottage Scale—Maximum yearly sales of Rs. 10,000.

(b) Small Scale—Maximum yearly sales of Rs. 1,00,000.

(c) Large Scale—Yearly sales over Rs. 1,00,000.

2. The following minimum requirements are laid down for cottage scale manufacturers:—

(a) The minimum area for manufacturing premises shall be 250 sq. ft.

(b) Minimum of 100 gallons of potable water shall be available per day.

(c) Wherever process of sterilization is involved in the manufacture, adequate arrangements will be made.

3. The following minimum requirements are laid down for small-scale manufacturers:—

(a) Minimum area for manufacturing premises shall be 500 sq. ft.

(b) A minimum of 250 gallons of potable water shall be available per day.

(c) Wherever process of sterilization is involved in the manufacture, adequate arrangements shall be made.

4. The following minimum requirements are laid down for large-scale manufacturers:—

(a) Minimum area for manufacturing premises shall be 1500 Sq. ft.

(b) A minimum of 1,000 gallons of potable water shall be available per day.

(c) Adequate number of kettles, exhausters, sterilizing equipment shall be provided wherever required.

(d) The manufacture of fruit products shall be supervised by a qualified person.

PART II

Specifications for fruit juice, pulp, concentrate, squashes, cordials, crush, fruit syrups, nectars, aerated water containing fruit juice or pulp and ready to serve fruit beverages.

Product	Variety	Special characteristics		General characteristics
		Minimum percentage of total soluble solids in the final product w/w	Minimum percentage of fruit juice in the final product w/w	
Fruit syrup	Any suitable kind and variety	65	25	
Crush	Do	55	25	Fruit juice shall be unconcentrated liquid product expressed from ripe fruit and may contain portions of the pulp and other cellular matter natural to the fruit. Concentrate, squash and crush shall contain fruit pulp. Cordials shall be the clear final product prepared by adding sugar to the clarified juice, that is, juice from which pulp and other cellular matter have been removed. The only substances that may be added to fruit juice or pulp are water, peel oil, fruit essences and flavours, common salt, sugar, invert sugar and/or liquid glucose, ascorbic acid, citric acid, permitted colours and preservatives. The acidity of the finished product shall not be less than 4 per cent. in the case of pure lemon juice or pulp and not less than 5 per cent. in the case of pure lime juice, but shall not
Squash and nectar	Do	40	25	
Cordial	Do	30	25	
Unsweetened juice	Do	Natural	100	
Sweetened juice	Do	10	85	
Ready-to-serve fruit beverage and aerated water containing fruit juice or pulp	Do	10	5	
Fruit juice concentrate	Do	32	100	

PART II—*Continued*

Specifications for fruit juice, pulp, concentrate, squashes, cordials, crush, fruit syrups, nectars, aerated water containing fruit juice or pulp and ready to serve fruit beverages.

Product	Variety	Special characteristics		General characteristics
		Minimum percentage of total soluble solids in the final product w/w	Minimum percentage of fruit juice in the final product w/w	
				exceed 3.5 per cent. in the case of other juice, crush, squash, cordial, ready-to-serve beverage and syrup expressed as anhydrous citric acid. Canned pulp or juice shall not show any positive pressure at sea level. Canned or bottled pulp or juice shall show no sign of bacterial growth when incubated at 37°C for one week. Canned pulp or juice will not contain any preservative. The finished product shall have a good flavour and be free from objectionable taints and flavours. It shall be of good keeping quality and should show no sign of fermentation. 'Ready-to-serve' beverage may be carbonated. When frozen, the product may be described as 'Ice Squash' or 'Ice Cordial' in conjunction with name of the fruit such as ice orange squash and the like. In case of Mango Juice, 45 per cent. water may be added if declared on the label.

PART III

Specifications for barley waters (lemon, orange, grapefruit etc.)

