DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY

(STUDY MATERIAL)

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LECTURE -1

Production and processing scenario of Fruits and vegetables in India and world-scope of fruit and vegetable processing industry in India- present status, constraints and prospective.

The Green Revolution and subsequent efforts through the application of science and technology for increasing food production in India have brought self-reliance in food. The impetus given by the Government, State Agricultural Universities, State Departments of Agriculture and other organizations through the evolution and introduction of numerous hybrid varieties of cereals, legumes, fruits and vegetables and Improved management practices have resulted in increased food production. However, the nation still faces the problem of the use of improper methods for the storage of food stuffs, leading to great wastage of the food produced. Such loses in the food front aggravate the existing syndromes of under nutrition and malnutrition.

Fruits and vegetables, which are among the perishable commodities, important ingredients in the human dietaries. Due to their high nutritive value they make significant nutritional contribution to human well-being. They are the cheaper and better source, the protective foods. If they can be supplied in fresh or preserved form throughout the year for human consumption, the national picture will improve greatly.

The perishable fruits and vegetables are available as seasonal surpluses during certain parts of the year in different regions and are wasted in large quantities due to absence of facilities and know-how for proper handling, distribution, marketing and storage. Furthermore, massive amounts of the perishable fruits and vegetables, produced during a particular season result in a glut in the market and become scarce during other seasons. Neither can they all be consumed in fresh condition nor sold at economically viable prices.

In developing countries agriculture is the mainstay of the economy. As such, it should be no surprise that agricultural industries and related activities can account for a considerable proportion of their output. Of the various types of activities that can be termed as agriculturally based, fruit and vegetable processing are among the most important. Therefore, fruit and vegetable processing has been engaging the attention of planners and policy makers as it can contribute to the economic development of rural population. The utilization of resources both material and human is one of the ways of improving the economic status of family.

In the post-green revolution era, even though food grains have been taken care of, fruits and vegetables for want of simple technologies of processing, preservation and transport to various places of need, have suffered post-harvest losses, estimated to be more than 25% and only about 1 % of the total fruits and vegetables produced are processed. All forms of preserved fruits are in the reach of only. the urban elite, and the rural masses who produce more than 90% of these fruits and vegetables are usually deprived of their usage.

India has made a fairly good progress on the Horticulture Map of the world with a total annual production of Fruits and Vegetables touching over 131 Million Tonnes during 1998-99. Today, India is the second largest producer of the Fruits (44 Million Tonnes) and Vegetables (87.5 Million Tonnes) as mentioned in Indian Horticulture Database-2000 published by National Horticulture Board. Our share in the world production is about 10.1 per cent in fruits and 14.4 per cent in vegetables. The Horticulture crops cover about 8 per cent of the total area contributing about 20 per cent of the gross agricultural output in the country. India produces 41.7% of the World mangoes, 25.7% of the bananas and 13.6 per cent of the world onion. However, the productivity of fruits and vegetables grown in the country is low as compared to the developed countries. The overall productivity of the fruits is 11.8 tonnes per hac. and veoetables is 14.9 tonnes ner hac.

Major World Producers of Fruits and Vegetables (1998-1999)*

Fruits		**Vegetables**	
Country	**Production ('000' Mtn)**	**Country**	**Production ('000' Mtn)**
WORLD	**434703**	WORLD	**606053**
INDIA	**44042**	INDIA	**87536**
CHINA	**53926**	CHINA	**237136**
BRAZIL	**37179**	USA	**34924**
USA	**31494**	TURKEY	**21743**
ITALY	**17676**	ITALY	**14501**
SPAIN	**13323**	JAPAN	**13629**
MEXICO	**12342**	IRAN	**12751**
FRANCE	**10863**	EGYPT	**12379**
TURKEY	**10263**	RUSSIAN FED	**12098**
PHILIPPINES	**10160**	SPAIN	**11496**

'" Source: Neai *et al.* (200m

Fruit and vegetable processing industries in India:

Fruits and vegetables and their products have gained considerable importance by contributing significantly to the economy of many countries in the world. In developing countries agriculture is the main stay of economy. Among the various activities, which are termed agriculturally based, fruits and vegetables processing are the most important. India has arable land of 184 million hectares producing various agro stocks including fruits and vegetables (151.5 MT) and is considered as a goldmine as far as raw material base for food processing industries is concerned. India is the second largest producers of fruits in the world producing 50 million tonnes and accounting for 10% of the world's fruit production. It is also the second largest producers of vegetables, producing 101 million tonnes accounting for 15% of the world's production. Apart from fruits and vegetables, India also produces about 20 million tonnes of root and tuber crops. Considering the wide ranging and large raw material base that the country offers, along with the consumer base of over one billion people, the processing industry holds tremendous opportunities for large investment. Depending on factors like availability, socio-economic conditions, tradition, taste and culture, some of these fruits and vegetables are regularly consumed in the fresh and processed forms.

Even though India is second largest producer of fruits and vegetables in the world after china, the present quantity of fruit and vegetable processing is very meager (around 2.2%) as compared to 80% in USA, 70% France, 80% Malaysia and 30% Thailand. The slow growth of Indian fruit and vegetable processing is still prevailing. The per capita availability of vegetables is around 195 g and it is much below the recommended daily allowance (RDA) of 280 g but as far as fruits are concerned, the situation is really encouraging with a per capita availability around 90 g as against RDA of 60 g. The fruit and vegetable processing in India is highly decentralized, small-scale industries accounting for 33%, organized 25%, unorganized 42% and large number of units in cottage/household and small scale sector, having capacities of up to 250 tonnes/ annum. In organized sector of India, there are about 5000 units and several thousands in unorganized sector of fruit and vegetable processing are in the job. The installed capacity of fruit and vegetable processing industry has increased from two million tonnes in year 2000 to only 2.1 million tonnes in 2006. Since 2000, the industry has seen significant growth in ready to serve beverages, fruit juices/pulps, dehydrated and frozen fruit and vegetable products, pickles, processed mushrooms and curried vegetables and units engaged in these segments are export oriented. India has exported total of 0.325 miilion tonnes of processed products valued at Rs. 4.34 billion during 2004 - 05, which was significantly increased to 0.55 million tonnes in the year 2006 - 07 valued at Rs. 17.31 billion.

India is progressing very fast in various spheres due to the rapid urbanization, increased literacy and rising per capita income are flourishing in a steady way. This has resulted in rapid growth and changes in demand patterns leading to tremendous new opportunities for exploiting the large latent market. An average Indian spends about 50% of household expenditure on food items. In addition, India is the largest democratic country with extensive administrative structure, sound financial network and independent judiciary. India has a strong raw material base available all round the year, vast domestic market and a number of incentives. Growth of processed food industry in India is hampered by numerous factors such as non availability of suitable quality raw material, low capacity utilization, obsolete technologies, lack of basic infrastructure for proper storage, preservation and distribution facilities resulting in the wastage of the commodity. To overcome the problem, government has recently established special economic zones (SEZs), for the purpose of promoting export. These SEZs do not impose duty on import of inputs and they enjoy the fiscal and foreign exchange procedure and allow 100% FDI. Indian government has already initiated measures to open the doors of the food processing industry to international players to improve the infrastructure, appropriate packaging material, adequate cold storage spaces and transportation facilities. It is imperative for the country’s pride and also for the economic growth to sustain and enhance its share in global food processing industry.

Indian government is striving hard to build a strong fruit and vegetable processing industry to sustain its market share in the global market. The concept of agri export zones and mega food parks has been conceptualized by the Indian Government to promote food-processing industry and also its sub-sector like fruit and vegetable processing industry in India. Indian government has considered for investing US $ 22.97 million in establishing around 10 mega food parks and offered the tax benefits to the concerned sub-sector of the food processing industry. The present fruits and vegetables processing scenario compared to the developed countries is not satisfactory. The factors responsible for this are many and complex in nature. The industries growth and potential may be reviewed in a manner enumerated below.

- The basic problem associated with the industry is the sustained availability of suitable raw material for processing. Moreover, the productivity is also very low as compared to many other countries. The cost of raw material used for processing is 3 to 4 times more as compared to costs in the world market.
- With the increasing competition from the international trade, quality of imported products will become more available in the developing countries. Therefore, to compete, the developing countries require proper post harvest management, distribution and processing chains. Hence, it is necessary to have better human resource capabilities in technology, management and marketing.
- Policies like participation of private sectors through contract farming and land-leasing arrangement can assure supply of good quality raw material to the fruit and vegetable processing industry.
- Clustering of small and medium units can reduce cost of production. Cluster project initiated by MoFPI may be of great help and it should be enforced.
- It is very vital to educate consumer about the processed fruit and vegetable based products and their nutritional quality.
- Backward-forward integration from farm to processors and consumers and also to generate more employment to eliminate poverty.
- It is imperative to have better linkages between fruit and vegetable processing industry, Government and other institutions.
- Should have control over taxation with other nations during export and import of the processed fruit and vegetable products.
- It is necessary to integrate food laws, which is expected to meet the requirements in the International trade and make the Indian food industry competitive in the global market.

LECTURE -2

Overview of Principles of preservation- Drying /dehydration-process-types pretreatments required-factors affecting rate of dehydration-Reconstitution - coefficient of rehydration.

Food preservation can be defined as the science which deals with the methods of prevention of decay or spoilage of food, thus allowing it to be stored in a fit condition for future use. It is better if the following directions are kept in mind to control the spoilage.

1. Raw materials should be thoroughly examined and handled hygienic conditions to avoid microbial spoilage.
2. Equipments must be cleaned every time before use.
3. The cans should be carefully filled and exhausted sufficiently to produce a good vacuum.
4. Processing should take place as soon as possible after sealing of cans or bottles. The cooling process should also be done in such a manner that the cans are left sufficiently warm to dry off surplus moisture but not hot enough to cause "stack" burning.
5. Use of contaminated water should be avoided.
6. The finished products after canning or bottling should be stored in well- ventilated rooms in a cool and dry place. High storage temperature should be avoided.

Freshly prepared products are highly attractive in appearance and possess good taste and aroma, but deteriorate rapidly if kept for some time. This is on account of several reasons such as. fermentation caused by moulds, yeasts and bacteria, enzymes present in the product may affect the colour and flavour adversely, e.g. apple juice turns brown due to the activity of oxidative enzymes in it, chemicals present in the pulp/juice may react with one another and spoil its taste and aroma, air coming in contact with the product, may react with the glucosidal materials present in it and render the product bitter, e.g., Navel orange and sweet lime juices often turn bitter when they are exposed to air even for a short time. and traces of metal from the equipment may get into the product and spoil its taste and aroma. In the preservation of foods by various methods, the following principles are involved:

1. Prevention or delay of microbial decomposition

(a) by keeping out microorganisms (asepsis);

(b) by removal of microorganisms, e.g., by filtration;

(c) by hindering the growth and activity of microorganisms, e.g., by low temperature, drying, anaerobic conditions, chemicals or antibiotics; and

(d) by killing the microorganisms, e.g., by heat or radiation.

2. Prevention or delay of self-decomposition of the food

(a) by destruction or inactivation of enzymes, e.g., by blanching;

(b) by prevention or delay of chemical reactions, e.g., prevention of oxidation by means of an antioxidant.

3. Prevention of damage by insects, animals, mechanical causes, etc.

To retain the natural taste and aroma of a product, it is necessary to preserve it soon after preparation, without allowing it to stand for any length of time. Various methods of preservation are employed and each has its own merits. The methods generally used are as under:

1. Asepsis (Absence of infection)

Asepsis means preventing the entry of microorganisms. Maintaining of general cleanliness while, picking, grading, packing and transporting of fruits and vegetables increases their keeping quality and the products prepared from them will be of superior quality.

Washing or wiping of the fruits and vegetables before processing should be strictly followed as dust particles adhering to the raw material contain microorganisms and by doing so the number of organisms can be reduced considerably.

2. Preservation by High Temperature

Coagulation of proteins and inactivation of their metabolic enzymes by the application of heat leads to the destruction of microorganisms present in foods. Further, heating can also inactivate the enzymes present in the food. Heating food to high temperatures can, therefore, help to preserve it. The specific treatment varies with:
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Thermal Death Time (TDTI) of bacteria

Bacteria	Time (min)	Temperature (0C)
Salmonella typhosa	4.3	60
Staphylococcus aureus	18.8	60
E. *coli* -/	20-30	57.3
Streptococcus thermophilus	15	70:.77
L. *bulgaricus*	30	**71**

The spare-farming bacteria found in tomato juice, however, require heating at a higher temperature of 88°C for a much longer duration. Heat resistance of bacterial spores are also, given be law in the Table.

Heat resistance of bacterial spores

Spore	Time (min) to kill at 100°C
B. *anthracis*	1.7
B. *subtilis*	15-30
C. *batulinum*	100-300
Flat sour bacteria	aver 1000

Enzymes also require air (oxygen) at normal temperature far their action and can, therefore, be destroyed at a moderate temperature by removing air from the juice. 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 85°C, or for one minute at 88°C.

Usually juices, R.T.S. and nectar are pasteurized at about 85°C for 25 to' 30 minutes according to' the nature of the juice and the size of the container.

Acid fruit juices require a lower temperature and less time far pasteurization than the less acid ones. Juice can be pasteurized in two' ways: (i) by heating it at a law temperature for a long period, or (ii) by heating at a high temperature for a short time only (HTST method). There are three methods of pasteurization.

(a) Bottle or 'Holding' pasteurization: This method is commonly used for the preservation of fruit juices at horne. The extracted juice is strained or clarified as the case may be, and filled in battles, leaving sufficient head space far the expansion of the juice during heating. The battles are then sealed air:tight and pasteurized.

(b) Overflow method: Juice is heated to' a temperature about 2.5°C higher than the pasteurization temperature, and then filled in hat sterilized battles up to' the brim, taking care that during filling and sealing the temperature of juice does not fall below the pasteurization temperature. The sealed battles are pasteurized at a temperature 2.5°C lower than the filling and sealing temperature and then cooled. This method is very suitable for grape juice because it minimizes the adverse effect of air and the quality of the juice.

(c) Flash pasteurization: The juice is heated rapidly to' a temperature of about 5.5°C higher than the pasteurization temperature and kept at this temperature for about a minute. The method has been developed specially for the canning of natural orange juice but can also be used for grape and apple juices. It has the following advantages:

(a) loss of flavour is minimum,
(b) vitamins are not destroyed
(c) effects economy of time and space.
(d) keeps the juice uniformly cloudy, and
(e) juice is heated uniformly and thus its cooked taste is minimum.

(ii) Sterilization

Sterilization by definition means the destruction of all viable microorganisms. Heat sterilization is the most effective process of food preservation. It has c severe effect on heat liable nutrients, particularly vitamins and mainly through Maillard reaction, the nutritional quality of proteins is reduced. By this method all microorganisms are completely destroyed due to high temperature. The time and temperature necessary for sterilization vary with the type of food. Fruit and tomato products should be heated at 100°C for 30 minutes so that the spore forming bacteria which are sensitive to high acidity may be completely killed. Vegetables like green peas, okra, beans. etc., being non-acidic and containing more starch than sugar, require higher temperature to kill the spore-forming organisms. Continuous heating for 30 to 90 minutes at 116°C is essential for their sterilization. Before using, empty cans and bottles should also be sterilized for about 30 minutes by placing them in boiling water. Temperatures above 100°C can only be obtained by using steam pressure sterilizers such as pressure cookers and autoclaves.

The major differences between pasteurization and sterilization are as under:

S. No.	Pasteurization	Sterilization
1.	partial destruction of microorganisms	Complete. destruction of microorganisms
2.	Temperature below 100 °C	Temperature 100 °C and above
3.	Normally used for fruits	Normally used for vegetables

A quick technique of "Aseptic Canning", using high temperature, has also been developed which not only reduces the sterilization time but also improves the quality of the product markedly. Another methods is "Hot Pack or Hot Fill", generally used in homes for preparation of jam and other products. Both are discussed here in brief.

Aseptic Canning

Aseptic canning is a technique in which food is sterilized outside the can and then aseptically placed in previously sterilized cans which are subsequently sealed in an aseptic environment.

This process, also known as Martin aseptic canning, was first commercialized in 1950. The method is basically a short-time, high-temperature sterilization process. It combines flash pasteurization and cooling with aseptic packaging of fluid and semi-fluid products, thus eliminating the retorting and subsequent cooling phases.

This process consists of four separate operations, carried out one after another in a closed interconnected apparatus: (i) sterilization of product by appropriate quick heating, holding and cooling, (ii) sterilization of containers and covers with superheated steam, Iiii) aseptic filling of cooled, sterile product into sterile containers, and (iv) aseptic sealing of the containers with sterile covers.

The temperature employed may be as high as 149°C and sterilization takes place in 1 or 2 seconds to yield products of the highest quality.

Details of process

Quick heating of liquid food may be done in a plate-type or in a tubular- scraped-surface-type heat exchanger. The latter consists essentially of a tube within a tube. Steam flows through the space between the tubes while food flows through the inner tube. The inner tube is also provided with a rotating shaft or mutator equipped with scraper blades to prevent the food from burning on the heat exchanger surface. In contact with the hot surface the thin layer of food is brought to sterilization temperature in a second or less. If it is desired to prolong the time beyond this, then a holding tube is added. Such rapid sterilization at extremely high temperatures, e.g., 1 or 2 seconds at 149°C, is sometimes referred to as ultra-high temperature (UHT) sterilization. The sterile food is now quickly cooled, since at these high temperatures product quality can be impaired in seconds. Quick cooling can be accomplished with the same types of plate or tubular-scraped-surface heat exchangers, by using refrigerants instead of steam.

The sterile cooled food now enters the aseptic canning line. This consists of a tunnel through which cans without their lids are conveyed and sterilized by superheated steam, a sterile filling zone also heated by steam where the cans enter a heated sterile can lid dispenser, and a closing machine which seals cans in a steam-heated sterile atmosphere. After the cans are sealed they are cooled by spraying water. Not only must the temperature of the food be accurately controlled before it enters the aseptic canning line, but can and lid sterilization temperatures must also be controlled since tinplate begins to melt at about *232°C* and the temperature of superheated steam can be higher than this. Aseptic packaging is not limited to metal containers. An aseptic system for bottling UHT sterilized cream has recently been introduced on a commercial basis. However, engineering problems related to breakage of glass due to thermal shock have not yet been completely solved.

Another form of aseptic packaging utilizes flexible packaging materials which are sterilized, formed, filled and sealed in a continuous operation. In some cases the disinfectant property of hydrogen peroxide is' combined with heat to make 'it possible to use lower temperatures for sterilizing less heat-resistant packaging materials. Coffee cream is packaged in small single service paper packets in this way. Chlorine and other chemicals can be expected to find wider use in such applications in the future.

Hot Pack or Hot Fill

This term refers to the filling of previously pasteurized or sterilized food, while still hot, into clean but not necessarily sterile containers, under clean but not necessarily aseptic conditions. Such packaging is based on the fact that the heat of the food and some holding period before cooling the closed container render the container commercially sterile, e.g., in home when fruit pulp and sugar are boiled together to make jam and the hot jam is poured into jars that have been previously boiled, the principle of hot pack is being employed.

3. Preservation by Low Temperature

Microbial growth and enzyme reactions are retarded in foods stored at low temperatures. The lower the temperature, the greater the retardation. Low temperatures can be produced by (i) cellar storage (about I5°C), (ii) refrigeration or chilling (0 to 5°C), and (iii) freezing (-18 to -40°C).

(i) Cellar storage (about 15°C) : The temperature in cellars (under- ground rooms) where surplus food is stored in many villages is usually not much below that of the outside air and is seldom lower than I5°C. It is not low enough to prevent the action of many spoilage organisms or of plant enzymes. Decomposition is, however, slowed down considerably. Root crops, potatoes, onions, apples and. similar foods can be stored for limited periods during the winter months.

(ii) Refrigeration or chilling (0 to 5°C): Chilling temperatures are obtained and maintained by means of ice or mechanical refrigeration. Fruits, vegetables and their products can be preserved for **a few** days to many weeks when kept at this temperature. The best storage temperature for many foods is slightly above O°C but his varies with the product and is fairly specific to it. Besides temperature, the relative humidity and the composition of the air can affect the preservation of the food. Commercial cold storages with proper ventilation and automatic control of temperature are now used throughout the country (mostly in cities) for the storage of semi-perishable foods such as potatoes and apples. This has made such foods available throughout the year and has also stabilized their prices.

(ii) Freezing (-18 to -40°C): Freezing method is the most harmless method of food preservation. Microbial growth is inhibited and the rate of chemical reactions is slowed down at low temperatures. In commercial frozen storage the activity of meat enzymes is stopped while plant foods have to be blanched before freezing to avoid undesirable quality changes. At temperatures below the freezing point of water (-18 to - 40°C) growth of microorganisms and enzyme activity are reduced to a minimum. Most perishable foods can be preserved for' several months if the temperature is brought down quickly (quick freezing) and the food kept at these temperatures. Foods can be quick frozen in about 90 minutes or less by: (i) placing them in contact with the coil through which the refrigerant flows, (ii) blast freezing in which cold air is blown across the food, and {iii) dipping in liquid nitrogen.

Quick frozen foods maintain their quality and freshness when they are thawed (brought to room temperature) because only very small ice crystals are formed when foods are frozen in this manner. Many microorganisms can survive this treatment and become active and spoil the food if it is kept at higher temperatures. Frozen foods should, therefore, always be kept at temperatures, below -5°c. Enzymes in certain vegetables can continue to act even after being quick frozen and so such vegetables have to be given a mild heat treatment called blanching (above 80°C) before they are frozen to prevent development of off-flavours.

The best way of preserving pure fruit juice is by freezing. Properly frozen juice retains its freshness, colour and aroma for a long time. This method is particularly useful in the case of juices whose flavour is adversely affected by heating. The juice is first deaerated and the vacuum filled with nitrogen gas. It is then transferred into containers which are hermetically sealed and frozen. Moulds are sometimes not affected by this technique. Juice can be kept in good condition for a long time in frozen form at -12 to -17°C by excluding air. It is defrosted before consumption.

4. Preservation by Chemicals

Microbial spoilage of food products is also controlled by using chemical preservatives which do not include salt, sugar, acetic acid, oils, alcohols, etc., but only microbial antagonists. The inhibitory action of preservatives is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes.

Pasteurized squashes, cordials and crushes have a cooked flavour. After the container is opened, they ferment and spoil within a short period, particularly in a tropical climate. To avoid this, it is necessary to use chemical preservatives. Chemically preserved squashes and crushes can be kept for a fairly long time even after opening the seal of the bottle. It is, however, essential that the use of chemicals is properly controlled, as their indiscriminate use is likely to be harmful. The preservative used should not be injurious to health and should be non-irritant. It should 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, but does not include common salt (sodium chloride), saltpetre (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 chemical preservatives permitted in many countries are :

(i) sulphur dioxide (including sulphites), and

(ii) benzoic acid (include benzoates)

These two are also allowed in India according to the Fruit Product Order (F.P.O.) of 1955.

(i) Sulphur dioxide

It is widely used throughout the world in the preservation of juice, pulp, nectar, squash, crush, cordial and other products. It has good preserving action against bacteria and moulds and inhibits enzymes, etc. In addition, it acts as an antioxidant and bleaching agent. These properties help in the retention of ascorbic acid, carotene and other oxidizable compounds. It also retards the development of nonenzymatic browning or discolouration (after killing the enzyme) of the product. It is generally used in the form of its salts such as sulphite, bisulphite and metabisulphite.

Potassium metabisulphite ($K_20.2S0_2$ or $K_2S_20_S$) is commonly used as a stable source of sulphur dioxide. Being a solid, it is easier to use than liquid or gaseous sulphur dioxide. It is fairly stable in neutral or alkaline media but decomposed by weak acids like carbonic, citric, tartaric and malic acids. When added to fruit juice or squash it reacts with the acid in the juice forming the potassium salt and sulphur dioxide, which is liberated and forms sulphurous acid with the water of the juice.

Sulphur dioxide has a better preservative action than sodium benzoate against bacteria and moulds. It also retards the development of yeasts in juice, but cannot arrest their multiplication, once their number has reached a high value. It is well known that fruit juices with high acidity do not undergo fermentation readily. The preservative action of the fruit acid is due to its hydrogen ion concentration. The pH for the growth of moulds ranges from 1.5 to 8.5, that of yeasts from 2.5 to 8.0 and of bacteria from 4.0 to 7.5. As fruit beverage like citrus squashes and cordials have generally a pH of 2.5 to 3.5, the growth of moulds and yeasts in them cannot be prevented by acidity alone. Bacteria, how- ever, cannot grow. The pH is, therefore, of great importance in the preservation of food product and by regulating it, one or more kinds of microorganism in the beverage can be eliminated . The concentration of Sulphur dioxide required to prevent the growth of microorganism at different pH levels are as under:

pH	Organisms and sulphur dioxide concentration (ppm)			
	Saccharomyces ellipsoideus (Yeast)	Mucor (Mould)	Penicillium (Mould)	Mixed bacteria
2.5	200	200	300	100
3.5	800	600	600	300
7.0	above 5000	above 5000	above" 5000	above

The toxicity of sulphur dioxide increases at high temperature. Hence its effectiveness depends on the acidity, pH, temperature and substances present in fruit juice.

According to Indian Fruit Product Order, the maximum amount of sulphur dioxide allowed in fruit juice is 700 ppm, in squash, crush and cordial 350 ppm and in RTS and nectar 100 ppm.

The advantages of using sulphur dioxide are : (a) it has a better preserving action than sodium benzoate against bacterial fermentation, (b) it helps to retain the colour of the beverage for a longer time than sodium benzoate, (c) being a gas, it helps in preserving the surface layer of juices also, (d) being highly soluble in juices and squashes, it ensures better mixing and hence their preservation, and (e) any excess of sulphur dioxide present can be removed either by heating the juice to about 71°C or by passing air through it or by subjecting the juice to vacuum. This causes some loss of the flavouring materials due to volatilization, which can be compensated by adding flavours.

The major limitations of sulphur dioxide are : (a) it cannot oe used in the case of some naturally co loured juices like those of phalsa, jamun, pomegranate, straw- berry, coloured grapes, plum, etc., on account of its bleaching action, (b) it cannot also be used for juices which are to be packed in tin containers, because it not only corrodes the tin causing pinholes, but also forms hydrogen sulphide which has a disagreeable smell and reacts with the iron of the tin container to form a black compound, both of which are highly undesirable, and (c) sulphur dioxide gives a slight taste and odour to freshly prepared beverages but these are not serious defects if the beverage is diluted before drinking.

(ii) Benzoic acid

It is only partially soluble in water hence its salt, sodium benzoate, is used. One part of sodium benzoate is soluble in 1.8 parts of water at ordinary temperature, whereas only 0.34 part of benzoic acid is soluble in 100 parts of water. Sodium benzoate is thus nearl1170 times as soluble as benzoic acid. Pure sodium benzoate is tasteless and odourless. The antibacterial action of benzoic acid is increased in the presence of carbon dioxide and acid, e.g., *Bacillus subtilis* 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 acetic acid fermentation. The quantity of benzoic acid required depends on the nature of the product to be preserved, particularly its acidity. In case of juices having a pH of 3.5 to 4.0, which is the range of a majority of fruit juices, addition of 0.06 to 0.10 per cent of sodium benzoate has been found to be sufficient. In case of less acid juices such as grape juice at least 0.3 per cent is necessary. The action of benzoic acid is reduced considerably at pH 5.0. Sodium benzoate in excess of 0.1 per cent may produce a disagreeable burning taste. According to F.P.O. its permitted level in RTS and nectar is 100 ppm and in squash, crush and cordial 600 ppm. In some European countries, especially Germany, generally methyl, ethyl and propyl esters of para-hydroxy benzoic acid are used. They are, however, not used in India. In the long run benzoic acid may darken the product. It is, therefore, mostly used in coloured products of tomato, phalsa, jamun, pomegranate, plum, water- melon, strawberry, coloured grapes, etc. The preservative should never be added in solid form but should be dissolved in a small quantity of juice or water, and the solution added to the bulk of the product. If this care is not taken, the solid may settle undissolved at the bottom of the container with the result that fermentation may start before the action of preservative can begin.

A number of chemicals such as hydrogen peroxide, formaldehyde, halogenated acetic acid, salicylic acid, etc., which were used as preservatives some years ago, have now been banned in many countries. In recent years, sorbic acid and tylosin, etc., are being tried.

5. Preservation by Drying

Microorganisms need moisture to grow so when the concentration of water in the .food is brought down below a certain level, they are unable to grow. Moisture can be removed by the application of heat as in sun-drying or by mechanical drying (dehydration). Sun-drying is the most popular and oldest method of preservation. In 'these days, mechanical drying has replaced sun-drying. This is a more rapid process as artificial heat under controlled conditions of temperature, humidity and air flow is provided and fruits and vegetables, e.g., green peas, cauliflower, mango, mahua, etc., are dried to such an extent that the microorganisms present in them fail to survive.In this method, juices are preserved in the form of powder. The juice is sprayed as a very fine mist into an evaporating chamber through which hot air is passed. The temperature of the chamber and the-flow of air are so regulated that dried juice falls to the floor of the chamber in the form of a dry powder. The powder is. collected and packed in dry containers which are then closed airtight. The powder when dissolved in water makes a fruit drink almost similar to the original fresh juice. Fruit juice powders are highly hygroscopic and require special care in packing. All juices cannot, however, be dried readily without special treatment. Mango juice powder is prepared by this technique but the method is very expensive and not popular in India.

6. Preservation by Filtration

In this method, the juices are clarified by settling or by using ordinary filters, and then passed through special filters which are capable of retaining yeasts and bacteria. Various types of germ-proof filters are used for this purpose. Recently this method has come into use in U.S.A., Germany, etc., for preserving apple and grape juices. It is not used in India. This method is used for soft drinks, fruit juices and wines.

7. Preservation by Carbonation

Carbonation is the process of dissolving sufficient carbon dioxide in water or beverage so that the product when served gives off the gas as fine bubbles and has a characteristic taste. Carbonation adds to the life of a beverage and contributes in some measure to its tang. Fruit juice beverages are generally bottled with carbon dioxide content varying from 1 to 8 g per litre. Though this concentration is much lower than that required for complete inhibition of microbial activity (14.6 g/litre), it is sufficient for supplementing the effect of acidity on pathogenic bacteria. Another advantage of carbonation is the removal of air thus creating 'an anaerobic condition, which reduces the oxidation of ascorbic acid and prevents browning.

Moulds and yeasts require oxygen for their growth and become inactive in the presence of carbon dioxide. In ordinary carbonated drinks, the oxygen which is normally present in solution in water in sufficient amount to bring about fermentation, is displaced by carbon dioxide. Although carbonated beverages con-tain sugar much below 66 per cent, the absence of air and the presence of carbon dioxide in them help to prevent the growth of moulds and yeasts.

High carbonation should, however, be avoided as it usually destroys the flavour of the juice. The keeping quality of carbonated fruit beverages is enhanced by adding about 0.005 per cent sodium benzoate. The level of carbonation required varies according to the type of fruit juice and type of flavour.

8. Preservation by Sugar

Syrups containing 66 per cent or more of sugar do not ferment. Sugar absorbs most of the available water with the result that there is very little water for the growth of microorganisms hence their multiplication is inhibited, and even those alreadv present die out qraduallv. Drv suqar does not ferment. Thus sugar acts as a preservative by osmosis and not as a true poison for microorganisms. Fruit syrup, jam, jelly, marmalade, preserve, candy, crystallized fruit and glazed fruit are preserved by sugar.

9. Preservation by Fermentation

Decomposition of carbohydrates by microorganisms or enzymes is called 'fermentation'. This is one of the oldest methods of preservation. By this method, foods are preserved by the alcohol or organic acid formed by microbial action. The keeping quality of alcoholic beverages, vinegars and fermented pickles de-pends upon the presence of alcohol, acetic acid and lactic acid, respectively. Care should be taken to seal the fermented products from air to avoid further unwanted or secondary fermentation. Wines, beers, vinegar, fermented drinks, fermented pickles, etc., are prepared by these processes. .

Fourteen per cent alcohol acts as a preservative in wines because yeasts, etc., cannot grow at that concentration. About 2 per cent acetic acid prevents spoilage in many products.

10. **Preservation by salt**

Salt at a concentration of 15 to 25 per cent is sufficient to preserve most products. It inhibits enzymatic browning and discoloration and also acts as a antioxidant. Salt in the form of brine is used for canning and pickling of vegetables which contain very little sugar and hence sufficient lactic acid cannot b formed by fermentation to act as preservative. It exerts its preservative action by (i) causing high osmotic pressure resulting in the plasmolysis of microbial cell! (ii) Dehydrating food as well as microorganisms by drawing out and tying up the moisture by ion hydration, (iii) ionizing to yield the chloride ion which is harmful to microorganisms, (iv) reducing the solubility of oxygen in water, sensitizing the cells against carbon dioxide, and interfering with the action of proteolytic enzymes.

11. Preservation by Acids

Low acid foods are spoilt rapidly. Highly acidic environment inhibits the growth of food spoilage organisms. Lowering the protein of certain foods b anaerobic fermentation, action on carbohydrates producing lactic acid is one the methods of food preservation. The same spoilage inhibitory effects can b produced by acidic additives such as vinegar or citric acid. Nutrient losses through fermentation are small. In fact, in certain cases, the nutrient levels are increase, particularly through microbial vitamin and protein synthesis. Acids are added to or allowed to form in foods to preserve them. Acetic (vinegar), citric (lime juice) and lactic acids are commonly used for preservation. About 2 per cent acetic acid prevents spoilage of many products. Onions are bottled in vinegar with a little salt. Vinegar is also added to pickles, chutneys, sauces and ketchups. Citric acid is added to many fruit squashes, jams and jellies to increase the acidity and prevent mould growth.

12. Preservation by Oil and Spices

A layer of oil on the surface of any food produces anaerobic conditions which prevent the growth of moulds and yeasts. Thus pickles in which enough oil is added to form a layer at the top can be preserved for long periods. Spices like turmeric, pepper, and asafoetida have little bacteriostatic effect and their ability to prevent growth of other microorganism is questionable. Their primary function is to impart their characteristic flavour to the food.

13. Preservation by Antibiotics

Certain metabolic products of microorganisms have been found to have germicidal effect and are termed as antibiotics. Their use in medicine for control- ling certain disease-producing organisms in the body is well known. Some antibiotics are also used to preserve fruits, vegetables and their products.

Nisin is an antibiotic produced by *Streptococcus lactis,* an organism commonly found in milk, curd, cheese and other fermented milk products. It is non- toxic and has no adverse effect on the sensory qualities of food. It is widely used in the food industry especially for preservation of acid foods in which it is more stable. It is commonly used in canning of mushrooms, tomatoes and milk products. 'Nisin suppresses the growth of spoilage organisms, mainly the gas-producing) spore-forming bacteria and toxin-producing *Clostridium botulinum.* Subtilin, an antibiotic obtained from certain strains of *Bacillus* *subtilis,* is used in preservation of asparagus, corn and peas. It is most effective against gram-positive bacteria and spore-forming organisms. Canned peas and tomatoes containing 10 and 20 ppm of subtilin respectively were found to be free of micro-organisms. Subtilin and nisin effectively reduce the thermal process requirements necessary to control the spoilage of several food products. Pimaricin, an antifungal antibiotic, can be used for treating fruits and fruit juices.

At present the above three antibiotics are permitted only in such foods as are cooked prior to use and in the process of cooking the residual antibiotic is expected to be destroyed.

14. Preservation by Irradiation

Sterilization of food by ionizing radiations is a recently developed method of preservation which has not yet gained general acceptance. The unacceptable flavour of some irradiated foods and the fear that radioactivity might be induced in such food has come in the way of its greater use. The harmful effects on the human body of radiation from nuclear explosions have given rise to such apprehension in the minds of many people.

When gamma rays or electron beams pass through foods there are collisions between the ionizing radiation and food particles at atomic and molecular levels, resulting in the production of ion pairs and free radicals. The reactions of these products among themselves and with other molecules result in physical and chemical phenomena which inactivate microorganisms in the food. Thus irradiation of food can be considered to be a method of "cold sterilization", i.e., food is free of microorganisms without high temperature treatment.

In the irradiation of foods for preservation, the radiation dose must be care- fully controlled. It should be sufficient to destroy pathogenic and spoilage causing organisms and to inactivate food enzymes. Apart from the intensity of radiation, the amount of radiation absorbed and the period of irradiation are also to be controlled. The WHO and the International Atomic Energy Agency have recommended that radiation dose of up to 1 rad is not hazardous. The longer the food is exposed to radiation, the more radiation will it absorb. Radiation energy must be provided in such a manner that it reaches every particle of food to ensure adequate killing of all microorganisms.

Different organisms are sensitive to radiation to different extents, e.g .. a dose of 10^3 to 10^7 rad kills microorganisms, 10^3 to 10^6 rad kill insects and 10^2 to 10^3 rad are lethal to humans. Sprouting of potatoes, onions. carrots, etc., are inhibited by $10^3$to 10^4 rad. In case of microorganisms, the approximate sterilizing dose for bacterial endospores ﬃ' 3.0 x 10^6 rad, while that for yeasts and fungi is 5.0 x 10^4 rad.

Ionizing radiations can be used for sterilization of foods in hermetically sealed packs, reduction of the spoilage flora on perishable foods, elimination of patho- gens in foods, control of infestation in stored cereals, prevention of sprouting of potatoes, onions, etc.

Reconstitution test for dried/dehydrated products

In reconstitution water is added to the product which is restored to a condition similar to that when it was fresh. This enables the food product to be cooked as if the person was using fresh fruit or vegetable. All vegetables are cooked but many of the dried fruits cap be used for eating after they have been soaked in water. The following reconstitution test is used to find out the quality of the dried products.

Reconstitution test

1. Weigh out a sample of 35 grams from the bulked and packed final product of the previous day's production.
2. Put the sample into a small container (beaker) and add 275 ml of cold water (and 3.5 g salt).
3. Cover the container (with a watch-qlass) and bring the water to the boil.
4. Boil gently for 30 minutes.
5. Turn out the sample onto a white dish.
6. At least two people should then examine the sample for palatability, toughness, flavour and presence or absence of bad flavours. The testers should record their results independently.
7. The liquid left in the container should be examined for traces of sand/soil and other foreign matter.

This test can be used also to examine dried products after they have been stored for some time. Evaluation of rehydration ratio may be performed according to the following calculations.

Rehydration ratio: If the weight of the dehydrated sample (a) used for the test is 5 g and the drained weight of the rehydrated sample (b) 30g, then

Rehydration ratio = b/a=30/5=6:1

Rehydration Coefficient: If the drained weight of 109 of dried sample containing 5% moisture after rehydration is 70g, and the fresh sample before drying contained 90% moisture, then

$$\text{Rehydration Coefficient} = \frac{\text{Drained wt of dehydrated sample} \times \left[100 - \text{Moisture content of sample before drying}\right]}{\left[\text{Wt. of dried sample taken for rehydration} - \text{Amount of moisture present in the dried sample taken for rehydration}\right] \times 100}$$

$$= \frac{70 \times (100 - 90)}{(10 - 0.5) \times 100} = 0.74$$

Per cent water in the rehydrated material: The drained weight of the rehydrated sample being known, the per cent water content in the rehydrated material is calculated by

$$\frac{\text{Drained wt of rehydrated material} - \text{Dry matter content in the sample taken for rehydration}}{\text{Drained wt of rehydrated material}} \times 100$$

Following the values given under "coefficient of rehydration", the moisture content in the rehydrated sample is $\frac{70 - 9.5}{70} \times 100 = 86.43\%$

A simpler test for eating quality can be carried out without weighing and measuring. The material is placed in a cooking pot with water (and a little salt). The pot is then covered and boiled as described above. Except for a few products which are eaten in the dry state, most dried fruit and all dried vegetables are prepared by soaking and cooking. Often this preparation is carried out incorrectly and dried products get a bad reputation. Good quality dried products, after cooking and if properly treated should be similar to cooked fresh produce. In order to get good results, the following methods are recommended:

Quick .method: Cold water, ten times the weight of the dry product, is added to the dried product. The container is covered, brought \ to the boil and simmered until the product is tender. The cooking time may be 15 to 45 minutes after the boiling point has been reached.