Product	Variety	Special characteristics			General Characteristics
		Minimum percentage of fruit juice in final product w/w	Minimum percentage of total soluble solids in the final product w/w	Minimum percentage of barley starch in the final product w/w	
Barley waters	Any suitable variety	25	30	0.25	Barley of good quality free from insect attack or fungal diseases shall be used. Fruit juice shall be derived from sound fresh fruit free from insect or fungal attack or any other blemish affecting the quality of the fruit. It shall be free from the pieces of skin, bits of coarse tissue and any extraneous matter. The only substances that may be added are water, sugar, dextrose, invert sugar or liquid glucose, peel oil, flavouring matter, common salt, ascorbic acid, citric acid in sufficient quantity to bring the acidity of the finished product upto a maximum of 2.5 per cent. as anhydrous citric acid, permitted colours and preservatives. The finished product shall have a good flavour characteristic of fruit used and be free from burnt or any other objectionable taints or flavours. It shall be of good keeping quality and shall show no sign of fermentation.

PART IV

Specifications for synthetic syrups, ginger cocktail, ginger beer, ginger ale and sharbats

Product	Variety	Special characteristics	General characteristics
		Minimum percentage of total soluble solids in the final products w/w	
Synthetic syrup and Sharbates	Any kind prepared from harmless herb flowers or essences	65	The only substances that may be added are water, citric acid, harmless herbs, drugs, flowers, essence, sugar, dextrose, invert sugar or, liquid glucose, permitted colours and preservatives. The finished product shall have a good and pleasant taste and flavour, truly characteristic of the flavouring material used and be free from burnt or any other objectionable taints and flavour and crystallization of sugar. It shall be of good keeping quality and should show no sign of fermentation. No artificial sweetening agent shall be used.
Ginger Cocktail	Any kind prepared from ginger or ginger essence	30	
Ginger Beer		30	
Ginger Ale		30	

The container of synthetic syrups will not bear any label which will lean the consumer into believing that it is genuine fruit product. In *addition the label will have the word* **"Synthetic"** *distinctly* and clearly displayed on it. Synthetic syrups will be clearly marked as "contains no fruit juice". Rose, Khus, Kewra, Sandal and other such syrups may not be declared as synthetic but shall not bear picture of fruits on the labels.

Specifications for bottled and canned fruits and vegetables

Product	Variety	Special Characteristics	General characteristics
Bottled or canned fruits	Any fruit of suitable variety	The head space in the can shall not be more than 5/8th of an inch. The drained weight of fruit shall not be less than 50 per cent. of the net weight of the contents (except in the case of berry fruit where this limit will be 40 per cent.). Drained weight shall be determined by draining the contents for two minutes on a sieve of dimensions 8″×8″ having 8 meshes per linear inch.	The fresh fruit to be canned shall be approaching maturity and it shall be practically free from blemishes and shall not have stalks, leaves and other extraneous matter. Where fruit is required to be cut, it shall be cut in halves, quarters or cubes or pieces, reasonably uniform in size. The only substances that may be added are fruits, sugar, invert sugar, citric acid and water. After processing, the fruit shall be firm and the covering liquid clear. The product shall not show any positive pressure at sea level and shall not show any sign of bacterial growth when incubated at 37°C. for one week. No preservative shall be added. No artificial colouring matter shall be present, except in the case of cherries and strawberries where permitted colour may be added. The finished product shall have the characteristic taste of the original material and shall be reasonably free from disintegration, damage from bruises and shall be uniformly prepared.
Bottled or canned vegetables	Any vegetable of suitable variety	The head space in the can shall not be more than 5/8th of an inch. The drained weight of the vegetables shall not be less than 55 per cent. of the net weight of the contents. (Except in the case of canned tomatoes where this limit will be 50 per cent.). Drained weight shall be determined by draining the contents for two minutes on a sieve of dimensions 8″×8″ having 8 meshes per linear inch.	The vegetables shall be reasonably fresh, tender, of good colour and flavour and shall be free from pods, stalks, detached skin, extraneous matter like woody fibre, roots etc., and shall be practically free from blemishes. The only substances that may be added are vegetables, sugar, salt, water, oil or fat, spices, sauce, citric acid and soluble calcium salt. The product shall not show any positive pressure at sea level and shall not show any sign of bacterial growth when incubated at 37°C and 55°C for one

PART V *(Continued)*

Specifications for bottled and canned fruits and vegetables

Product	Variety	Special characteristics	General characteristics
			week. No preservative shall be used. No artificial colouring matter shall be present except in case of peas where permitted colour may be added.
			The finished product shall have the characteristic taste of the original material and shall be reasonably free from disintegration, damage from bruises and shall be uniformly prepared.