Slow method: This gives better results than the quick method. Cold water is added to the dry food and is left to soak for 1 to 2 hours before cooking. The product is then cooked in the same water as that in which it was soaked. The actual cooking time will probably be shorter than that for the quick method. Besides above, following points should also be kept in mind while reconstituting and cooking the dehydrated fruits and vegetables-

. (i) If too much water is added the cooked product will have little flavour. However, if too little water is added the product may dry and bum. This can be avoided by adding small quantities of water during cooking.

(ii) Always cook with a lid on the container.

(iii) Salt, if required, should be added when the cooking is almost complete.

LECTURE-3

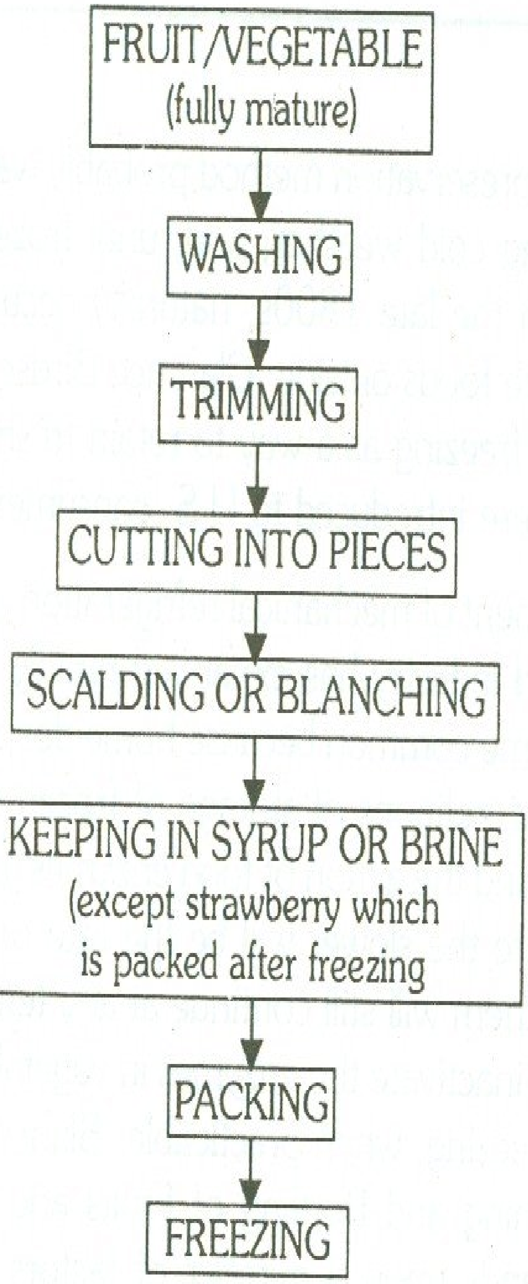
Freezing-process-types of freezing-changes during cold storage-thawing; Canning of fruits and vegetables-process-unit operations.

Freezing as a preservation method probably was observed by prehistoric people during cold weather; and, until frozen storage cabinets were developed in the late 1800s, naturally occurring snow and ice were used to freeze foods outside. Clarence Birdseye was one of the first to experiment with quick freezing as a way to retain fresh taste and texture. In the 1930s, his products were introduced to U.S. consumers.

With the development of mechanical refrigeration and of quick-freezing techniques, the frozen food industry has expanded rapidly. Even in homes, freezing of foods has now become common because home deep-freezers are readily available. Under the usual conditions of storage of frozen foods microbial growth is prevented completely and the action of food enzymes greatly retarded. The lower the storage temperature the slower will be the rate of a chemical or enzymatic reaction, but most of them will still continue at any temperature. Therefore, it is a common practice to inactivate the enzymes in vegetables by scalding or blanching the latter before freezing, when practicable. Blanching has been discussed in the chapter on "Canning and Bottling of Fruits and Vegetables". The rate of freezing of food depends upon a number of factors such as the method employed, the temperature, circulation of air or refrigerant, size and shape of package, kind of food, etc.

When compared to most other food preservation methods, freezing requires the least amount of food preparation before storage and under optimum conditions it has the best nutrient, flavour, and texture retention. Since food remains microbiologically safe during freezing, its shelf life is determined by chemical and physical changes that occur during storage. Rancidity-oxidative with and without enzyme involvement and tissue damage from ice formation are responsible for most of the quality deterioration in frozen foods. At (-18°C) fruits can usually retain good quality for 12 months and vegetables for 8-12 months. Increasing storage temperature results in shorter shelf lives. For each 18°F (10°C) increase in temperature, the storage time is approximately cut in half. Sliced' foods (increased surface areas), cured foods (low $a_{w)}$, and fatty foods (rancidity) lose quality more rapidly. Freezing is cheaper than canning and frozen products are of better quality than canned products, but for storage of frozen products uninterrupted supply of electricity if essential, which is a problem at least in homes.

TECHNOLOGICAL FLOWSHEET FOR PREPARATION OF FRUITS/ VEGETABLES FOR FREEZING



Methods of freezing

There are various methods of freezing:

(1) Sharp freezing (Slow freezing)

This technique, first used in 1861, involves freezing by circulation of air, either naturally or with the aid of fans. The temperature may vary from -15 to -29°C and freezing may take from 3 to 72 hours. The ice crystals formed are large and rupture the cells. The thawed tissue cannot regain its original water content. The first products to be sharp frozen were meat and butter. Nowadays freezer rooms are maintained at -2'3 to -29°C or even lower, in contrast to the earlier temperature of -18°C.

(2) Quick freezing

In this process the food attains the temperature of maximum ice crystal formation (0 to -4°C) in 30 minutes or less. Such a speed results in formation of very small ice crystals and hence minimum disturbance' of cell structure. Most foods are quick frozen by one of the following three methods :

(A) By direct immersion

Since liquids are good heat conductors, food can be frozen rapidly by direct immersion in a liquid such as-brine 'or sugar solution at low temperature, Berries in sugar solution" packed fruit juices and concentrates are frozen in this manner. The refrigeration medium must be edible and capable of remaining unfrozen at -18°C and slightly below. Direct immersion equipments such as Ottesen Brine Freezer, Zarotschenzeff "Fog" Freezer, T.v.A. Freezer, Bartlett Freezer, etc., of commercial importance earlier, are not used today.

Advantages

(i) There is perfect contact between the refrigerating medium and the product, hence the rate of heat transfer is very high.

(ii) Fruits are frozen with a coating of syrup which preserves the colour and flavour during storage.

(iii) The frozen product is not a solid block because each piece is separate.

Disadvantages

(i) Brine is a good refrigerating medium but it cannot be used for fruits.
(ii) It is difficult to make a syrup that will not become viscous at low temperature.
(iii) The refrigeration temperature must be carefully controlled, as at high temperature the medium will enter the product by osmosis and at low temperature the medium may freeze solid.

(iv) It is very difficult to maintain the medium at a definite concentration and also to keep it free from dirt and contamination.

(B) By indirect contact with refrigerant

Indirect freezing may be defined as freezing by contact of the product with a metal surface which is itself cooled by freezing brine or other refrigerating media. This is an old method of freezing in which the food or package is kept in contact with the passage through which the refrigerant at -18 to -46°C flows. Knowles Automatic Package Freezer, Patterson Continuous Plate Freezer, FMC Continuous Can Freezer and Birdseye Freezers are based on this principle.

C) By air blast (Air blast freezing)

This refers to vigorous circulation of cold air in order to freeze the product. Freezing is done by placing the foodstuffs on trays or on a belt which are then passed slowly through an insulated tunnel containing air in it. Here the air temperature is approximately -18 to -34°C or even lower. This process is economical and a variety of sizes and shapes can be accommodated.

'Rapid freezing rates are achieved commercially in a variety of ways. Individually quick frozen vegetables are frozen by blowing cold air (air blast freezing) as vegetables pass through the freezer on a belt or by "tossing" the vegetables with cold air as they pass through the freezer on a mesh screen (fluidized bed freezing). Plate freezing is also used. In this method packaged vegetables are placed on a metal surface that is cooled by refrigerants and another plate may be placed on top of the package. Vegetables frozen by blast methods are in discrete pieces and usually cooked without thawing but solid masses of foods such as pureed squash may be thawed before cooking.

(a) Fluidized bed freeing

This is a modification of air blast freezing. The foodstuff is fluidized to form a bed of particles, and then frozen. Air is forced upward through the belt to partially lift or suspend the particles. If the air is appropriately cooled, drying can be done quite speedily. The depth of the bed of particles varies with the product. Solid food particles of the size of pea's up to strawberries can be frozen with a depth of 1 to 5". Peas and whole kernel corn are easily fluidized particles and the bed depth used is slightly more than one inch. Green beans/French beans are partially fluidizable products, and the depth is 8 to 10 inches.

Fluidized bed freezing has certain advantages:

- it gives more sufficient heat transfer and more rapid rates of freezing;
- extent to which the product gets dehydrated is less, and
- defrosting of equipment is required less frequently.

(b) Plate freezing

In this method, food products are placed in contact with a cold surface. The cooling temperature of the metal surface is accomplished by using cold brine or vaporizing refrigerants. This process is suitable for packaged food products which may rest on/slide against or be pressed between cold metal plates. The process is also suitable for unpacked foodstuffs, e.g., shrimps, which can be frozen by freeze adhesion to a slowly rotating cold drum. Fruit juices can also be frozen in cylindrical scraped-surface heat exchangers. Contact-plate freezing is quite economical. It minimizes problems of dehydration, defrosting of equipment and packet bulging.

The advantages claimed for quick freezing over slow freezing (sharp freezing) are: (i) smaller ice crystals are formed, hence there is less mechanical destruction of intact cells of the food, (ii) period for ice formation is shorter, therefore, there is less time for diffusion of soluble material and for separation of ice, (iii) more rapid prevention of microbial growth, and (iv) more rapid slowing down of enzyme action.

(3) Cryogenic freezing

Although most foods retain their quality when quick frozen by the above methods, a few (mushrooms, sliced tomatoes, whole strawberries and raspberries) require ultrafast freezing. Such materials are subjected to cryogenic freezing which is defined as freezing at very low temperature (below -60°C). The refrigerants used at present in cryogenic-freezing are liquid nitrogen and liquid carbon dioxide. In the former case, freezing may be achieved by (i) immersion in the liquid, (ii) spraying of liquid, or (iii) circulation of its vapour over the product to be frozen.

(4) Dehydro-freezing

This is a process where freezing is preceded by partial dehydration. In case of some fruits and vegetables about '50 per cent of the moisture is removed by dehydration prior to freezing. This has been found to improve the quality of the food. Dehydration does not cause deterioration and dehydrofrozen foods are relatively more stable.

(5) Freeze-drying

In this process food is first frozen at -18°C on trays in the lower chamber of a freeze drier and the frozen material dried (initially at 30°C for 24 hours and then at 20°C) under high vacuum (0.1 mm Hg) in the upper chamber. Direct sublimation of the ice takes place without passing through the intermediate liquid stage. The product is highly hygroscopic, excellent in taste and flavour and can be reconstituted readily. Mango pulp, orange juice concentrate, passion fruit juice and guava pulp are dehydrated by this method.

Changes during freezing

Quick-freezing rapidly slows down chemical and enzymatic reactions in foods and stops microbial growth. A similar effect is produced by sharp freezing, but less rapidly. The physical effects of freezing are of great importance. There is an expansion in volume of the frozen food and ice crystals form and grow in size. These crystals are larger in -slow freezing than in quick freezing and more ice accumulates between tissue cells and may crush the cells. During freezing, water is redistributed in food by the formation of ice crystals. This alters the characteristics of a food upon thawing since separated water usually does not return to its original position. Ice crystals themselves do not preserve the food but in fact damage it. When water changes state from liquid to solid, there is a 9% increase in volume that is responsible for many of the inferior textural characteristics of frozen food. Undesirable texture changes in thawed tomatoes and potatoes are extreme examples. It is claimed that ice crystals rupture fruit and vegetable tissue cells and even microorganisms. The increased concentration of. solutes in the cells hastens their salting out, dehydration and denaturation of proteins and causes irreversible changes in colloidal systems, such as the syneresis of hydrophilic coloids. Further, freezing is considered to be responsible for killing microorganisms. The vegetative cells of yeasts and moulds and many Gram-negative bacteria are susceptible, while Gram-positive bacteria including staphylococci and enterococci are moderately resistant, while spores of bacilli and clostridia are insensitive to freezing.

Changes during storage

Chemical and physical reactions that decrease overall quality continue even in foods stored at OaF (-18°C). The losses that occur during a normal storage period usually exceed any damage that occurs to the food during the initial freezing or thawing.

(A) Physical changes

Fluctuation in storage temperature results in an increase in the size of ice crystals resulting in physical damage to the food.

(i) Recrystallization

Recrystallization is a physical change in which many small ice crystals combine to form a smaller number of large crystals. Temperature fluctuations during storage and longer storage times enhance recrystallization. Recrystallization also occurs in the early stages of thawing where it often damages plant' cells that were left intact during the initial freezing process. The end result is decreased quality of products that had been properly frozen. Recrystallization frequently spoils ice cream. Large molecular weight compounds such as gums and modified cellulose may physically inhibit the growth of ice crystals and are added commercially for this reason. Householders add gelatin and fat-cream instead of milk to reduce recrystallization.

(2) Sublimation

Desiccation of the food at its surface is likely to take place during storage. When water goes from the solid to the gaseous state without passing through the liquid phase as opposed to the way ice would normally melt if placed in a glass of water, it is called sublimation. Freezer burn is caused by sublimation of ice from the surface of the food into the air inside the freezer. Freezer burn can affect the quality so adversely that the food is discarded. Subllmation is possible when the water vapour pressure of the ice is higher than the vapour pressure of the surrounding air. This vapour pressure difference occurs between all frozen foods and the air. The surface of freezer burned food usually appears as dry, grainy and brownish spots where the chemical changes take place and the tissues become dry and tough.

Wrapping to form moisture-proof barriers is the most effective preventive measure for freezer burn. Vapour-resistant materials and tape and containers without excess space reduce the amount of air-to-surface exposure. Foods wrapped in single layers with larger surface area : volume ratios are more susceptible to freezer burn and the accompanying quality loss, though single layers freeze more rapidlyso ice crystal size is smaller and more evenly distributed, which is desirable. Perhaps package shape should be determined by expected storage 'time since ice crystal damage can occur immediately. Freezer burn is more likely to occur with increased lengths of time, so labelling packages with storage dates and keeping a list on the outside of the freezer to aid inventory control reduces the chance of freezer burn.

(3) Denaturation

Protein alterations responsible for a decrease in solubility. are collectively known as denaturation. As the ionic concentration increases in freezing, through a reduction in water content, the proteins form bonds with each other instead of water, and insoluble complexes result. This change (protein denaturation) may be responsible for increased toughness in frozen foods.

(8) Chemical changes

Microbial growth ceases at temperatures below 28°F (-2°C) for most foods, but chemical reactions continue in foods even at OaF (-18°C). Such reactions include lipid oxidation, Maillard and enzymatic browning, flavour deterioration,

Thawing

Plant and animal tissues and gels-this encompasses most foods-thaw more slowly than they freeze. It takes longer to thaw a food than to freeze it because the heat transfer is by conduction. During freezing, the outer surfaces contain ice crystals first, followed by the center portions. In thawing, the outer portions firs change from solid ice to liquid water followed by melting of the central portions. Initially the temperature rise is rapid, but this only occurs before much of the outer surface has changed to the liquid state; most foods remain solid until 23°F Nonflowable water is a better insulator than ice. A plateau stage follows which is the result of this unflowering water impairing heat transfer. When thawing is done with microwaves, conduction is not the major method of heat transfer and this scenario does not apply.

During thawing, the food passes slowly through temperatures near the melting point where chemical reactions and recrystallization can occur. Thus, there is more opportunity for the quality of the food to be decreased during thawing than freezing. This is particularly the case when householders exercise little care in thawing the food they so carefully blanched, wrapped, and quickly froze. Rapid thawing minimizes recrystallization and limits the time cells are exposed to detrimental concentrations of solutes at high subfreezing temperatures.

Rapid and safe thawing at the household level requires some judgment decisions. A single method is not best for all situations. Thawing cooked foods a room temperature may be more rapid than in the refrigerator, but it may pose (health hazard when the outer portions are warmed beyond safe temperatures Thawing with microwaves is efficient but often uneven and, because parts may become warm, it should be done just before cooking or serving. Thawing wrapper foods under cool running water is a rapid and safe method, but due to high water waste, it is not commonly used. Placing wrapped foods in still water may not be safe if forgotten. Cooking vegetables directly from the frozen state minimize thawing changes, but will increase the cooking time. For solid blocks of food, this may result in over-cooking outer layers.

Canning:

The process of sealing foodstuffs hermetically in containers and sterilizing them by heat for long storage is known as canning. In 1804, Appert in Frarice invented a process of sealing foods hermetically in containers and sterilizing them by heat. Appert is known as the 'Father of Canning'. This work formed the foundation for modern canning procedure. In honor of the inventor, canning is also known as appertizing. Saddington in England was the first to describe a method of canning of foods in 1807. In 1810, Peter Durand, another Englishman, obtained the first British Patent on canning of foods in tin containers. In 1817, William Underwood introduced canning of fruits on a commercial scale in U.S.A. Fruits and vegetables are canned in the season when the raw material is available in plenty. The canned products are sold in the off-season and give better returns to the grower.

Principle and Process of Canning

Destruction of spoilage organisms within the sealed container by means of heat.

Process

(1) Selection of fruits and vegetables

(i) Fruits and vegetables should be absolutely fresh.

(ii) Fruits should be ripe, but firm, and uniformly mature. Over-ripe fruits should be rejected because they are infected with microorganisms and give a poor quality product. Unripe fruits should be rejected because they generally shrivel and toughen on canning.

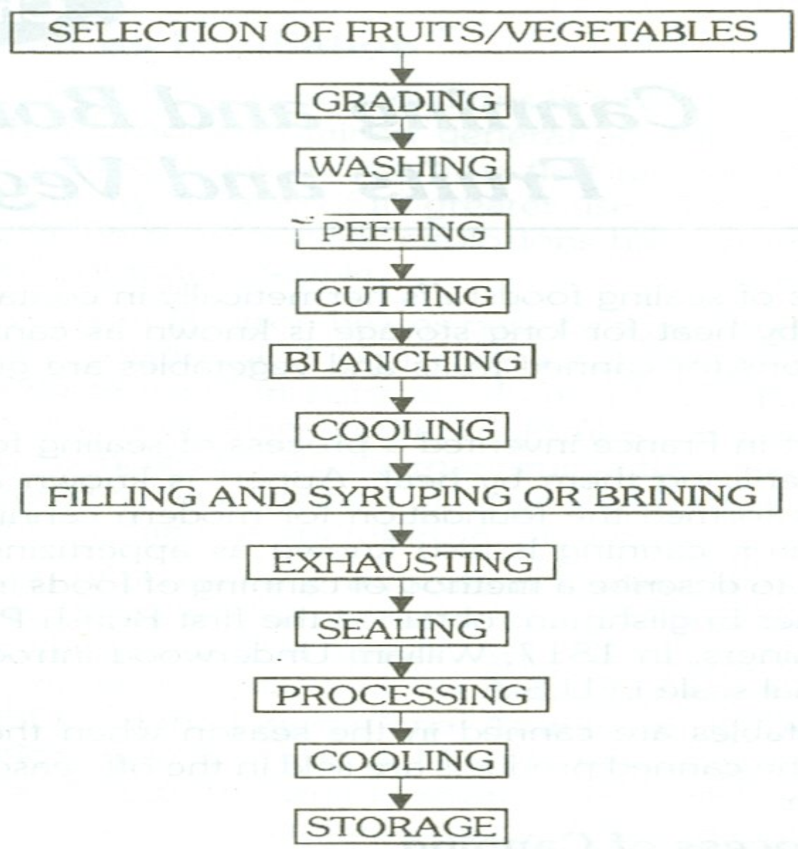
(iii) All vegetables except tomatoes should be tender.

(iv) Tomatoes should be firm, fully ripe and of deep red colour.

(v) Fruits and vegetables should be free from dirt.

(vi) They should be free from blemishes, insect damage or mechanical injury.

FLOW-SHEET FOR CANNING PROCESS



(2) Grading

The selected fruits and vegetables are graded according to size and colour to obtain uniform quality. This is done by hand or by machines such as screw grader and roller grader. Fruits like berries, plums and cherries are graded whole, while peaches, pears, apricots, mangoes, pineapples, etc., are generally graded after cutting into pieces or slices.

(3) Washing

It is important to remove pesticide spray residue and dust from fruits and vegetables. One gram of soil contains 10^{12} spores of microorganisms. Therefore, removal of microorganisms by washing with water is essential. Fruits and vegetables can be washed in different ways. Root crops that loosen in soil are washed by soaking in water containing 25 to 50 ppm chlorine (as detergent). Other methods of washing are spray washing, steam washing, etc.

(4) Peeling

The objective of peeling is to remove the outer layer. Peeling may be done in various ways.

(i) Hand peeling: It is done mostly in case of fruits of irregular shape, e.g., mango and papaya, where mechanical peeling is not possible.

(ii) Steam peeling : Free-stone and clingstone peaches are steam peeled in different ways. The former are cut and steam washed. Potatoes and tomatoes are peeled by steam or boiling water.

(iii) Mechanical peeling : This is done in case of apples, peaches, pineapples and cherries and also for root vegetables like carrots, turnips and potatoes.

(iv) Lye peeling : Fruits like peaches, apricots, sweet oranges, mandarin oranges and vegetables like carrots and sweet potatoes are peeled by dipping them in 1 to 2 per cent boiling caustic soda solution (lye) for 30 seconds to 2 minutes depending on their nature and maturity. Hot lye loosens the skin from the flesh by dissolving the pectin. The peel is then removed easily by hand. Any trace of alkali is removed by washing the fruit or vegetable thoroughly in running cold water or dipping it for a few seconds in 0.5 per cent citric acid solution. This is a quick method where by cost and wastage in
peeling is reduced.

(v) Flame peeling: It is used only for garlic and onion which have a papery outer covering. This is just burnt off. Vegetables like peas are shelled, carrots are scraped, and beans are snipped or trimmed. \

(5) Cutting

Pieces of the size required for canning are cut. Seed, stone and core are removed. Some fruits like plum from which the seeds cannot be taken out easily are canned whole.

(6) Blanching

It is also known as scalding, parboiling or precooking. Fruits are generally not blanched leaving the oxidizing enzyme system active. Sometimes fruit is plunged for a given time-from half to, say, five minutes, according to variety-into water at from 180°F to 200^{o}F, and then immediately cooled by immersion in cold water. The object is to soften the texture and so enable a greater weight to be pressed into the container without damage to the individual fruit. Blanching is Usually done in case of vegetables by exposing them to boiling water or steam for 2 to 5 minutes, followed by cooling. I he extent ot blanching varies with the toed. This brief heat treatment accomplishes the following:

(i) Inactivates most of the plant enzymes which cause toughness, discolouration (polyphenol oxidase). mustiness, off-flavour (peroxidase), softening and loss of nutritive value.
(ii) Reduces the area of leafy vegetables such as spinach by shrinkage or wilting, making their packing easier.
(iii) Removes tissue gases which reduce sulphides.
(iv) Reduces the number of microorganisms by as much as 99%.

(v) Enhances the green colour of vegetables such as peas, broccoli and spinach.

(vi) Removes saponin in peas.

(vii) Removes undesirable acids and astringent taste of the peel, and thus improves flavour.

(viii) Removes the skin of vegetables such as beetroot and tomatoes which helps in their peeling.

Disadvantages

(i) Water-soluble materials like sugar and anthocyanin pigments are leached by boiling water.

(ii) Fruits lose their colour, flavour and sugar.

(7) Cooling

After blanching, the vegetables are dipped in cold water for better handling and keeping them in good condition.

(8) Filling

Before filling, cans are washed with hot water and sterilized but in developing countries these are subjected to a jet of steam to remove dust and foreign material. Automatic, large can-filling machines are used in advanced countries but choice grades of fruits are normally filled by hand to prevent bruising in India. Hand filling is the common practice. After filling, covering with syrup or brine is done and this process is called syruping or brining.

(9) Exhausting

The process of removal of air from cans is known as exhausting. After filling and lidding or clinching, exhausting is essential. The major advantages of exhausting are as under:

(i) Corrosion of the tinplate and pin holing during storage is avoided.

(ii) Minimizes discolouration by preventing oxidation.

(iii) Helps in better retention of vitamins particularly vitamin C.

(iv) Prevents building of cans when stored in hot climate or at high altitude.

(v) Reduces chemical reaction between the container and the contents.

(vi) Prevents development of excessive pressure and strain during sterilization.

Containers are exhausted either by heating or mechanically. The heat treatment method is generally used. The cans are passed through a tank of hot water at 82 to 87°C or move on a belt through a covered steam box. In the water exhaust box, the cans are placed in such a manner that the level of water is 4-5 cm below their tops. The exhaust box is heated till the temperature of water reaches 82 to 100^0c and the centre of the can shows a temperature of about 79°C. The time of exhausting varies from 6 to 1 a minutes, depending on the nature of the product. In the case of glass jars or bottles, vacuum closing machines are generally used. The bottles or jars are placed in a closed chamber in which a high vacuum is maintained.

It is preferable to exhaust the cans at a lower temperature for a longer period to ensure uniform heating of the contents without softening them into pulp. Exhausting at high temperature should be avoided because. The higher the temperature, the more is the volume of water vapour formed, and consequently the greater the vacuum produced in the can.

(10) Sealing

Immediately after exhausting the cans are sealed airtight by means of a can sealer. In case of glass jars a rubber ring should be placed between the mouth of the jar and the lid, so that it can be sealed airtight. During sealing the temperature should not fall below 74°C.

(11) Processing

Heating of foods for preserving is known as processing, however, in canning technology processing means heating or cooling of canned foods to inactivate bacteria. Many bacterial spores can be killed by either high or very low tempera- ture. Such drastic treatment, however, affects the quality of food. Processing time and temperature should be adequate to eliminate all bacterial growth. Moreover, over-cooking should be avoided as it spoils the flavour as well as the appearance of the product. Almost all fruits and add vegetables can be processed satisfactorily at a temperature of 100°C, i.e., in boiling water. The presence of acid retards the growth of bacteria and their spores. Further, they do not thrive in heavy sugar syrup which is normally used for canning of fruits. Vegetables (except the more acid ones like tomato and rhubarb) which are non-acid in nature, have a hard texture, and proximity to soil which may infect them with spore-bearing organisms are processed at higher temperatures of 115 to 121^{0}*C.*

The sourness of fruits and vegetables is due to their acid content (measured in pH) which has a great influence upon the destruction of microorganisms. The lower the pH the greater is the ease with which a product can be processed or sterilized. Fruits and vegetables can be classified into the following four groups according to their pH value.

Class	**pH**	**Product**
Low acid (called non-acid)	above 5.0	Veg such as peas, lima bean, asparagus, cauliflower, potato, spinach, beet, corn, french bean'
Medium acid	4.5-5.0	Turnip, carrot, okra, cabbage, pumpkin, beet, green bean, etc., and products like soups and sauces
Acid	3.7-4.5	Tomato, pear, banana, mango, jackfruit, pineapple, sweet cherry, peach, apple and
High acid	below 3.7	juice, rhubarb, prune, sauerkrau pickle, chutn

Bacterial spores can be more easily destroyed at pH 3.0 (fruits) than at pH 5.0 to 6.0 (vegetables, except tomato and rhubarb). Bacterial spores do not grow or germinate below pH 4.5. Thus, a canned product having pH less than 4.5 can be processed in boiling water but a product with pH above 4.5 requires processing at 115 at *121^0C* under a pressure of 0.70 to 1.05 kg/cm^2 (10 to 15 lb/sq inch). It is essential that the centre of the can should attain these high temperatures.

The temperature and time of processing vary with the size of the can and the nature of the food: the larger the can, the greater is the processing time. The processing time 'for different canned fruits and vegetables is given in the tables Under 'Canning of Fruits' and 'Canning of Vegetables'. Fruits and acid vegetables are generally processed in open type cookers, continuous non-agitating cookers and continuous agitating cookers, while vegetables (non-acid) are processed under steam pressure in closed retorts known as automatic pressure cookers. In India, small vertical stationary retorts (frontispiece) are generally used for canned vegetable processing. The sealed cans are placed in the cookers, keeping the level of water 2.5 to 5.0 cm above the top of the cans. The cover of the cooker is then screwed down tightly and the cooker heated to the desired temperature. The period of sterilization (processing) should be counted from the time the water starts boiling. After heating for the required period the cooker is removed from the fire and the petcock is opened. When the pressure comes down to zero the cover is removed and the cans are taken out.

(12) Cooling

After processing. the cans are cooled rapidly to about *39°C* to stop the cooking process and to prevent stack-burning. Cooling is done by the following methods:

(i) dipping or immersing the hot cans in tanks containing cold water;

(ii) letting cold water into the pressure cooker specially in case of vegetables;

(iii) Spraying cans with jets of cold water; and

(iv) exposing the cans to air.

Generally the first method, i.e., dipping the cans in cold water, is used. If canned products are not cooled immediately after processing, peaches and pears become dark in colour, tomatoes turn brownish and bitter in taste, peas become pulpy with cooked taste and many vegetables develop flat sour (become sour).

(13) Storage

After labelling the cans, they should be packed in strong wooden cases or corrugated cardboard cartons and stored in a cool and dry place. The outer surface of the cans should be dry as even small traces of moisture sometimes induce rusting. Storage of cans at high temperature should be avoided, as it shortens the shelf-life of the product and often leads to the formation of hydrogen swell.

The marketable life of canned products varies according -to the type of raw materials used. Canned peach, grapefruit, pineapple, beans, spinach, pea etc., can be stored for about two years, while pear, apricot, carrot, beetroot, tomato, etc., can be stored for a comparatively short period only.

Containers for packing of **canned products**

Both tin and glass containers are used in the canning industry, but tin containers are preferred.

(1) Tin containers

Tin cans are made of thin steel plate of low carbon content, lightly coated on both sides with tin metal. It is difficult to coat the steel plate uniformly and during the process of manufacture small microscopic spots are always left uncoated, although the coating may appear perfect to the eye. The contents of the can may react with these uncoated spots resulting in discolouration of the product or corrosion of the tin plate. When the corrosion is severe, black stains of iron sulphide are produced. It is necessary, therefore, to coat the inside of the can with some material (lacquer) which prevents discolouration but does not affect the flavour or wholesomeness of the contents. This process is known as "lacquering".

Two types of lacquers are used:

(i) Acid-resistant: Acid-resistant lacquer is a golden coloured enamel and cans coated with it are called R-enamel or A.R cans. These cans are used for packing acid fruits which are of two kinds : (a) those whose colouring matter is insoluble in water, e.g., peach, pineapple, apricot, grapefruit, and (b) those in which it is water-soluble, e.g., raspberry, strawberry, red plum and coloured grape. Fruits of group (a) are packed in plaincans and those of group (b) in lacquered cans.

(ii) Sulphur-resistant: This lacquer is also of a golden colour and cans coated with it are called C-enamel or S.R. cans. They are meant for non-acid foods only and should not be used for any highly acid product as acid eats into the lacquer. These cans are used for pea, corn, lima bean, red kidney bean, etc.

Size of cans: The sizes of cans in general use are given below:

Trade name of can	Size (mm)
Al	68 x 102
1-lb Jam	78x 90
AJ-T	78 x 119
A2	87 x 114
1-lb Butter	103 x 70
A 2-lb Jam	103 x 102
A 21/2	103 x 119
7-lb Jam	157 x 148
A 10	157 x 178

Recently, a midget can has become highly popular for fruit juices, mango nectar, etc. It holds about 165 ml of beverage and is a very popular picnic pack.

Tin containers are preferred to glass containers because of certain advantages:

(i) Ease of fabrication,
(ii) Strength to withstand processing,
(iii) light weight,
(iv) Ease in handling,
(v) Cheapness, and
(vi) Can be handled by high speed machines.

Causes of spoilage of canned foods

Spoilage of canned products may be due to two reasons:
(A) Physical and chemical changes, and
(B) Microorganisms.

(A) Spoilage due to physical and chemical changes

(1) Swell: When the ends of an apparently normal and perfect can with good vacuum become bulged it is termed as 'Swell' or 'Blower'. The bulge is due to the positive internal pressure of gases formed by microbial or chemical action.

(i) Hydrogen swell: This type of bulging is due to the hydrogen gas produced by the action of food acids on the metal of the can. The bulging ranges from 'Flipping' to the 'Hard Swell'. The food generally remains free of harmful microorganisms and is **fit** for consumption.

(ii) Flipper: The can appears normal, but when struck against a tabletop one or both ends become convex and springs or flips out, but can be pushed back to normal condition by a little pressure. Such a can is termed as "flipper" and may be an initial stage of swell or hydrogen swell. It may also be caused by overfilling, under-exhausting or gas pres- sure due to spoilage.

(iii) Springer: A mild swell at one or both ends of a can is called a 'springer' which may be an initial' stage of hydrogen swell or be due to insufficient exhausting or overfilling of the can. The bulged ends (or at least one end) can be pressed back to the original position, but will again become convex after some time.

(iv) Soft swell: At a more advanced stage, swell develops at both ends of the can which can be pressed and returned to normal position, but springs back when the pressure is removed. A swell of this type is termed as "soft swell" and is more or less similar to that of flipper.

(v) Hard swell: This is the final stage of swell. The bulged ends cannot be pressed back to normal position and the cans ultimately burst.

The following precautions are necessary to prevent the formation of hydro- gen swells:

(a) Good quality tin plate should be used for making the cans. The quality is related to the porosity of the tin coating. The greater the porosity, the greater is the possibility of corrosion of the can. The porosity can, however, be decreased by increasing the thickness of the coating and making it more uniform. Plain cans are less susceptible to hydrogen swell formation than lacquered cans.

(b) About '0.5 per cent citric acid should be added to the syrup used for canning fruits of low acidity such as cherry, mango, papaya, etc. Citric acid checks the formation of hydrogen swell to a great extent.

(c) Before placing the lid a head space of 0.6 to 0.9 cm should be left in the can which is to be exhausted.

(d) The lid should be placed firmly or clinched before exhausting to ensure a high vacuum in the can.

(e) Cans should be exhausted for a fairly longtime, but without affecting the quantity of the product unduly. The larger the quantity of oxygen remaining in the can, the greater would be the corrosion because oxygen combines with the nascent hydrogen formed by the action of acid on the tin container. In the absence of air, the rate of corrosion is low. Oxygen can be excluded from the can by filling it properly and exhausting it thoroughly.

(f) The sealing temperature should not be below 74°C.

(g) At high storage temperature hydrogen formation will be more,

(2) Overfilling: Spoilage due to overfilling is common. During retorting, overfilled cans become strained due to expansion of the contents, and in the absence of vacuum in them swelling takes place. If the cans are properly heat exhausted, the excess material overflows from it due to expansion and thus spoilage because of overfilling is "avoided.

(3) Faulty retort operation: When the steam pressure is reduced rapidly at the end of processing, high pressure develops inside the cans resulting in their distortion and the cans when cooled look like "swells". Cans of very thin tin plate should not be used as they cannot withstand the pressure which develops in the cans while processing.

(4) Under-exhausting: Cans are exhausted to remove most of the air. This helps in the" proper filling of fruits and vegetables and also creates a good vacuum, which is necessary to accommodate any pressure that might develop inside the can as a result of production of hydrogen due to corrosion. Improperly exhausted cans may suffer severe strain during heat processing due to the large internal pressure of the gas present in it. Under-exhausted cans show strain ranging from slight flipping to distortion, depending upon the amount of gas evolved from the product and the size of the head space. All the gas must be removed by tilting the can and pressing its ends. Longer exhausting at a lower temperature of about 79°C gives better results than a short one at about 87°C, 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 cans after exhausting and before closing should, therefore, be avoided.

(5) Panelling: It is generally seen in large sized cans that the body is pushed inward due to the high vacuum inside. This also occurs when the tin plate is thin or the cans are pressure cooled at very high pressure. In very severe cases, seam leakage may occur but normally this is not regarded as spoilage.

(6) Rust: Cans having external rust must be thoroughly examined after removing the rust and, if the walls show a pitted appearance, should be rejected as spoiled. Cans slightly" affected by rust if not used immediately should be rejected. Rust is mostly seen under the label and subsequently affects the label as well. Rust formation can be checked if the cans are externally lacquered.

(7) Foreigil"flavours: During preparation, filling, storage or even transportation, conditions may become unhygienic and the products may develop foreign or "off-flavours". If unsuitable metallic containers are used, a "metallic flavour" develops. Flavour is an important characteristic for maintaining which packages must be examined at regular intervals.

(8) Damage: Rough handling of cans due to carelessness or ignorance may damage them. If any cans show signs of leakage or severe distortion they must be rejected.

(9) Undesirable texture : Texture is another important characteristic, like flavour and colour, which is detected easily by a consumer. In order to main- tain the standard of a product its texture should be tested periodically. Although there are no precise parameters for measuring texture, an instrument like "Tenderometer", which measures the resistance to shearing and relative tenderness, can be used for peas and beans. Calcium salts present in the water used for canning have a "toughening effect" on peas and beans, but such hardening is considered desirable for potatoes and tomatoes. Care should be taken that the processing of soft fruits does not result in their becoming pulp.

(10) Corrosion of cans: Cans become corroded or perforated due to the acidity of the contents, specially highly acid fruits. In recent years, attempts have been made to reduce the spoilage by using improved lacquers for internal coating of cans.

(11) Leakage: A leaking can is known as a "Leaker". This may be due to: (i) defective seaming, (ii) nail holes caused by faulty nailing of cases while packing, (iii) excessive internal pressure due to microbial spoilage sufficient to burst the can, (iv) internal or external corrosion, and (v) mechanical dam- age during handling.

(12) Breathing: There may be a very tiny leak in the can through which air can pass in and destroy the vacuum. In such cases the food is damaged due to rusting of the can caused by oxygen in the air but still remains fit for consumption.

(13) Bursting: This may be caused by the excess pressure of gases produced by decomposition of the food by microorganisms, or by hydrogen gas formed by the chemical action of food acids on the tin plate. In such cases the canned product cannot be used.

(14)Buckling : Sometimes due to improper cooling, distortion of the can takes place resembling 'swell'. Although the distortion can be corrected by pressing, the cans are often badly strained and the contents become spoiled due to entry of microorganisms through the strained seams. This type of spoilage is known as "Buckling" Sometimes a peak or small ridge forms on the can which is known as "Peaking".

(15) Discolouration : This can be detected by visual examination of the can and its contents. Discolouration may be due to biological causes like enzymatic and non-enzymatic browning or metallic contamination. Enzymatic browning due to the enzyme polyphenol oxidase present in fruits and vegetables can be avoided by placing the peeled and cut pieces in 2 per cent salt solution. Non-enzymatic browning is caused by reactions between (i) nitrogenous compounds and sugars, (ii] nitrogenous compounds and organic acids, (iii) sugars and organic acids, and (iv) among organic acids themselves. These reactions are known as Maillard reactions. Metallic contamination is mainly due to iron and copper salts. Some fruits and vegetables contain tannins which react with the iron of the tin plate to form black ferric tannate, which spoils the appearance of the contents. Sometimes hydrogen sulphide gas is produced by the reaction between fruit acids and the tin coating, which in turn reacts with the iron 'of the tin plate to form black iron sulphide. Discolouration is also caused by traces of copper (1 ppm) from the metal vessels used; in contact with hydrogen sulphide copper forms black copper sulphide. Metallic contamination can be avoided by using glass containers, coating the interiors of cans with lacquer and also eliminating the use of iron and copper vessels.

(16) Stack burning: If processed cans are not allowed to cool "own sufficiently before storing, the contents remain hot for a long time. This is known as "stack burning" which results in discolouration, cooked flavour and very soft or pulpy product. Therefore, it is necessary to cool the cans quickly to about 39°C before storage.

(8) Microbial spoilage

(1) Pre-processing spoilage: This type of spoilage occurs because of the time gap between filling and heat processing of the containers. Although processing checks the growth of organisms the gas already present in the can causes swelling and flipping, so delay between filling and processing must be avoided, and also at all stages in the preparation of raw materials for canning.