Peas or any other product which have been dried or otherwise processed before canning must be described as processed and may not be described as 'Green Fresh' or garden produce. It shall be clearly marked as prepared from dried raw material. Dehydrated and dry fruits if canned shall be clearly marked as prepared from dried raw material.

PART VI

Specifications for jams and fruit cheese

Product	Kind and variety of fruit	Minimum percentage of fruit in the final product on fresh fruit basis w/w	Minimum percentage of soluble solids in the final product w/w	Special characteristics	General characteristics
Jams and Fruit Cheese	Any fruit. Any suitable variety	45 In case of raspberry and strawberry jams 25	68	The finished product shall have a heavy consistency	It may be a single or mixed fruit jam. The fruit used shall be mature, fresh, sound, clean and free from fermentation and mould. Dry or canned fruit, preserved pulp or juice may be used. Pectin derived from any fruit may be added when necessary. The only substances that may be added are sugar, dextrose, invert sugar or liquid glucose, flavouring matter, ascorbic acid, citric acid, permitted colours and preservatives. It shall have the flavour of the original fruit and shall be free from burnt or other objectionable flavours, crystallization, mould growth and shall show no sign of fermentation. If packed in cans, it shall not show any positive pressure at sea level. No artificial sweetening matter shall be added.

When dry fruit is used it shall be clearly declared on the label.

PART VII

Specifications for fruit jellies and marmalades

Product	Kind and variety of fruit	Minimum percentage of fruit in the final product on fresh fruit basis w/w	Minimum percentage of soluble solids in the final product w/w	Special Characteristics	General characteristics
Fruit jelly & marmalade	Any fruit. Any suitable variety	45	65	Fruit jellies shall be made from clear strained fruit extract prepared by boiling the fruit with water. Marmalades shall be made either from strained extract from citrus fruits prepared by boiling the fruit with water or shall be made from fruit juice or pulp. Marmalade shall have suspended slices of peel.	The fruit used shall be sound, clean & free from fermentation and mould. The finished product shall be reasonably uniform and shall be of good keeping quality and attractive colour. The only substances that may be added are sugar, dextrose, invert sugar or liquid glucose, ascorbic acid, critic acid, permitted colours and preservatives. Fruit jelly shall be a product of gelatinous consistency prepared by boiling strained fruit extract with sugar. It shall be clear, sparkling, transparent and of an attractive colour. It should not be syrupy, sticky or gummy and should retain the flavour and aroma of the original fruit. No artificial sweetening matter shall be added. It shall show no sign of fermentation.

The jelly made from sugar and chemical pectin shall be clearly declared as synthetic jelly

PART VIII

Specifications for candied and crystallized or 'glacéd' fruit and peel

Product	Kind and variety	Special characteristics		General characteristics
		Percentage of total sugar w/w	Percentage of reducing sugar to total sugar w/w	
Candied and crystallized or glacéd fruit and peel	Any fruit of suitable variety	Not less than 70	Not less than 25	Candied fruit or peel shall be derived from firm ripe or a slightly mature fruit practically free from insect or fungal attack or any other blemish affecting the quality of the fruit. The only substances that may be added are sugar, dextrose, invert sugar or liquid glucose, citric acid, soluble calcium salts, flavouring matter, permitted colours and preservatives. 'Glacéd' fruit or peel shall be derived from candied product coating with a thin transparent layer of heavy syrup with or without pectin which has dried to a more or less firm texture on the fruit. Crystallized fruit or peel shall be derived from candied product by coating with pure white crystallized sugar or by drying the syrup on wet candied fruit. The finished product shall be translucent and not hard or granular. It shall have a good flavour and shall be free from burnt or any other objectionable flavour.