(2) Under-processing spoilage: Under-processing of canned foods result in their spoilage by thermophilic bacteria and mesophilic organisms and this is termed as "under-processed" spoilage.

(3) Infection due to leakage through seams: A large number of cans after processing show signs of microbial spoilage due to leakage of 'Can seams. Cans which are water-cooled are more likely to leak than air- cooled ones. In such cases the cans mayor may not swell depending upon the type of organism and if there is a defect in the seam it permits free passage of the gas formed in the can. For reducing this type of spoilage the bacterial level of the cooling water should be low and the cans should be properly exhausted to reduce seam strain. Moreover, buckling also allows the entry of microorganisms.

LECTURE-4

Contraction -types of concentration-changes during concentration.

Food Concentration

Foods are concentrated for many of the same reasons that they are dehydrated. Concentration can be a form of preservation, but only for some foods. Concentration reduces weight and volume and results in immediate economic advantages. Nearly all liquid foods to be dehydrated are concentrated before they are dried because in the early stages of water removal, moisture can be more economically removed in highly efficient evaporators than in dehydration equipment. Further, increased viscosity from concentration often is needed to prevent liquids from running off drying surfaces or to facilitate foaming or puffing. Also, some concentrated foods are desirable. Components of diet in their own right. For example concentration of fruit juices plus sugar yields jelly. Many concentrated foods, such as frozen orange juice concentrate and canned soups, are easily recognized because of the need to add water before they are consumed.

The more common concentrated foods include evaporated and sweetened condensed milks, fruit and vegetable juices and nectars, sugar syrups and flavored syrups, jams and jellies, tomato paste, many types of fruit purees used by bakers, candy makers, other food manufacturers, and many more.

Methods of Concentration

(i) Solar Concentration

As in food dehydration, one of the simplest methods of evaporating water is with solar energy. This was done to derive salt from sea water from earliest times and is still practiced today in the United States in man-made lagoons. However, solar evaporation is very slow and is suitable only for concentrating salt solutions.

(ii) Open Kettles

Some foods can be satisfactorily concentrated in open kettles that are heated by steam. This is the case for some jellies and jams and for certain types of soups. However, high temperatures and long concentration times damage most foods. In addition, thickening and burn-on of product to the kettle wall gradually lower the efficiency of heat transfer and slow the concentration process. Kettles and pans are still widely used in the manufacture of maple syrup, but here high heat is desirable to produce colour from caramelized sugar and to develop typical flavour.

(iii) Flash Evaporators

Subdividing the food material and bringing it into direct contact with the heating medium can markedly speed concentration. This is done in flash evaporators. Clean steam superheated at about 150°C is injected into food which is pumped into an evaporation tube where boiling occurs. The boiling mixture then enters a separator vessel in which the concentrated food is drawn off at the bottom and the steam plus water vapour from the food is evacuated through a separate outlet. Because temperatures are high, foods that lose volatile flavor constituents will yield these to the exiting steam and water vapour. These can be separated from the vapour by essence-recovery equipment on the basis of different boiling points between the essences and water.

(iv) Thin-Film Evaporators

In thin-film evaporators, food is pumped into a vertical cylinder which has a rotating element that spreads the food into a thin layer on the cylinder wall. The cylinder wall of double jacket construction usually is heated by steam. Water is quickly flashed from the thin food layer and the concentrated food is simultaneously wiped from the cylinder wall. The concentrated food and water vapour are continuously discharged to an external separator, from which product is removed at the bottom and water vapour passes to a condenser. In some systems the water vapour temperature is raised by mechanical vapour recompression to yield steam for reuse to save energy. Product temperature may reach 85°C or higher, but since residence time of the concentrating food in the heated cylinder may be less than' a minute, heat damage is minimal.

(v) Vacuum Evaporators

Heat-sensitive foods are most commonly concentrated in low-temperature vacuum evaporators. Thin-film evaporators frequently are operated under vacuum by connecting a vacuum pump' or steam ejector to the condenser. It is common to construct several vacuum vessels in series so that the food product moves from one vacuum chamber to the next and thereby becomes progressively more concentrated in stages. The successive stages are maintained at progressively higher degrees of vacuum, and the hot water vapour arising from the first stage is used to heat the second stage, the vapour from the second stage heats the third stage, and so on. In this way, maximum use of heat energy is obtained. Such a system, called a multiple effect vacuum evaporator. Systems employed in the grape juice industry continuously concentrate juice from an initial solids content of 15% to a final
solids concentration of 72% at rates of 4500 gal of single strength juice per hour. Similar systems concentrate tomato juice from 6% solids to 30% solids at rates of 15,000 gal or more of single strength juice per hour. Use of energy-saving mechanical vapour recompression is common.

. Even with efficient vacuum evaporators where water may boil at 30°C or slightly lower, some volatile flavour compounds are lost with the evaporating water vapour. These volatile essences can be recovered, or "stripped", from the water vapour and returned to the cool concentrated food as has been mentioned earlier. However, it is possible to concentrate foods at still lower temperatures and further minimize heat damage and volatile flavour loss; one method of doing so is known as freeze concentration.

(vi) Freeze Concentration

When a solid or liquid food is frozen, all of its components do not freeze at once. First to freeze is some of the water which forms ice crystals in the mixture. The remaining unfrozen food solution is now higher in solids concentration.

It is possible, before the entire mixture freezes, to separate the initially formed ice crystals. One way of doing this is to centrifuge the partially frozen slush through a fine-mesh screen. The concentrated unfrozen food solution passes through the screen while the frozen water crystals are retained and can be discarded. Repeating this process several times on the concentrated unfrozen food solution can increase its final concentration several-fold. Freeze concentration has been known for many years and has been applied commercially to orange juice.

(vii) Ultrafiltration arid Reverse Osmosis/Hyperfiltration

Low-temperature separation and concentration processes employing selective membranes are increasingly being used in the food industry. These applications are largely dependent on membrane properties such as water permeability rate; solute and macromolecule rejection rates, and length of useful membrane life. Different membranes are required for different liquid foods. There are two types of pressure-driven membrane separation processes: (a) reverse osmosis/hyperfiltration, and (b) ultrafiltration. In the former. micromolecular solutes are selectively removed, _ whereas the latter separates out relatively larger solute molecules or colloids. Ultrafiltration membranes are generally "less tight" than reverse osmosis membranes; that is, they restrict macromolecules such as proteins but with moderate pressure allow smaller molecules such as sugars and 'salts to pass through. Reverse osmosis membranes are "tighter", and with greater pressure will permit the passage of water but hold back various sugars, salts, and larger molecules. In nature, osmosis involves the movement of water through a perm-selective membrane from a region of higher concentration to a region of lower concentration. The region of lower concentration generally contains solutes in solution and has associated with it an osmotic pressure. It is possible to reverse the normal flow of water through the membrane by applying pressure on the solute side of the membrane in excess of the osmotic pressure. Various polymers are used for reverse osmosis membranes; these are cellulosic esters, mixed esters of cellulose with acetate/propionate/butyrate, cellulose triacetate, polyacrylonitrile and its copolymers, polyurethanes, etc. Polymers used for ultrafiltration membranes should be rigid/glassy, should not be detectably softened or plasticized by water, and be relatively insensitive to hydrolytic and/or oxidative degradation in aqueous environments. Examples are polymethyl methacrylate, polyvinyl-chloride, polystyrene, poly acrylonitrile, rigid cellulosic esters. These synthetic membranes are manufactured with considerable control over their physical and chemical properties.

Applied to food concentration, ultrafiltration and reverse osmosis processes involve pumping liquid foods under pressure against perm-selective membranes in a suitable support. Equipment may be similar to pressure filters in design. Filtrates passing through one membrane may be further modified by passing through a second tighter membrane. These membrane permeation processes are being used in concentration of beverages and fruit juices, coffee and tea extracts, emulsions, dairy products; concentration and purification of macro-molecules like proteins and enzymes; desalting of protein solutions; treatment of processing wastes, etc.

Changes during Concentration

Concentration processes that expose food to 100°C or higher temperatures for prolonged periods can cause major changes in organoleptic and nutritional properties. Cooked flavours and darkening of colour are two of the more common results. With most foods the lower the concentration temperature the better, since the reconstituted concentrated food should resemble as closely as possible the natural product. Even at the lowest temperatures, however, concentration can cause other changes that are undesirable. Two such changes involve sugars and proteins. All sugars have an upper limit of concentration in water beyond which they are not soluble. For example, at room temperature, sucrose is soluble to the extent of about 2 parts sugar in 1 part water. If water is removed beyond this concentration level, the sugar crystallizes out. This can result in gritty, sugary jellies or jams. It also results in a condition known as "sandiness" in certain milk products when lactose crystallizes due to overconcentration.

As for effects on' proteins, it has been pointed out that proteins can be easily denatured and precipitated from solution. One cause of denaturation can be high concentration of salts and minerals in solution with the protein. As protein-containing foods such as milk are concentrated, the levels of milk salts and minerals can become sufficiently high to partially denature the milk protein and cause it to slowly gel.

Microbial destruction, another type of change that may occur during concentration, will be largely dependent on temperature. Concentration at a temperature of *100DC* or slightly above will kill many microorganisms but cannot be depended on to destroy bacterial spores. When the food contains acid, such as fruit juices, the kill will be greater, but again sterility is unlikely. On the other hand, when concentration is done under vacuum, many bacterial species not only survive the low temperatures but multiply in the concentrating equipment. It, therefore, is necessary to stop frequently and sanitize low-temperature evaporators. and where sterile concentrated foods are required, to resort to an additional preservation treatment.

LECTURE-5

Chemical preservation-different types of chemicals used in processing of Fruits and vegetables-Preservation by Sulphur dioxide and Sodium benzoate- safe limits of usage.

Chemical preservation

Microbial spoilage of food products is also controlled by using chemical preservatives which do not include salt, sugar, acetic acid, oils, alcohols, etc., but only microbial antagonists. The inhibitory action of preservatives is due to their interfering with the mechanism of cell division, permeability of cell membrane and activity of enzymes.

Pasteurized squashes, cordials and crushes have a cooked flavour. After the container is opened, they ferment and spoil within a short period, particularly in a tropical climate. To avoid this, it is necessary to use chemical preservatives. Chemically preserved squashes and crushes can be kept for a fairly long time even after opening the seal of the bottle. It is, however, essential that the use of chemicals is properly controlled, as their indiscriminate use is likely to be harmful. The preservative used should not be injurious to health and should be non-irritant. It should 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, but does not include common salt (sodium chloride), saltpetre (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 chemical preservatives permitted in many countries are :

(i) sulphur dioxide (including sulphites), and
(ii) benzoic acid (include benzoates)

These two are also allowed in India according to the Fruit Product Order (F.P.O.) of 1955.

(i) Sulphur dioxide

It is widely used throughout the world in the preservation of juice, pulp, nectar, squash, crush, cordial and other products. It has good preserving action against bacteria and moulds and inhibits enzymes, etc. In addition, it acts as an antioxidant and bleaching agent. These properties help in the retention of ascorbic acid, carotene and other oxidizable compounds. It also retards the development of nonenzymatic browning or discolouration (after killing the enzyme) of the product. It is generally used in the form of its salts such as sulphite, bisulphite and metabisulphite.

Potassium metabisulphite ($K_20.2S0_2$ or $K_2S_20_S$) is commonly used as a stable source of sulphur dioxide. Being a solid, it is easier to use than liquid or gaseous sulphur dioxide. It is fairly stable in neutral or alkaline media but decomposed by weak acids like carbonic, citric, tartaric and malic acids. When added to fruit juice or squash it reacts with the acid in the juice forming the potassium salt and sulphur dioxide, which is liberated and forms sulphurous acid with the water of the juice.

Sulphur dioxide has a better preservative action than sodium benzoate against bacteria and moulds. It also retards the development of yeasts in juice, but cannot arrest their multiplication, once their number has reached a high value. It is well known that fruit juices with high acidity do not undergo fermentation readily. The preservative action of the fruit acid is due to its hydrogen ion concentration. The pH for the growth of moulds ranges from 1.5 to 8.5, that of yeasts from 2.5 to 8.0 and of bacteria from 4.0 to 7.5. As fruit beverage like citrus squashes and cordials have generally a pH of 2.5 to 3.5, the growth of moulds and yeasts in them cannot be prevented by acidity alone. Bacteria, how- ever, cannot grow. The pH is, therefore, of great importance in the preservation of food product and by regulating it, one or more kinds of microorganism in the beverage can be eliminated . The concentration of Sulphur dioxide required to prevent the growth of microorganism at different pH levels are as under:

pH	Organisms and sulphur dioxide concentration (ppm)			
	Saccharomyces ellipsoideus (Yeast)	Mucor (Mould)	Penicillium (Mould)	Mixed bacteria
2.5	200	200	300	100
3.5	800	600	600	300
7.0	above 5000	above 5000	above" 5000	above

The toxicity of sulphur dioxide increases at high temperature. Hence its effectiveness depends on the acidity, pH, temperature and substances present in fruit juice. According to Indian Fruit Product Order, the maximum amount of sulphur dioxide allowed in fruit juice is 700 ppm, in squash, crush and cordial 350 ppm and in RTS and nectar 100 ppm.

The advantages of using sulphur dioxide are : (a) it has a better preserving action than sodium benzoate against bacterial fermentation, (b) it helps to retain the colour of the beverage for a longer time than sodium benzoate, (c) being a gas, it helps in preserving the surface layer of juices also, (d) being highly soluble in juices and squashes, it ensures better mixing and hence their preservation, and (e) any excess of sulphur dioxide present can be removed either by heating the juice to about 71°C or by passing air through it or by subjecting the juice to vacuum. This causes some loss of the flavouring materials due to volatilization, which can be compensated by adding flavours.

The major limitations of sulphur dioxide are : (a) it cannot oe used in the case of some naturally coloured juices like those of phalsa, jamun, pomegranate, straw- berry, coloured grapes, plum, etc., on account of its bleaching action, (b) it cannot also be used for juices which are to be packed in tin containers, because it not only corrodes the tin causing pinholes, but also forms hydrogen sulphide which has a disagreeable smell and reacts with the iron of the tin container to form a black compound, both of which are highly undesirable, and (c) sulphur dioxide gives a slight taste and odour to freshly prepared beverages but these are not serious defects if the beverage is diluted before drinking.

(ii) Benzoic acid

It is only partially soluble in water hence its salt, sodium benzoate, is used. One part of sodium benzoate is soluble in 1.8 parts of water at ordinary temperature, whereas only 0.34 part of benzoic acid is soluble in 100 parts of water. Sodium benzoate is thus nearl1170 times as soluble as benzoic acid. Pure sodium benzoate is tasteless and odourless. The antibacterial action of benzoic acid is increased in the presence of carbon dioxide and acid, e.g., *Bacillus subtilis* 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 acetic acid fermentation. The quantity of benzoic acid required depends on the nature of the product to be preserved, particularly its acidity. In case of juices having a pH of 3.5 to 4.0, which is the range of a majority of fruit juices, addition of 0.06 to 0.10 per cent of sodium benzoate has been found to be sufficient. In case of less acid juices such as grape juice at least 0.3 per cent is necessary. The action of benzoic acid is reduced considerably at pH 5.0. Sodium benzoate in excess of 0.1 per cent may produce a disagreeable burning taste. According to F.P.O. its permitted level in RTS and nectar is 100 ppm and in squash, crush and cordial 600 ppm. In some European countries, especially Germany, generally methyl, ethyl and propyl esters of para-hydroxy benzoic acid are used. They are, however, not used in India. In the long run benzoic acid may darken the product. It is, therefore, mostly used in coloured products of tomato, phalsa, jamun, pomegranate, plum, water- melon, strawberry, coloured grapes, etc. The preservative should never be added in solid form but should be dissolved in a small quantity of juice or water, and the solution added to the bulk of the product. If this care is not taken, the solid may settle undissolved at the bottom of the container with the result that fermentation may start before the action of preservative can begin.

A number of chemicals such as hydrogen peroxide, formaldehyde, halogenated acetic acid, salicylic acid, etc., which were used as preservatives some years ago, have now been banned in many countries. In recent years, sorbic acid and tylosin, etc., are being tried.

LECTURE-6

Hurdle concept- Intermediate moisture foods.

Hurdle technology:

Hurdle technology is a method of ensuring that pathogens in food products can be eliminated or controlled. This means the food products will be safe for consumption, and their shelf life will be extended. Hurdle technology usually works by combining more than one approach. These approaches can be thought of as "hurdles" the pathogen has to overcome if it is to remain active in the food. The right combination of hurdles can ensure all pathogens are eliminated or rendered harmless in the final product. Hurdle technology has been defined by Leistner (2000) as an intelligent combination of hurdles which secures the microbial safety and stability as well as the organoleptic and nutritional quality and the economic viability of food products. The organoleptic quality of the food refers to its sensory properties, that are its look, taste, smell and texture.

Examples of hurdles in a food system are high temperature during processing, low temperature during storage, increasing the acidity, lowering the water activity or redox potential, or the presence of preservatives. According to the type of pathogens and how risky they are, the intensity of the hurdles can be adjusted individually to meet consumer preferences in an economical way, without compromising the safety of the product.

Hurdles:

Each hurdle aims to eliminate, inactivate or at least inhibit unwanted microorganisms. Common salt or organic acids can be used as hurdles to control microbials in food. Many natural antimicrobials such as nisin, natamycin and other bacteriocins, and essential oils derived from rosemary or thyme, also work well.

Principal hurdles used for food preservation (after Leistner, 1995)[3][4]

Parameter	Symbol	Application
High temperature	F	Heating
Low temperature	T	Chilling, freezing
Reduced water activity	a_w	Drying, curing, conserving
Increased acidity	pH	Acid addition or formation

Reduced redox potential	E_h	Removal of oxygen or addition of ascorbate
Biopreservatives		Competitive flora such as microbial fermentation
Other preservatives		Sorbates, sulfites, nitrites

"Traditionally, fermented seafood products common in Japan, provide a typical example of hurdle technology. Fermentation of sushi employs hurdles that favour growth of desirable bacteria but inhibit the growth of pathogens. The important hurdles in the early stages of fermentation are salt and vinegar. Raw fish is cured in salt (20–30%, w/w) for one month before being desalted and pickled in vinegar. The main target of these hurdles is *C. botulinum*. Growth of lactic acid bacteria during fermentation results in acid production from metabolism of added sugars and rice. The result is a pH hurdle important in controlling growth of *C. botulinum*."

Types of hurdles used for food preservation (from Ohlsson and Bengtsson, 2002)

Type of hurdle	**Examples**
Physical	Aseptic packaging, electromagnetic energy (microwave, radio frequency, pulsed magnetic fields, high electric fields), high temperatures(blanching, pasteurization, sterilization, evaporation, extrusion, baking, frying), ionizing radiation, low temperature (chilling, freezing), modified atmospheres, packaging films (including active packaging, edible coatings), photodynamic inactivation, ultra-high pressures, ultrasonication, ultraviolet radiation
Physicochemical	Carbon dioxide, ethanol, lactic acid, lactoperoxidase, low pH, low redox potential, low water activity, Maillard reactionproducts, organic acids, oxygen, ozone, phenols, phosphates, salt, smoking, sodium nitrite/nitrate, sodium or potassium sulphite, spices and herbs, surface treatment agents
Microbial	Antibiotics, bacteriocins, competitive flora, protective cultures

INTERMEDIATE-MOISTURE FOODS (IMF)

Adjustment and control of water activity to preserve semimoist foods has attracted increasing attention. Intermediate-moisture foods or semimoist foods, in one form or another, have been important items of diet for a very long time. Generally, they contain moderate levels of moisture, of the order of 20- 50% by weight, which is less than is normally present in natural fruits and 'vegetables, but more than is left in conventionally dehydrated products. In addition, 'intermediate-moisture foods contain sufficient dissolved solutes to decrease water activity below that required to support microbial growth. As a consequence, intermediate-moisture foods do not require refrigeration to prevent microbial deterioration. There are various kinds of intermediate-moisture foods: natural products such as honey; manufactured confectionery products high in sugar, jellies, jams, and bakery items such as fruit cakes; and partially dried products including figs, dates etc. In all of these products, preservation is partially from high osmotic pressure associated with the high concentration of solutes; in some, additional preservative effect is contributed by salt, acid, and other specific solutes.

LECTURE-7

Irradiation- process-principle and application in fruit and vegetable Industry-safedoses of usage.

Irradiation

Sterilization of food by ionizing radiations is a recently developed method of preservation which has not yet gained general acceptance. The unacceptable flavour of some irradiated foods and the fear that radioactivity might be induced in such food has come in the way of its greater use. The harmful effects on the human body of radiation from nuclear explosions have given rise to such apprehension in the minds of many people.

When gamma rays or electron beams pass through foods there are collisions between the ionizing radiation and food particles at atomic and molecular levels, resulting in the production of ion pairs and free radicals. The reactions of these products among themselves and with other molecules result in physical and chemical phenomena which inactivate microorganisms in the food. Thus irradiation of food can be considered to be a method of "cold sterilization", i.e., food is free of microorganisms without high temperature treatment.

In the irradiation of foods for preservation, the radiation dose must be care- fully controlled. It should be sufficient to destroy pathogenic and spoilage causing organisms and to inactivate food enzymes. Apart from the intensity of radiation, the amount of radiation absorbed and the period of irradiation are also to be controlled. The WHO and the International Atomic Energy Agency have recommended that radiation dose of up to 1 rad is not hazardous. The longer the food is exposed to radiation, the more radiation will it absorb. Radiation energy must be provided in such a manner that it reaches every particle of food to ensure adequate killing of all microorganisms.

Different organisms are sensitive to radiation to different extents, e.g .. a dose of 10^3 to 10^7 rad kills microorganisms, 10^3 to 10^6 rad kill insects and 10^2 to 10^3 rad are lethal to humans. Sprouting of potatoes, onions. carrots, etc., are inhibited by $10^3$to 10^4 rad. In case of microorganisms, the approximate sterilizing dose for bacterial endospores ffi' 3.0 x 10^6 rad, while that for yeasts and fungi is 5.0 x 10^4 rad.

Ionizing radiations can be used for sterilization of foods in hermetically sealed packs, reduction of the spoilage flora on perishable foods, elimination of patho- gens in foods, control of infestation in stored cereals, prevention of sprouting of potatoes, onions, etc.

LECTURE-8

Processing Technology of Jam – What is Jam?-Ingredients and their role in quality of Jam- Processing of Jam (flowcharts)-Tests for end point determination-Problems in Jam making.

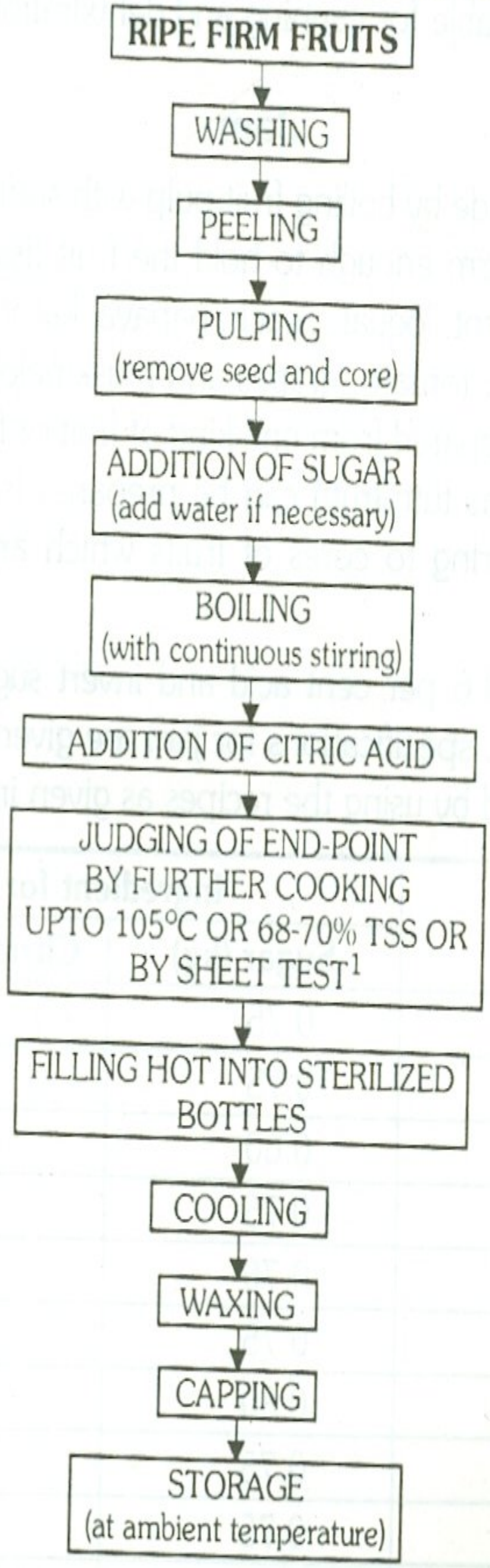
Jam

Jam is a product made by boiling fruit pulp with sufficient sugar to a reasonably thick consistency, firm enough to hold the fruit tissues in position, Apple, pear, sapota (chiku), apricot, loquat, peach, papaya, karonda, carrot, plum, straw- berry, raspberry, mango, tomato, grapes and muskmelon are used for preparation of jams. It can be prepared from one kind of fruit or from' two or more kinds. Commercial jams such as tutti-frutti can be prepared from pieces of fruit, fruit scraping and pulp adhering to cores of fruits which are available in plenty in canning factories.

Jam contains 0.5-0.6 per cent acid and invert sugar should not be more than 40 per cent. In the home it can be prepared by using the recipes as given in the table.

Fruit/Vegetable	Ingredient for one kg pulp		
	Sugar (kg)	Citric acid	Water
Aonla	0.75	-	150
Apple	0.75	2.0	100
Apricot	0.60	1.0	100
Carrot	0.75	2,5	200
Grapes	0.70	1.0	50
Guava	0.75	2.5	150
Karonda	0.80	-	100
Loquat	0.75	1.0	100
Mango	0.75	1.5	50
Musk melon	0.75	2.5	50
Plum	0,80	-	150
Peach	0.80	3.0	100
Pear	0.75	1.5	100

TECHNOLOGICAL FLOW-SHEET FOR PROCESSING OF JAM



Problems in jam production

(i) Crystallization: The final product should contain 30 to 50 per cent invert sugar. If the percentage is less than 30, cane sugar may crystallize out on storage and if it is more than 50 the jam will become a honey-like mass due to the formation of small crystals of glucose. Corn syrup or glucose may be added along with cane sugar to avoid crystallization.

(ii) Sticky or gummy jam: Because of high percentage of total soluble solids, jams tend to become gummy or sticky. This problem can be solved by addition of pectin or citric acid, or both.

(iii) Premature setting: This is due to low total soluble solids and high pectin content in the jam and can be prevented by adding more sugar. If this cannot be done a small quantity of sodium bicarbonate is added to reduce the acidity and thus prevent pre-coagulation.

(iv) Surface graining and shrinkage: This is caused by evaporation of moisture during storage of jam. Storing in a cool place can reduce it.

(v) Microbial spoilage: Sometimes moulds may spoil the jam during storage but they are destroyed if exposed to less than 90 per cent humidity. Hence, jams should be stored at 80 per cent humidity. Mould growth can also prevented by not sealing the filled jar and covering the surface of jam with a disc of waxed paper because mould does not grow under open conditions as rapidly as in a closed space. It is also advisable to add 40 ppm sulphur dioxide in the form of KMS. In the case of cans, sulphur dioxide should not be added to the jam as it causes blackening of the internal surface of the can. Yeasts are not a serious problem due to the high concentration of sugar.

LECTURE-9

Pectin-properties-theories –Olsen's theory ,Spencer's theory , Hinton's theory, Fibril theory. Processing of Jam(flowcharts)-Tests for end point determination-Problems in Jam making.

Pectin

Pectin is a structural heteropolysaccharide contained in the primary cell walls of terrestrial plants. It was first isolated and described in 1825 by Henri Braconnot.[2] It is produced commercially as a white to light brown powder, mainly extracted from citrus fruits, and is used in food as a gelling agent particularly in jams and jellies. It is also used in fillings, medicines, sweets, as a stabilizer in fruit juices and milk drinks, and as a source ofdietary fiber.

Pectins, also known as pectic polysaccharides, are rich in galacturonic acid. Several distinct polysaccharides have been identified and characterised within the pectic group. Homogalacturonans are linear chains of α-(1-4)-linked D-galacturonic acid. Substituted galacturonans are characterized by the presence of saccharide appendant residues (such as D-xylose or D-apiose in the respective cases of xylogalacturonan and apiogalacturonan) branching from a backbone of D-galacturonic acid residues. Rhamnogalacturonan I pectins (RG-I) contain a backbone of the repeating disaccharide: 4)-α-D-galacturonic acid-(1,2)-α-L-rhamnose-(1. From many of the rhamnose residues, sidechains of various neutral sugars branch off. The neutral sugars are mainly D-galactose, L-arabinose and D-xylose, with the types and proportions of neutral sugars varying with the origin of pectin. Another structural type of pectin is rhamnogalacturonan II (RG-II),

which is a less frequent complex, highly branched polysaccharide. Rhamnogalacturonan II is classified by some authors within the group of substituted galacturonans since the rhamnogalacturonan II backbone is made exclusively of D-galacturonic acid units.Isolated pectin has a molecular weight of typically 60–130,000 g/mol, varying with origin and extraction conditions.In nature, around 80 percent of carboxyl groups of galacturonic acid are esterified with methanol. This proportion is decreased to a varying degree during pectin extraction. The ratio of esterified to non-esterified galacturonic acid determines the behavior of pectin in food applications. This is why pectins are classified as high- vs. low-ester pectins (short HM vs. LM-pectins), with more or less than half of all the galacturonic acid esterified.

The non-esterified galacturonic acid units can be either free acids (carboxyl groups) or salts with sodium, potassium, or calcium. The salts of partially esterified pectins are called pectinates, if the degree of esterification is below 5 percent the salts are called pectates, the insoluble acid form, pectic acid.Some plants such as sugar beet, potatoes and pears contain pectins with acetylated galacturonic acid in addition to methyl esters. Acetylation prevents gel-formation but increases the stabilising and emulsifying effects of pectin. Amidated pectin is a modified form of pectin. Here, some of the galacturonic acid is converted with ammonia to carboxylic acid amide. These pectins are more tolerant of varying calcium concentrations that occur in use. To prepare a pectin-gel, the ingredients are heated, dissolving the pectin. Upon cooling below gelling temperature, a gel starts to form. If gel formation is too strong, syneresis or a granular texture are the result, whilst weak gelling leads to excessively soft gels. In high-ester pectins at soluble solids content above 60% and a pH-value between 2.8 and 3.6, hydrogen bonds and hydrophobic interactions bind the individual pectin chains together. These bonds form as water is bound by sugar and forces pectin strands to stick together. These form a 3-dimensional molecular net that creates the macromolecular gel. The gelling-mechanism is called a low-water-activity gel or sugar-acid-pectin gel.In low-ester pectins, ionic bridges are formed between calcium ions and the ionised carboxyl groups of the galacturonic acid. This is idealised in the so-called "egg box-model". Low-ester pectins need calcium to form a gel, but can do so at lower soluble solids and higher pH-values than high-ester pectins. Amidated pectins behave like low-ester pectins but need less calcium and are more tolerant of excess calcium. Also, gels from amidated pectin are thermo-reversible; they can be heated and after cooling solidify again, whereas conventional pectin-gels will afterwards remain liquid.

High-ester pectins set at higher temperatures than low-ester pectins. However, gelling reactions with calcium increase as the degree of esterification falls. Similarly, lower pH-values or higher soluble solids (normally sugars) increase gelling speed. Suitable pectins can therefore be selected for jams and for jellies, or for higher sugar confectionery jellies.

The pectic substances are also of considerable importance in the firming of canned tomatoes, apples, and other fruits by calcium salts. Canned tomatoes which are graded A and which therefore bring the highest price must be relatively firm, yet full-colored. However, during ripening, tomatoes pass through this period rapidly, soften, and on canning undergo considerable maceration and shredding. The addition of small amounts of calcium salts to the pack increases the firmness of the fruit. Calcium salts can be added to the dip or placed in the can with the salt. Calcium chloride is permitted in the United States at a level of 0.07 per cent; and salts such as calcium citrate, sulfate, or phosphate may be used at equivalent levels calculated on the basis of calcium ion. This level has no effect on the flavor of the fruit but produces a marked effect on the firmness. The method is also used widely for firming both canned and frozen sliced apples as well as baked apples. It has also been shown to be effective.

Sources of production

Apples, guavas, quince, plums, gooseberries, oranges and other citrus fruits, contain large amounts of pectin, while soft fruits like cherries, grapes and strawberries contain small amounts of pectin.

Typical levels of pectin in plants are (fresh weight):

- apples, 1–1.5%
- apricot, 1%
- cherries, 0.4%
- oranges, 0.5–3.5%
- carrots approx. 1.4%
- citrus peels, 30%

The main raw-materials for pectin production are dried citrus peel or apple pomace, both by-products of juice production. Pomace from sugar-beet is also used to a small extent.From these materials, pectin is extracted by adding hot dilute acid at pH-values from 1.5 – 3.5. During several hours of extraction, the protopectin loses some of its branching and chain-length and goes into solution. After filtering, the extract is concentrated in vacuum and the pectin then precipitated by adding ethanol or isopropanol. An old technique of precipitating pectin with aluminium salts is no longer used (apart from alcohols and polyvalent cations; pectin also precipitates with proteins and detergents).

Alcohol-precipitated pectin is then separated, washed and dried. Treating the initial pectin with dilute acid leads to low-esterified pectins. When this process includes ammonium hydroxide, amidated pectins are obtained. After drying and milling, pectin is usually standardised with sugar and sometimes calcium-salts or organic acids to have optimum performance in a particular application. Worldwide, approximately 40,000 metric tons of pectin are produced every year.

The main use for pectin (vegetable agglutinate) is as a gelling agent, thickening agent and stabilizer in food. The classical application is giving the jelly-like consistency to jams or marmalades, which would otherwise be sweet juices. For household use, pectin is an ingredient in gelling sugar (also known as "jam sugar") where it is diluted to the right concentration with sugar and some citric acid to adjust pH. In some countries, pectin is also available as a solution or an extract, or as a blended powder, for home jam making. For conventional jams and marmalades that contain above 60% sugar and soluble fruit solids, high-ester pectins are used. With low-ester pectins and amidated pectins less sugar is needed, so that diet products can be made.Pectin can also be used to stabilize acidic protein drinks, such as drinking yogurt, and as a fat substitute in baked goods. Typical levels of pectin used as a food additive are between 0.5 – 1.0% - this is about the same amount of pectin as in fresh fruit.

In medicine, pectin increases viscosity and volume of stool so that it is used against constipation and diarrhea. Until 2002, it was one of the main ingredients used in Kaopectate a drug to combat diarrhoea, along with kaolinite. Pectin is also used in throat lozenges as a demulcent. In cosmetic products, pectin acts as stabilizer. Pectin is also used in wound healing preparations and specialty medical adhesives, such ascolostomy devices. Also, it is considered a natural remedy for nausea.

Functional properties of pectin

It is the hydrocolloid character of pectin which makes it such important and versatile adduct in certain food system. Most important raw material for the production of commercial pectin is apple pomace, peels of various citrus fruits. Apple pomace have low content of pectin [15%] and on the other hand lime peel have to the extend of 50%.

Degree of methoxylation of pectin

It has been found that galactouronic acid unit of pectin is partially esterified with methyl group. The DM of pectin decides the sped of gelation and pectins with high DM also set at higher temperature which will influence their end use. The pectin having DM of more than 50% is called as high methoxyl [HM] pectin and pectin with DM of less than 50% is called as low methoxyl[LM] pectin. HM have quite specific gelling property as it require high soluble solids i.e. above 55% and low pH. LM are able to form thermo- reversible gels and need Ca ions for gel formation.

Measurement of grades of pectin

Initially pectin was graded as per SAG value but now a days it is being estimated as breaking strength and as internal strength as being measured by pektionometer and Stevens- LFRA Texture Analyser respectively.

Pectin and gel formation

Pectin is readily soluble in water when the concentration of soluble solids is below 25%. As the sugar or total solids [TS %] content increases through processing, the available free moisture is removed and pectin will dehydrate. The precipitated macromolecule will form a lattice through the gel and being negatively charged, pectin molecules in solution will repel one another. By lowering the pH [increasing the hydrogen ion concentration], the repulsion effect will be reduced and gel

Theories of gel 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 depends on

- Concentration of pectin in solution
- Constitution of pectin
- pH of the pectin solution
- Concentration of sugar in solution
- Temperature of mixture

Fibril theory

According to Cruess, when sugar is added to pectin solution, it destabilizes the pectin-water equilibrium and the pectin conglomerates forming a network of fibrils holds the sugar solution in the interfibrillar spaces. The strength of the jelly depends on the strength of fibrils, their continuity and rigidity. The greater the amount of pectin, greater number of fibrils formed and the network will be more continue and dense. The firmness of network depends on concentration of sugar and acidity. Increasing amount of sugar reduces the of water to be supported by pectin firbrils, lower amount of sugar can be compensated by using additional amount of pectin. The fibrils of the pectin become tough in the presence of acid and thus hold sugar. If a larger amount of acid is present, fibrils lose their elasticity with the result that the jelly becomes syrupy, due to hydroxylation of pectin. If acid is present in smaller amount, a weak fibril is formed which is unable to support the sugar solution. It can be made up by adding more pectin. Ultimately, the maximum amount of acid which can be added to the pectin solution, without any undesirable effect, is determined by the degree of decomposition of the pectin.

Spencer's theory

Pectin particles are negatively charged. A pectin solution is most stable at the neutral pH . Thus increase in acidity or alkanity decreases the stability of pectin solution. In jelly formation , sugaracts as a precipitating gent, and the presence of acid helps it. Some salts also help in the precipitation of pectin, while others hinder t according to their capacity to increase or decrease thestability. Thus, more the acid present lesser will be the sugar requirement.

Olsen's theory

If pectin is taken to be a negatively charged hydrophilic colloid, the following may be assumed.

- Sugar acts as dehydrating agent, which disturbs the equilibrium existing between water and pectin.
- Sugar does not dehydrate the pectin micelles instantaneously, but requires the time to bring about an equilibrium
- If the negative charge on pectin is reduced, with the help of H+ concentration, pectin precipitates and form a network of insoluble fibers provided that the sugar is present in sufficient concentration.
- The rate of hydration and precipitation of pectin increases with the addition of acid upto an optimum of about pH 2.0, in direct proportion to H+ concentration
- As the system reaches an equilibrium, the jelly strength becomes the maximum
- Salt 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 f the jelly or by combination of both

Hinton's theory

It s based upon the assumption that pectins are complex mixtures of variables composition. According to it, gelations of pectin are a type of coagulation in which the coagulated particles forma continuous network. It is only the non ionized, and not the ionized pectin, which enters into jelly formation. To form a jelly, therefore, the concentration of non ionized pectin must exceed a certain saturation limit, which varies with the concentration of total solids in the mixture.

Strength of Pectin Jellies

- **Quantity of pectin :** the larger the amount of pectin present, the higher is the jelly strength
- **Quantity of acid :** the larger the amount of acid presents, the lower the pH and higher is the jelly strength.
- **Quantity of salts :** Jelly strength is affected by the presence of salt as also by the temperature of gelation and the tie elapsing between the additions of sugar and pouring of equally into containers
- **Quantity of sugar :** the higher the sugar concentration, the greater is the jelly strength
- **Temperature of gelation:** more jelly strength is obtained when sugar + pectin is heated upto 21 to 100 °C

LECTURE-10 AND 11

Jelly and Marmalades – Jelly- Difference between Jam and Jelly-Processing of Jelly-End point determination-Failure of Jellies to set- Cloudy or foggy Jellies-Formation of crystals- Syneresis.

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Marmalades-what is a marmalade-types-Jam marmalade-Jelly marmalade-Problem in marmalade making.