PART IX

Specifications for preserves

Product	Kind and variety of fruit	Minimum percentage of fruit portion in the final product w/w	Minimum percentage total soluble solids in the final product w/w	General characteristics
Preserves	Any fruit of suitable variety	55	68	It may be a single or mixed preserve but fruit or vegetable used shall be mature, fresh, sound and clean. The only substances that may be added are sugar, dextrose, invert sugar or liquid glucose, flavouring matter, citric acid, ascorbic acid, permitted colours and preservatives. The fruit shall retain form and shall be permiated with the syrup without shrivelling of the individual pieces. It shall be of good keeping quality and attractive colour and it shall be free from burnt and other objectionable flavour, crystallization and mould growth. The product shall not show any fermentation when examined. When packed in cans, it shall show no positive pressure at sea level.

When packed in sanitary top cans, the content shall not be less than 85 per cent. of the total space of the can.

PART X

Specifications for fruit chutneys

Product	Variety	Special Characteristics		Mould count	General characteristics
		Minimum percentage of fruit in the final product w/w	Minimum percentage of total soluble solids in the final product w/w		
Fruit Chutney	Any fruit of suitable variety	40	50	Not in excess of 40 per cent. of the field examined	The product shall be derived from fruit free from insect or fungal attack. All ingredients used in the preparation of chutney shall be thoroughly clean. The only substances that may be added are fruit, fruit pulp, raisins, dry fruit, spices, salt, sugar, onion, garlic, vinegar, acetic acid and permitted preservatives. It shall be of good keeping quality and shall show no sign of fermentation when incubated at 28-30°C and 37°C.

When it is declared as fruit chutney, the names of fruits may not be declared on the label.

Any fruit when calculated in combination with raisins, and dry fruits if used in excess of 5 per cent. of 40 per cent. fruit content in mango chutney or other chutneys shall be declared on the label.

PART XI

Specifications for tomato juice and soups

Product	Variety	Minimum percentage of total soluble solids w/w free of salt	Special characteristics mould count	General characteristics
Tomato juice and soup	Any suitable variety of tomato	Tomato juice 5 Tomato soup 7	Not in excess of 30 per cent. of the field examined	Tomato juice shall be liquid product derived from sound fresh and fully ripe tomatoes practically free from insect and fungal attack or any other blemish affecting the quality of the fruit and may contain finely divided insoluble solids from the flesh of tomatoes. It shall be free from pieces of skin, seeds, bits of coarse tissue and any extraneous matter. The only substances that may be added are salt, not in excess of 1.5 per cent. by weight, sugar, dextrose, malic acid, ascorbic acid, citric acid and permitted colours. In tomato soup the only substances that may be added are spices, sugar, salt, starch, butter and milk solids. The finished product shall have a good flavour characteristic of tomato and be free from burnt or any other objectionable flavour. It shall be of good keeping quality and shall show no sign of fermentation when incubated at 37°C for 7 days. When canned it shall not show any positive pressure at sea level.

PART XII

Specifications for tomato puree and paste

Product	Variety	Special characteristics		General characteristics
		Mould count	Minimum percentage of soluble solids w/w free of salt	
Tomato puree and paste	Any suitable variety of tomato	Not in excess of 60 per cent. of the field examined	Tomato Puree 9 Tomato Paste 25	The product shall be derived from sound, fresh and fully ripe tomatoes practically free from insect or fungal attack or any other blemish affecting the quality of the fruit. Properly prepared and strained tomatoes shall be free from skins and seeds. The only substances that may be added are common salt, citric acid, ascorbic acid, spices, permitted colours and preservatives. The finished product shall have a good flavour characteristic of the tomato and be free from burnt or any other objectionable flavour. It shall be of good keeping quality and shall show no sign of fermentation when incubated at 37°C for seven days. When canned, it shall not show any positive pressure at sea level.

Percentage of total soluble solids shall be declared on the label.

PART XIII

Specifications for tomato ketchup and sauces

Product	Variety	Minimum acidity as acetic acid	Minimum total soluble solids w/w	Special characteristics			General characteristics
				Mould count	Yeast and spores	Bacteria	
Tomato ketchup	Any suitable variety of tomato	1.2 per cent.	25 per cent.	Not in excess of 40 per cent. of the fields examined	Not in excess of 125 per 1/60 c.m.m.	Not in excess of 100 million per c.c.	The products shall be derived only from sound and wholesome tomatoes practically free from insect or fungal or any other blemish affecting the quality of the fruit. Skins and seeds shall be excluded. The only substances that may be added are spices, salt, sugar, vinegar, acetic acid, onion, garlic, permitted colours and preservatives. It shall not contain any other fruit or vegetable substances. The finished product shall have good flavour and shall be free from burnt or any other objectionable flavours. It shall be of good keeping quality and shall show no sign of fermentation.

PART XIII(A)

Specifications for sauces

Product	Kind and variety	Special characteristics				General characteristics
		Mould count	Yeast and spores	Bacteria	Minimum percentage of acidity as acetic acid w/w	
Sauce	Any suitable kind and variety of fruit or vegetable	Not in excess of 40 per cent. of the field examined	Not in excess of 125 per 1/60 c.m.m	Not in excess of 100 million per c.c.	1.2	The product shall be derived from wholesome fruits and vegetables which shall be practically free from insect or fungal attack or blemishes affecting the quality of the fruit. The only substances that may be added are fruit, vegetable pulp, juice, dried fruits, sugar, spices, salt, vinegar, citric acid, acetic acid, malic acid, onion, garlic, flavouring materials, permitted colours and preservatives. The finished product shall have good flavour and shall be free from burnt or other objectionable flavours. It shall be of good keeping quality and shall show no sign of fermentation when incubated at 37°C.

The names of the fruit, vegetables or dried fruit used shall be described on the label.

PART XIV

Specifications for brewed and synthetic vinegar

Product	Variety	Special characteristics: Minimum percentage of acidity in final product (w/v)	General characteristics
Brewed and synthetic Vinegar	Any suitable medium such as fruits, malt, molasses, sugarcane juice, etc.	Brewed Vinegar—3.75 Synthetic vinegar—3.75	"Brewed Vinegar means a liquid derived from alcoholic and acetous fermentation of any suitable medium such as fruits, malt, molasses, sugarcane, etc. Brewed Vinegar shall conform to the following standards:— 1. It shall contain at least 3.75 grams of acetic acid per 100 ml. 2. It shall contain at least 1.5 per cent W/V of total solids and 0.18 per cent ash. 3. It shall not contain (i) sulphuric acid or any other mineral acid (ii) lead or copper (iii) arsenic in amounts exceeding 1.5 parts per million and (iv) any foreign substance or colouring matter except caramel. 4. Malt Vinegar, in addition, shall have at least 0.05 per cent. of Phosphorus pentoxide (P_2O_6) and 0.04 per cent. of nitrogen. Brewed Vinegar shall not be fortified with acetic acid".

The kind of medium used for preparing brewed vinegar shall be declared on the label. Synthetic vinegar shall be distinctly labelled as "Synthetic Vinegar" and shall state on label "prepared from acetic acid."

PART XV

Specifications for pickles in vinegar

Product	Variety	Special characteristics: Minimum percentage of acidity of fluid portion as acetic acid	General characteristics
Pickles in vinegar	Any vegetable of suitable variety	2	The vegetables used in the preparation of pickles shall be wholesome. They shall be practically free from fungal or insect attack. All the ingredients used shall be thoroughly clean and free from extraneous matter. The fluid portion of the pickles which shall be vinegar, shall constitute not more than 1/3 of the total content and shall not contain any ingredient than spices, salt and sugar. The pickles shall be free from added copper, mineral acids, alum, preservatives or harmful colours and shall show no sign of fermentation. The product shall be reasonably free from sediment.