Jelly

A jelly is a semi-solid product prepared by boiling a clear, strained solution of pectin-containing fruit extract, free from pulp, after the addition of sugar and acid. 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 keep its shape when removed from the mould. It should be firm enough 'to retain a sharp edge but tender enough to quiver when pressed. It should not be gummy, sticky or syrupy or have crystallized sugar. The product should be free from dullness, with little or no syneresis (weeping), and neither tough nor rubbery.

According to their pectin and acid contents:

1. ***Rich in pectin and acid:*** Sour and crab apple, grape, sour guavas, lemon, oranges (sour), plum (sour), jamum.
2. ***Rich in pectin but low in acid:*** Apple (low acid varieties), unripe banana, sour cherry, fig (unripe), pear, ripe guava, peel of orange and grapefruit.
3. ***Low in pectin but rich in acid:*** Apricot (sour), sweet cherry, sour peach, pineapple and strawberry.
4. ***Low in pectin and acid:*** Ripe apricot, peach (ripe), pomegranate, rasp berry, strawberry and any other over-ripe fruit.

In the home it can be prepared by using following recipes:

Fruit	**Ingredients for one**	
	Sugar (kg)	**Citric acid**
Guava	0.75	3.0
Sour apple	0.75-1.00	2.0
Gooseberry	0.80	-
Karonda	0.75	-
Jamun	0.75	1.0
Wood apple	1.00	-
Plum	0.75	2.5
Loquat	0.80	2.0
Papaya	0.75	3.0

Important considerations in jelly making

Pectin, acid, sugar (65%), and water are the four essential ingredients. Pectin test and determination of end-point of jelly formation are very important for the quality of the jelly.

(A) Pectin

Pectin substances present in the form of calcium pectate are responsible for the firmness of fruits. Pectin is the most important constituent of jelly. It is a commercial term for water-soluble pectinic acid which under suitable conditions forms a gel with sugar and acid. In the early stage of development of fruits, the pectic substance is a water-insoluble protopectin which is converted into pectin by the enzyme protopectinase during ripening of fruit. In over-ripe fruits, due to the presence of pectic methyl esterase (PM E) enzyme, the pectin gets largely converted to pectic acid which is water-insoluble. This is one of the reasons that both immature and overripe fruits are not suitable for making jelly and only ripe fruits are used.

The setting of pectin is also dependent upon the pH and sugar concentration. Stiffness of the gel increases with increasing concentration of pectin up to a certain point beyond which the addition of more pectin has little effect. Too little pectin gives a soft syrup instead of gel. Pectin tends to keep the sugar from crystallizing by acting as a protective colloid, but is not effective when the concentration of sugar is 70 per cent or more. The jellying power of fruit pectin depends upon the amount of pectin used as well as its degree of polymerization and acetyl content.

The amount of pectin extracted varies with the method of extraction, the ripeness of the fruit, the quantity of water added for extracting the juice and the kind of fruit. Usually about 0.5-1. 0 per cent of pectin of good quality in the extract is sufficient to produce good jelly. If the pectin content is higher a firm and tough jelly is formed and if it is less the jelly may fail to set.

Determination of pectin content : The pectin content of the strained extract is usually determined by one of the following two methods.

(i) Alcohol test: This method, involving precipitation of pectin with alcohol, is outlined below: One teaspoonful of strained extract is taken in a beaker and cooled, and 3 teaspoonfuls of methylated spirit are poured gently down the side of the beaker which is rotated for mixing and allowed to stand for a few minutes.

(a) If extract is rich in pectin, a *single, transparent lump* or *clot will form.* An equal amount of sugar is to be added to the extract for preparation of jelly.

(b) If extract contains a moderate amount of pectin, *the clot will* be *less firm and fragmented.* Three-fourths the amount of sugar is to be added.

(c) It extract is poor in pectin, numerous *small granular clots will* be *seen.* One-half the amount of sugar is added.

(ii) Jelmeter test : The jelmeter is held in the left hand with the thumb and forefinger. The bottom of the jelmeter tube is closed with the little finger. The strained extract is poured into the jelmeter with a spoon, held in the right hand, till it is filled to the brim. While still holding the jelmeter, the little finger is removed from the bottom end and the extract is allowed to flow or drip for exactly one minute, at the end of which the finger is replaced. The reading of the *level* of extract in the jelmeter is noted. This figure indicates how many parts of sugar are to be added to one part of juice.

(8) Acid

The jellying of extract depends on the amount of acid and pectin present in the fruit. Of the three acids citric, malic and tartaric found in fruits, tartaric acid *gives* the best results.The.final jelly should contain at least 0.5 per cent (preferably 0.75%) but not more than 1 per cent total acids because a larger quantity of acid may cause syneresis.

pH of extract : Jelly strength increases with the increase in pH until optimum is reached. Further addition of acid decreases the jelly strength. The optimum pH for a jelly containing 1 per cent pectin is approximately 3.0, 3.2 and 3.4 for 60, 65 and 70 per cent TSS, respectively. The pH of the jelly can be controlled by (i) adjusting pH of extract with acid/alkali, and (ii) adding a suitable buffer. Fruits also contain salts like sodium citrate, sodium potassium tartrate, etc., which *have* buffering action and help to control pH. In general, the optimum pH value for jelly is 3.2.

(C) Sugar

This essential constituent of jelly imparts to it sweetness as well as body. If the concentration of sugar is high, the jelly retains less water resulting in a stiff jelly, probably because of dehydration.

Inversion of sugar : When sugar (sucrose) is boiled with an acid, it is hydrolyzed into dextrose and fructose, ths degree of inversion depending on the pH and duration of boiling. Because of partial inversion of the sucrose, a mixture of sucrose, glucose and fructose are found in the jelly. This mixture is more soluble in water than sucrose alone and hence the jelly can hold more sugar in solution without crystallization.

(D) Judging of end-point

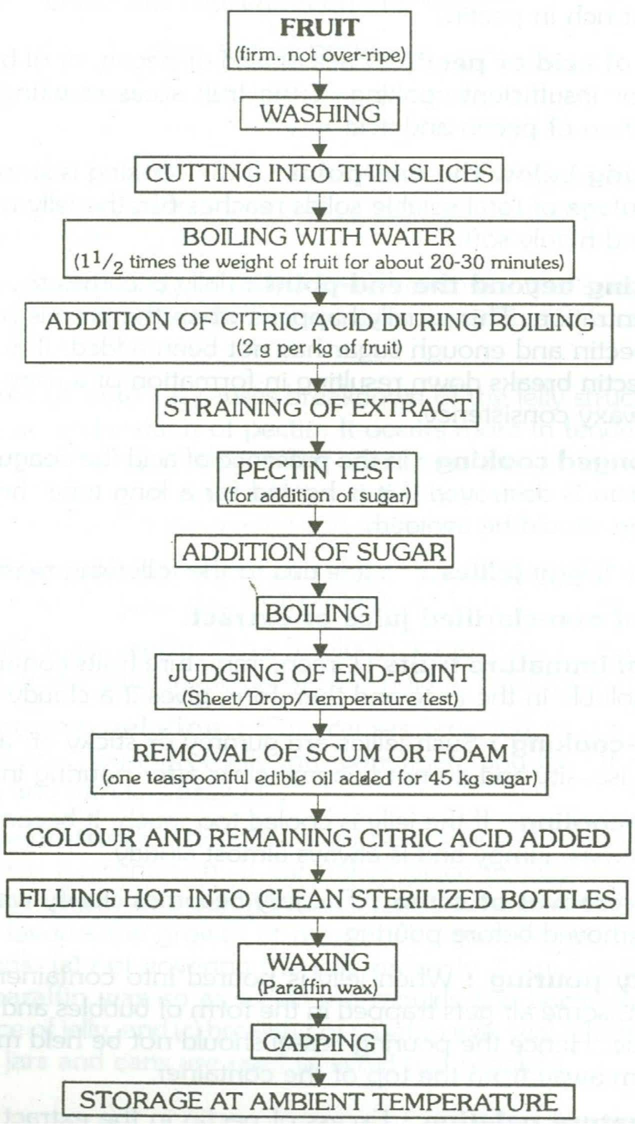
Boiling of jelly should not be prolonged, because excessive boiling results in a greater inversion of sugar and destruction of pectin. The important point to remember is that it is the fruit extract which requires boiling and not the added sugar. If a jelly is cooked for a prolonged period, it may become gummy, sticky, syrupy and deteriorate in colour and flavour. The end-point of boiling can be judged in the following way:

i) Sheet or flake test: A small portion of jam is taken out during boiling, in a spoon or wooden ladle and cooled slightly. It is then allowed to drop. If the product falls off in the form of a sheet or flakes instead of flowing in a continuous stream or syrup, it means that the end-point has been reached and the product is ready, otherwise, boiling is continued till the sheet test is positive.

(ii) Drop test: A drop of the concentrated mass is poured into a glass containing water. Settling down of the drop without disintegration de- notes the end-point.

(iii) Temperature test: Asolution containing 65 per cent total soluble solids boils at 105°C. Heating of the jelly to this temperature would automatically bring the concentration of solids to 65 per cent. This is the easiest way to ascertain the end-point.

TECHNOLOGICAL FLOW-SHEET FOR PROCESSING OF JELLY



Problems in jelly making : The most important difficulties that are experienced are as follows:

1. **Failure to set:** This may be due to :

(i) **Addition of too much sugar** : It results in a syrupy or highly soft jelly which can be corrected by addition of sufficient quantity of fresh, strained extract rich in pectin.

(ii) **Lack of acid or pectin:** Lack of acid or pectin, or of both, in the fruit used or insufficient cooking of the fruit slices resulting in inadequate extraction of pectin and acid.

(iii) **Cookirig below the end-point** : If the cooking is stopped before the percentage of total soluble solids reaches 65, the jelly may remain syrupy and highly soft.

(iv) **Cooking beyond the end-point** : 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 acid is in excess, the pectin breaks down resulting in formation of a ropy syrup or a jelly with waxy consistency.

(v) **Prolonged cooking:** In the presence of acid the coagulating property of pectin is destroyed if it is heated for a long time, hence prolonged heating should be avoided.

2. **Cloudy or foggy jellies:** It is due to the following reasons:

(i) **Use of non-clarified juice or extract.**

(ii) **Use of immature fruits:** Green, immature fruits contain starch which is insoluble in the juice and therefore, gives it a cloudy appearance.

(ili) **Over-cooking:** Such jellies are gummy or sticky on account of their high viscosity and do not become clear after pouring into containers.

(iv) **Over-cooling:** If the jelly is cooled too much, it becomes viscous and sometimes, lumpy and is always almost cloudy.

(v) **Non-removal of scum** : The jelly becomes cloudy when the scum is not removed before pouring.

(vi) **Faulty pouring:** When jelly is poured into containers from a grea height, some air gets trapped in the form of bubbles and makes the jelly opaque. Hence the pouring vessel should not be held more than about 2.5 em away from the top of the container.

(vii) **Premature gelation** : Excess of pectin in the extract causes prerna ture gelation with the result that air may get trapped in the jelly and thus make it opaque. It can be avoided by :

(a) Heating the solution to the boiling point and immediately pouring it into containers so as to reduce the time of contact between pectin, acid and boiling sugar;

(b) Using low concentration of sugar;

(c) Using a slow-setting pectin; and

(d) Not using acid during cooking and instead putting a concentrated solution of acid in the container prior to pouring the cooked juice.

3. **Formation of crystals** : It is due to addition of excess sugar and also to over-concentration of jelly.

4. **Syneresis or weeping of jelly:** The phenomenon of spontaneous exudation of fluid from a gel is called syneresis or weeping and is caused by several factors: .

i) Excess of acid : It causes breakdown of the jelly structure by hydrolysis or decomposition of pectin. It occurs more in tender jellies and can be prevented by mixing either some quantity of juice low in acid or more of pectin, so that a larger quantity of sugar can be added which helps in reducing the acidity and increasing the volume of jelly.

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

(iii) **Premature gelation** : This causes breaking of the pectin network during the pouring of jelly into containers and thus the jelly becomes weak and remains broken.

(v) **Fermentation:** Though a high percentage of sugar (65%) prevents ordinary fermentation, it can takes place in jelly if syneresis occurs. Storage of jelly in a damp place, even if covered with a seal of paraffin wax, favours the growth of mould. The growth may be due to several reasons: (a) not covering the jelly properly, (b) not pouring sufficiently hot paraffin wax so as to kill the moulds and bacteria present on the surface of jelly, and (c) breaking of paraffin wax seal. Hermetically sealable glass jars and cans are used to avoid this problem.

Marmalade

This is a fruit jelly in which slices of the fruit or its peel are suspended. The term is generally used for products made from citrus fruits like oranges and lemons in which shredded peel is used as the suspended material. Ci n us marmalades are classified into (i) jelly marmalade, and (ii) jam marmalade.

(1) Jelly marmalade: The following combinations give good quality of jelly marmalade:

(i) Sweet orange (Malta) and khatta or sour orange *(Citrus* aurantium) in the ratio of 2: 1 by weight. Shreds of Malta orange peel are used.

(ii) Mandarin orange and khatta in the ratio of 2: 1 by weight. Shreds of Malta orange peel are used.

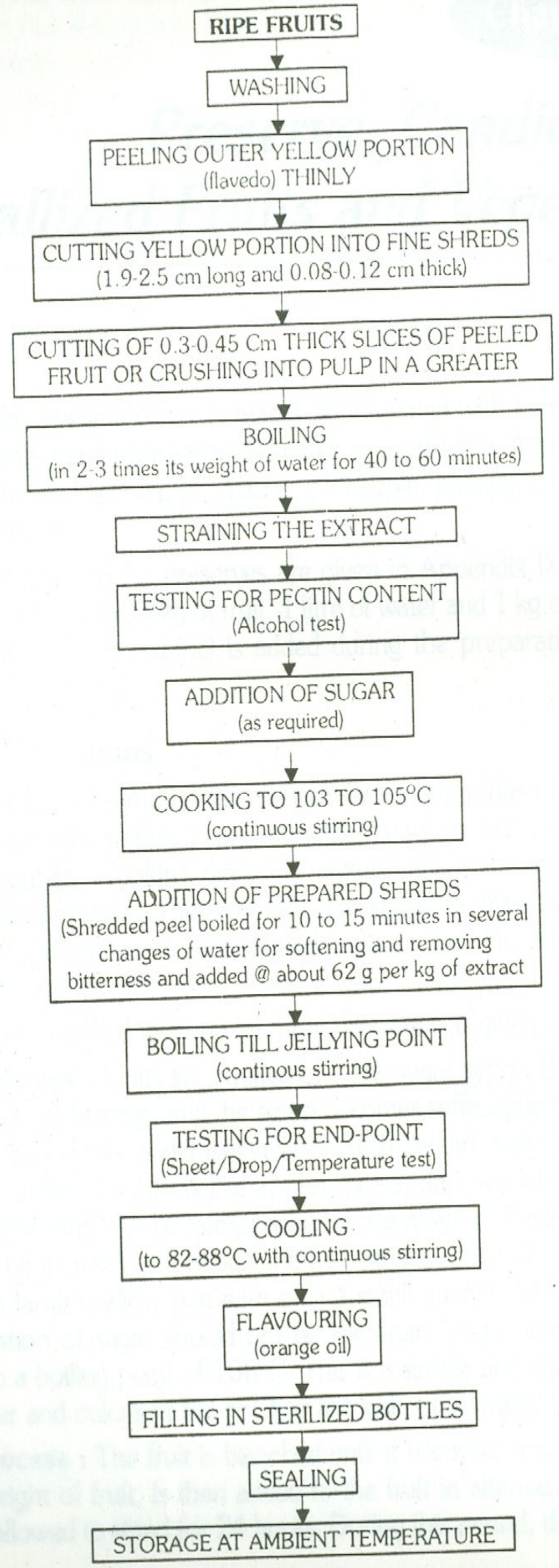
(iii) Sweet orange (Malta) and galgal *(Citrus iimonia)* in the ratio of 2: 1 by weight. Shreds of Malta orange peel are used.

(2) Jam marmalade : The method of preparation is practically the same as that for jelly marmalade. In this case the pectin extract of fruit is not clarified and the whole pulp is used. Sugar is added according to the weight of fruit, generally in the proportion of 1: 1. The pulp-sugar mixture is cooked till the TSS content reaches 65 per cent.

Problems in marmalade making

Browning during storage is very common which can be prevented by addition of 0.09 g of KMS per kg of marmalade and not using tin containers. KMS dissolved in a small quantity of water is added to the marmalade while it is cooling. KMS also eliminates the possibility of spoilage due to moulds.

TECHNOLOGICAL FLOW-SHEET FOR PROCESSING OF MARMALADE



LECTURE-12 & 13

Fruit preserves and candied fruits-What are fruit preserves?-Preparation of fruits preserves-problems in making; Candied fruits-Preparation of candied fruits; Glazed fruit-preparation.

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Glazed fruit- preparation, Crystallized fruit-preparation-problems in preparation of preserves and candied fruit.

Preserve

A mature fruit/vegetable or its pieces impregnated with heavy sugar syrup till it becomes tender and transparent is known as a preserve. Apple, pear, mango, cherry, karonda, strawberry, pineapple, papaya, etc., can be used for making preserves.

In the home they can be prepared using 1 kg of fruit, 1 liter of water and 1 kg of sugar. A little quantity of acid (citric or tartaric) is added during the preparation to prevent crystallization of the syrup.

General considerations

Cooking of fruit in syrup is difficult because the syrup has to be maintained at a proper consistency so that it can permeate the whole fruit without causing it to shrink or toughen. Cooking directly in syrup causes shrinking of fruit and reduces absorption of sugar. Therefore, the fruit should be blanched first to make it soft enough to absorb water, before steeping in syrup. However, highly juicy fruits may be cooked directly.

Fruits may be cooked in syrup by three processes as given below:

(i) Rapid process: Fruits are cooked in low-sugar syrup. Boiling is continued with gentle heating until the syrup becomes sufficiently thick. Soft fruits such as strawberries and raspberries, 'which require very little boiling for softening, unlike hard fruits like apples, pears, and peaches, which require prolonged heating, can be safely cooked in heavy syrup. Rapid boiling should, however, be avoided as it makes the fruit tough, especially when heating is done in a large shallow pan with only a small quantity of syrup. The final concentration of sugar should not be less than 68 per cent which corresponds to a boiling point of 106°C. This is a simple and cheap process but the flavour and colour of the product are lost considerably during boiling.