When more than one vegetable is used, the product shall be labelled as "mixed pickles".

PART XVI

Specifications for pickles in citrus juice or in brine

Product	Variety	Minimum percentage of salt (w/v)	Special characteristics	General characteristics
Pickles in citrus juice or in brine	Any fruit or vegetable of suitable variety	12	In case of pickles in citrus juice, citric acid shall not be less than 1.2 per cent. Only citrus fruit juices shall be used.	The vegetable and fruits used in the preparation of pickles shall be wholesome. They shall be free from fungal or insect attack or any type of rot. All the ingredients used shall be thoroughly clean and free from extraneous matter. Only substances that may be added are spices, salt, sugar, jaggery, onions, garlic and soluble calcium salts. Pickles shall be free from added copper, alum, mineral acids or preservatives.

PART XVII

Specifications for oil pickles

Product	Variety	Oil	General characteristics
Oil pickles	Any fruit or vegetable of suitable variety	Any edible vegetable oil like rapeseed, mustard, olive oil, etc.	The fruits and vegetables used in the preparation shall be wholesome and shall be free from fungal or insect attack. The only substances that may be added are spices, salt, oils, sugar, jaggery, onions, garlic, acetic acid, turmeric, condiments. All the ingredients used shall be thoroughly clean and free from extraneous matter. The pickles shall be of pleasant taste and flavour, and be free from added copper, alum, mineral acid or preservatives.

Kind of fruit or vegetable used shall be declared on the label.

PART XVIII

Specifications for sun-dried and dehydrated fruit

Product	Variety	General characteristics
Sun-dried and dehydrated fruits	Any fruit of suitable variety	The fruit used for drying shall be clean, wholesome and shall be practically free from insect or fungal attack. The dried or dehydrated fruits may contain permitted preservatives. The product shall be free from visible mould, insect or larvae.

The kind of dried fruit packed in the container shall be declared on the label.

PART XIX

Specifications for sun-dried and dehydrated vegetables

Product	Variety	Special characteristics	General characteristics
Sun-dried and dehydrated vegetables	Any vegetable of suitable variety	Ash insoluble in Hydrochloric acid shall be not more than 0.5 per cent.	The product shall be prepared from wholesome vegetables free from blight, discolouration or fungi. The only edible portion of the vegetable shall be used and it shall be free from stalks, peels, stems and extraneous leaves. The dried or dehydrated vegetable may contain permitted preservatives. The finished product shall be of good edible quality and shall reasonably reconstitute to its original shape and quality on boiling for fifteen minutes to an hour. The finished product shall be free from visible mould, insect or larvae.

Kind of dry vegetable shall be declared on the label.

PART XX

1. Fruit and vegetable products shall be packed in such suitable containers as are described below and all containers shall be securely packed and sealed.

(a) Canned fruits, juices and vegetables. Sanitary top cans made from suitable kind of tin-plate shall be used for canning fruits, juices and vegetables.

(b) Bottled fruits, juices and vegetables. Bottles and jars capable of giving hermetic seal shall be used.

(c) Juices, squashes, crush, cordials, syrups, barley waters and other beverages shall be packed in clean bottles and securely sealed. These products when frozen and sold in the form of ice shall be packed in suitable cartons. Juices or pulp may be packed in wooden barrels when sulphited.

(d) Preserves, jams, jellies and marmalades—New cans, new cannisters, clean jars, bottles, chinaware jars or aluminium containers may be used for packing these products and they shall be securely sealed.

(e) Vinegar, pickles, ketchup, sauces and chutneys. Clean bottles, jars, and wooden casks may be used.

(f) Candied fruits and peels and dried fruits and vegetables. Paper bags, cardboard or wooden boxes, new tins, bottles, jars, aluminium or other suitable approved containers shall be used.

2. Following particulars shall be clearly marked on the containers:

(a) Kind and variety of fruit.

(b) Nature of the product, *viz.*, juice, squash, marmalade, etc.

(c) Net weight or volume of the contents (variation in net content may be 5 per cent. in case of bottled fruit products)

(d) Name of the manufacturer and place of manufacture or the brand owner's name and place of manufacture.

(e) Where any permitted preservative and/or colouring agent other than natural colour is added, a statement to the effect that it contains permitted preservative and/or colouring agent other than natural colour.

PART XXI

Limits of Heavy Metals in Fruit products

Lead—Not more than 5 parts per million.

Copper—Not more than 15 parts per million.

Zinc—Not more than 19 parts per million.

Tin—Not more than 143 parts per million.

Arsenic and arsenious oxide—Not more than 1.43 parts per million.

PART XXII

List of Permissible Harmless Food Colours

1. Natural colouring matter which may be used:

The following natural colouring principles, whether isolated from natural colours or produced synthetically, may be used in or upon any article of food:—

(*a*) Cochineal or Carmine
(*b*) Carotene and Carotenoids
(*c*) Chlorophyll
(*d*) Lactoflavin
(*e*) Caramel
(*f*) Annatto
(*g*) Ratanjot
(*h*) Saffron
(*i*) Curcumin

2. Coal tar dyes which may be used:

No coal tar dyes or a mixture thereof except the following shall be used in fruit products.

Colour	Common name	Colour index	Chemical class
1. Red	Ponceau 4 R	185	Azo
	Carmoisine	179	"
	Red 6B	57	"
	Red FB	225	"
	Acid Magenta II	692	Triphenylmethane
	Fast Red E	182	Azo
2. Yellow	Tartrazine	640	Pyrazolone
	Sunset Yellow FCF	*	Azo
3. Blue	Blue VRS	672	Triphenylmethane
	Indigo Carmine	1180	Indigoid
4. Black	Brilliant Black	BN	Bisazo

*F. D. & C. Index No. 6.

3. Dyes when used in fruit products shall be pure and free from all harmful impurities.

The maximum limit of any permitted coal tar colours or mixture of permitted coal tar colours which may be added to any fruit product shall not exceed 1.5 grains per pound of the final fruit product for consumption.

PART XXIII

Limits for permitted preservative in fruit products

Permitted preservatives are:

(*a*) Benzoic acid including salts thereof; and

(*b*) Sulphurous acid including salts thereof.

Only one of the preservatives will be used in the fruit products listed below:

	Fruit products	Preservative	Parts per Million
1.	Fruit and fruit pulp or juice (not dried) for conversion into jam or crystallized, glacéd or cured fruit or other products.		
	(*a*) Cherries	Sulphurdioxide	3,000
	(*b*) Strawberries & Raspberries	-do-	2,000
	(*c*) Other fruits	-do-	1,000
2.	Fruit juice concentrate	-do-	1,500
3.	Dried fruits		
	(*a*) Apricots, peaches, apples, pears and others	-do-	2,000
	(*b*) Raisins or sultanas	-do-	750
4.	Squashes, crushes, fruit syrups, cordials, fruit juices and barley waters	Sulphurdioxide or Benzoic acid	350 600
5.	Jam, marmalade, preserve and fruit jelly	Sulphurdioxide or Benzoic acid	40 200
6.	Crystallized, glacéd or cured fruit (including candied peel).	Sulphurdioxide	150
7.	Fruit and fruit pulp not otherwise specified in this schedule	-do-	350
8.	Sweetened ready-to-serve beverages	-do- or Benzoic acid	70 120
9.	Pickles and chutneys made from fruit and vegetables	Benzoic acid	250
10.	Tomato and other sauces	-do-	750
11.	Dehydrated vegetables	Sulphurdioxide	2,000
12.	Tomato puree and paste	Benzoic acid	250
13.	Syrups and *Sharbats*	Sulphurdioxide or Benzoic acid	350 600

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