(ii) Slow process : The fruit is blanched until it becomes tender. Sugar, equal to the weight of fruit, is then added to the fruit in alternate layers and the mixture allowed standing for 24 hours. During this period, the fruit gives out

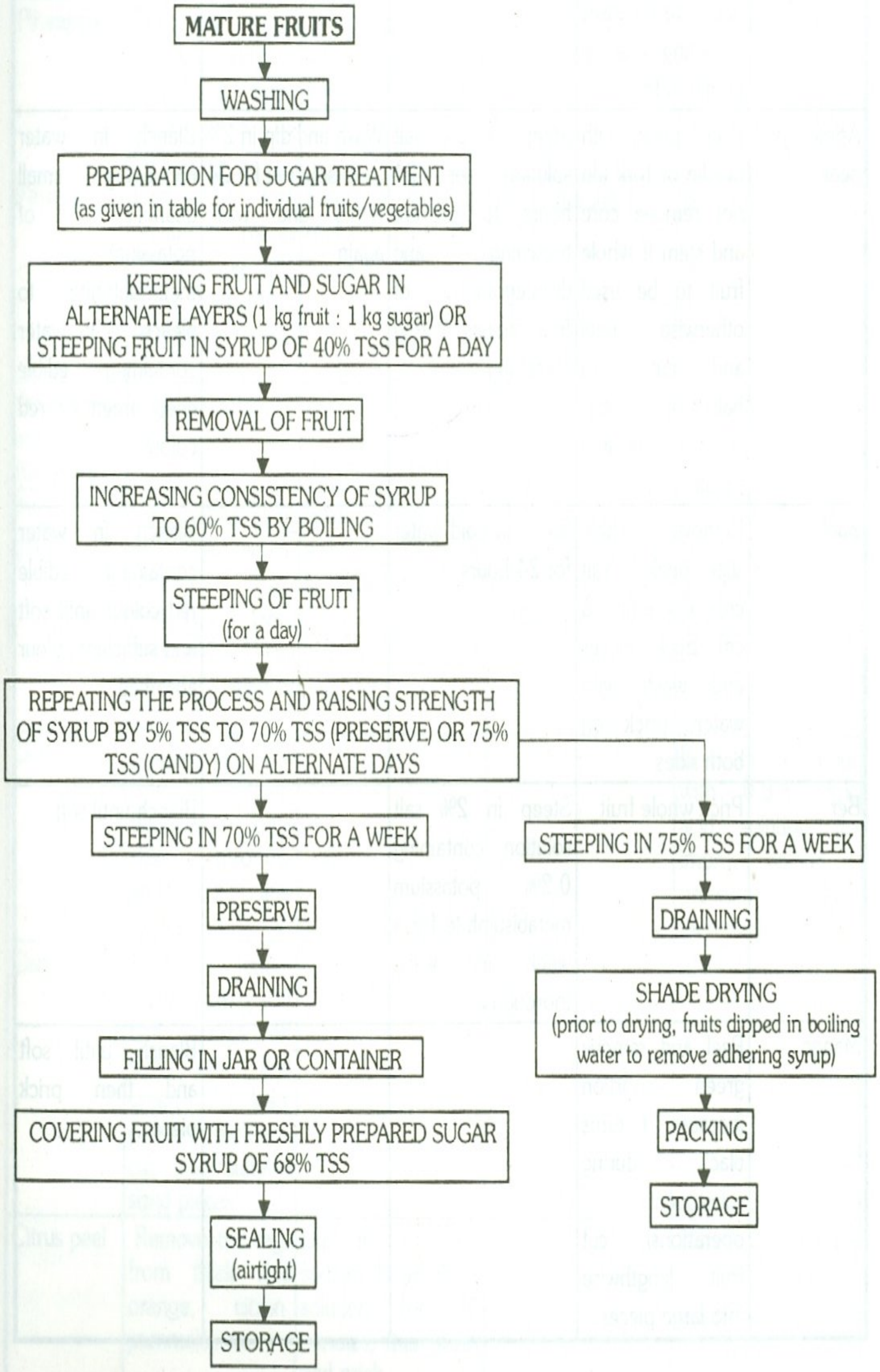
Water and the sugar goes into solution, result in a syrup containing 37-38 per cent total soluble solids. Next day the syrup is boiled after removal of fruits to raise its strength to about 60 per cent total soluble solids. A small quantity of citric or tartaric acid (1 to 1.5 g per kg sugar) is also added to invert a portion of the cane sugar and thus prevent crystallization. The whole mass is then boiled for 4-5 minutes and kept for 24 hours. On the third day, the strength of syrup is raised to about 65 per cent, total soluble solids by boiling. The fruit is then left in the syrup for a day. Finally, the strength of the syrup is raised to 70 per cent total soluble solids and the fruits are left in it for a week. The preserve is now ready and is packed in containers. In practice, the number of steps may be varied.

(iii) Vacuum process : The fruit is first softened by boiling and then placed in the syrup which should have 30-35 per cent total soluble solids. The fruit- syrup blend is then transferred to a vacuum pan and concentrated under reduced pressure to 70 per cent total soluble solids. Preserves made by this process retain the flavour and colour of the fruit better than by the other two methods. In all these processes, the fruit is kept covered with syrup during cooking as well as afterwards otherwise it will dry up and the quality of the product would be affected. The product should be cooled quickly after the final boiling to prevent discolouration during storage. The fruits are drained free of syrup and filled in dry containers or glass jars. Freshly prepared boiling syrup containing 68 per cent total soluble solids is then poured into the jars/containers which are then sealed airtight. In commercial scale production, however, it is better to sterilize the cans to eliminate any possibility of spoilage of product during storage.

Candied fruits/vegetables

A fruit/vegetable impregnated with cane sugar or glucose syrup, and subsequently drained free of syrup and dried, is known as candied fruit/vegetable. The most suitable fruits for candying are aonla, karonda, pineapple, cherry, papaya, apple, peach" and peels of orange, lemon, grapefruit and citron, ginger, etc. Pineapple cores, which are a waste product in the canning of pineapples, can be candied directly without any preliminary treatment. There is scope for developing this useful by-product. F.P.O. specifications.The process for making candied fruit is 'practically similar to that for preserves. The only difference is that the fruit is impregnated with syrup having a higher percentage of sugar or glucose. A certain amount {25-30 per cent} of invert sugar or glucose, viz. confectioners glucose (corn syrup, crystal syrup or commercial glucose), dextrose or invert sugar is substituted for cane sugar. The total sugar content of the impregnated fruit is kept at about 75 per cent to prevent fermentation. The syrup left over from the candying process can be used for candying another batch of the same kind of fruit after suitable dilution, for sweetening chutneys, sauces and pickles, and in vinegar making.

PROCESSING FLOW-SHEET FOR MANUFACTURING OF PRESERVE AND CANDY



Glazed fruits and vegetables

Covering of candied fruits/vegetables with a thin transparent coating of sugar, which imparts them a glossy appearance, is known as glazing. The preparation of glazed fruits has been described by Cruess as under:

Cane sugar and water (2: 1 by weight) are boiled in a steam pan at 113- *114°C* and the scum is removed as it comes up. Thereafter the syrup is cooled to *93°C* and rubbed with a wooden ladle on the side of the pan when granulated sugar is obtained. Dried candied fruits are passed through this granulated portion of thesugar solution, one by one, by means of a fork, and then placed on trays in a warm dry room. They may also be dried in a drier at *49°C* for 2-3 hours. When they become crisp, they are packed in airtight containers for storage.

Crystallized fruits/vegetables

Candied fruits/vegetables when covered or coated with crystals of sugar, either by rolling in finely powdered sugar or by allowing sugar crystals to deposit on them from a dense syrup are called crystallized fruits. The candied fruits are placed on a wire mesh tray which is placed in a deep vessel. Cooled syrup (70 per cent total soluble solids) is gently poured over the fruit so as to cover it entirely. The whole mass is left undisturbed for 12 to 18 hours during which a thin coating of crystallized sugar is formed. The tray is then taken out carefully from the vessel and the surplus syrup drained off. The fruits are then placed in a single layer on wire mesh trays and dried at room temperature or at about *49°C* in driers.

Problems in preparation of preserves and candied fruits

(i) Fermentation: It is due to low concentration of sugar used in the initial stages of preparation of preserves. Sometimes fermentation also occurs during storage due to low concentration of sugar and insufficient cooking. This can be prevented by boiling the product at suitable intervals, by adding the required quantity of sugar and by storage in a cool and dry place.

(ii) Floating of fruits in jar : It is mainly due to filling the preserve without cooling and can be avoided by cooling the preserve prior to filling.

(iii) Toughening of fruit skin or peel: It may be due to inadequate blanching or cooking of fruits hence blanching till tender is necessary. Toughness may develop when cooking is done in a large shallow pan with only a small quantity of syrup.

(iv) Fruit shrinkage : Cooking of fruits in heavy syrup greatly reduces absorption of sugar and causes shrinkage. Therefore, fruits should be blanched first or cooked in low-sugar syrup.

(v) Stickiness: It may develop after drying or during storage due to insufficient consistency of the syrup, poor quality packing and damp storage conditions.

If candied and crystallized fruits are stored under humid conditions, they lose some of their sugar due to absorption of moisture from the air. Further, they become mouldy if they are not sufficiently dried and are packed in wet containers.

There is considerable scope for exporting preserves and candies. Since these products are hygroscopic, water-proof packaging like metal and glass containers which are impermeable to water vapour should be used. Newer flexible plastic films would be cheap and highly effective. There is need for exploring the possibilities of utilizing various types of plastics for packaging of such products.

LECTURE-14 & 15

Chutneys-Preparation of chutney; Pickles-Types of Pickling-Pickling with salt-Dry salting-Brining.

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Pickling with Vinegar and fermentation – Saurkraut -Role of lactic acid bacteria in pickling; Pickling with oil –pickling with mixture of salt, oil and spices-Problems/ spoilage in pickles.

Chutneys

A good quality chutney should be palatable and appetizing. Mango chutney is an important food product exported from India to many countries. Apple and apricot chutneys are also very popular in the country. The method of preparation of chutney is similar to that for jam except that spices, vinegar and salt are added. The fruits/vegetables are peeled, sliced or grated, or cut into small pieces and cooked in water until they become sufficiently soft. The quality of chutney depends to a large extent on its cooking which should be done for a long time at a temperature below the boiling point. To ensure proper thickening, cooking is done without a lid even though this results in some loss of volatile oils from the spices. Chopped onion and garlic are added at the start to mellow their strong flavours. Spices are coarsely powdered before adding. Vinegar extract of spices may be used instead of whole spices. Spice and vinegar are added just before the final stage of cooking, because prolonged boiling causes loss of some of the essential oils of spices and of vinegar by volatilization. In mango and apricot sweet chutneys, where vinegar is used in large quantity, the amount of sugar added may be reduced, because vinegar itself acts as a preservative. These chutneys are cooked to the consistency of jam to avoid fermentation.

Recipes for chutneys

Some common recipes for preparation of chutney are given below. However, it is always possible to go beyond a recipe, ignoring conventional tastes and creating something new.

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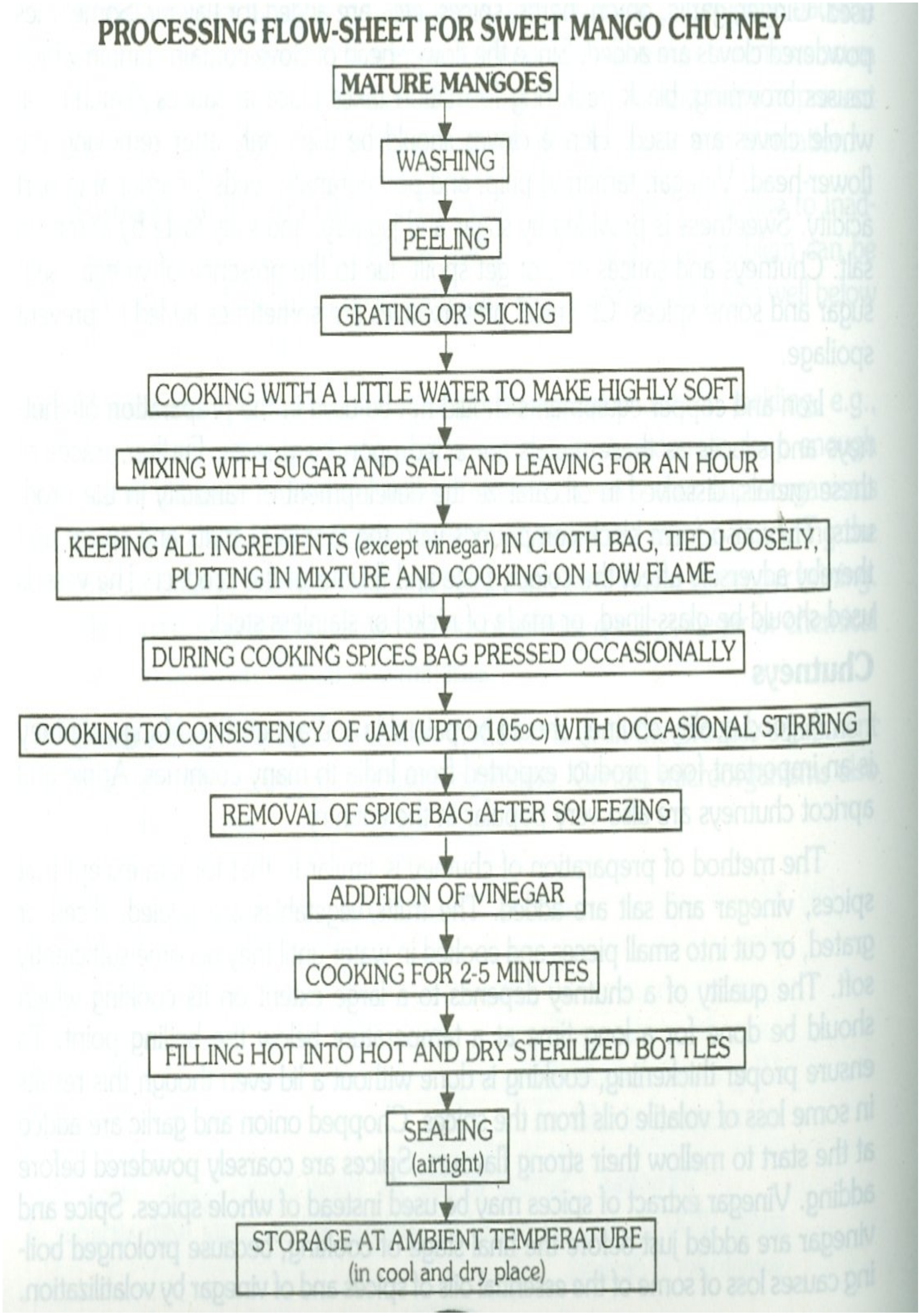
Sweet mango chutney

Mango slices or shreds 1 kg, sugar or gur 1 kg, salt 45 g, onions (chopped) 50 g, garlic (chopped) 15 g, ginger (chopped) 15 g, red chilli powder 10 g, black pepper, cardamom (large), cinnamon, cumin, aniseed (powdered) 10 g each, clove (headless) 5 numbers and vinegar 170 ml.



Pickles

The preservation of food in common salt or in vinegar is known as pickling. It is one of the most ancient methods of preserving fruits and vegetables. Pickles are good appetizers and add to the palatability of a meal. They stimulate the flow of gastric juice and thus help in digestion. Several kinds of pickles are sold in the Indian market. Mango pickle ranks first followed by cauliflower, onion, turnip and lime pickles. These are commonly made in homes as well as commercially manufactured and exported. Fruits are generally preserved in sweetened and spiced vinegar, while vegetables are pre- served in salt.

Pickling is the result of fermentation by lactic acid-forming bacteria" which are generally present in large numbers on the surface of fresh vegetables and fruits. These bacteria can grow in acid medium and in the presence of 8-10 per cent salt solution, whereas the growth of a majority of undesirable organisms is inhibited -. Lactic acid bacteria are most active at 30°C, so this temperature must be maintained as far as possible in the early stage of pickle making When vegetables are placed in brine, it penetrates into the tissues of the former and soluble material present in them diffuses into the brine by osmosis, The soluble material includes fermentable sugars and minerals. The sugars serve as food for lactic acid bacteria which convert them into lactic and other acids. The acid brine thus formed acts upon vegetable' tissues to produce the characteristic taste and aroma of pickle. In the dry salting method several alternate layers of vegetables and salt (20- 30 g of drysalt per kg vegetables) are kept in a vessel which is covered with a cloth and a wooden board and allowed to stand for about 24 hours. During this period, due to osmosis, sufficient juice comes out from the vegetables to form brine. Vegetables which do not contain enough juice (e.q., cucumber) to dissolve the added salt are covered with brine (steeping in a concentrated salt solution is known as brining). The amount of brine required is usually equal to half the volume of vegetables. Brining is the most important step in pickling. The growth of a majority of spoilage organisms is inhibited by brine containing 15 per cent salt. Lactic acid bacteria, which are salt-tolerant, can thrive in brine of 8-10 per cent strength though fermentation takes place fairly well even in 5 per cent brine. In a brine containing 10 per cent salt fermentation proceeds somewhat slowly. Fermentation takes place to some extent up to 15 per cent but stops at 20 per cent strength. It is, therefore, advisable to place the vegetables in 10 per cent salt solution for vigorous lactic acid fermentation.

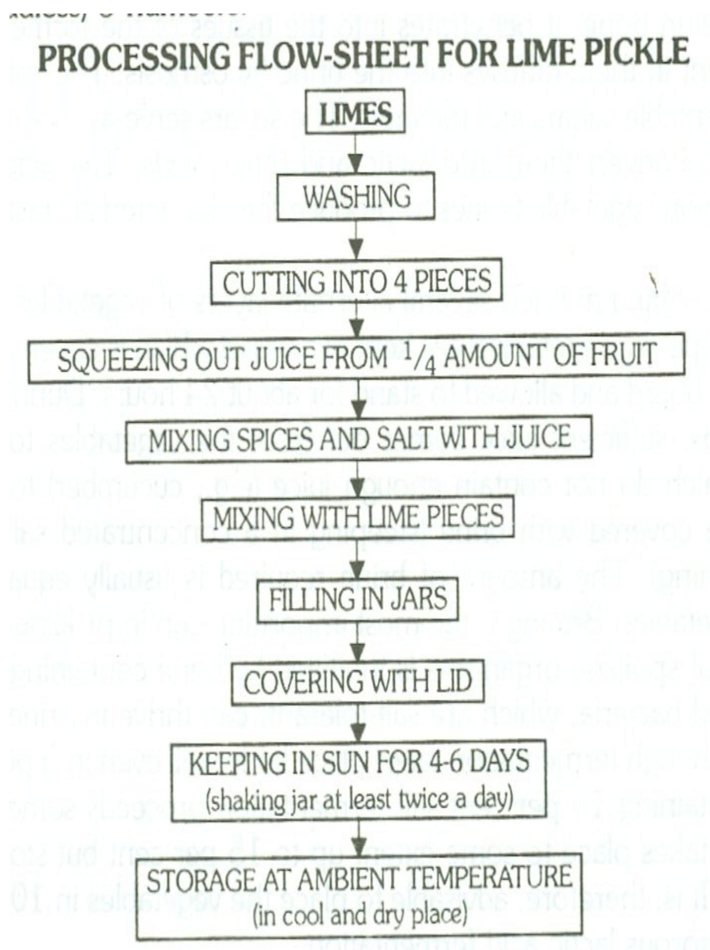
As soon as the brine is formed, the fermentation process starts and carbon dioxide begins to evolve. The salt content is now increased gradually, so that by the time the pickle is ready, salt concentration reaches 15 per cent. When fermentation is over, gas formation ceases. Under favourable conditions fermentation is completed in 7 to 10 days. When sufficient lactic add has been formed, lactic acid bacteria cease to grow and no further change takes place in the vegetables. However, precautions should be taken against spoilage by aerobic microorganisms in the presence of air pickle scum is formed which brings about putrefaction and destroys the lactic acid. Properly brined vegetables keep well in vinegar for a long time.

At present, pickles are prepared with salt, vinegar, oil or with a mixture of salt, oil, spices and vinegar. These methods are discussed below:

(1) Preservation with salt

Salt improves the taste and flavour and hardness the tissues of vegetables and controls fermentation. Salt content of 15 per cent or above prevents microbial spoilage. This method of preservation is generally used only for vegetables which contain very little sugar and hence sufficient lactic acid cannot be formed by fermentation to act as preservative. However, some fruits like lime, mango, etc., are also preserved with salt. The preparation of some pickles is described below :

(i) **Lime pickle:** Lime 1 kg, salt 200 g, red chilli powder 15 g, cinnamon, cumin, cardamom (large) and black pepper (powdered) each 10 g, clove (headless) 5 numbers.



(2) Preservation with vinegar

A number of fruits and vegetables are preserved in vinegar whose final concentration, in terms of acetic acid, in the finished pickle should not be less than 2 per cent. To prevent dilution of vinegar below this strength by the water liberated from the tissues, the vegetables or fruits are generally placed in strong vinegar of about 10 per cent strength for several days before pickling. This treatment helps to expel the gases present in the intercellular spaces of vegetable tissue. Vinegar pickles are the most important pickles consumed in other countries. Mango, garlic, chillies, etc., are preserved as such in vinegar. Some common recipes for vinegar pickles are given below:

(i) **Papaya pickle:** Peeled papaya pieces 1 kg, salt 100 g, red chilli powder 10 g, cardamom (large), cumin, black pepper (powdered) each 10 g, vinegar 750m.

(3) Preservation with oil

The fruits or vegetables should be completely immersed in the edible oil. Cauliflower, lime, mango and turnip pickles are the most important oil pickles. Methods of preparation of some oil pickles are given below :

Mango pickle: Mango pieces 1 kg, salt 150 g, fenugreek (powdered) 25 g, turmeric (powdered) 15 g, nigella seeds 15 g, red chilli powder 10 g, clove (headless) 8 numbers, black pepper, cumin, cardamom (large), aniseed (powdered) each 15 g, asafoetida 2 g, mustard oil 350 ml Gust sufficient to cover pieces).

(4) Preservation with mixture of salt, oil, spices and vinegar

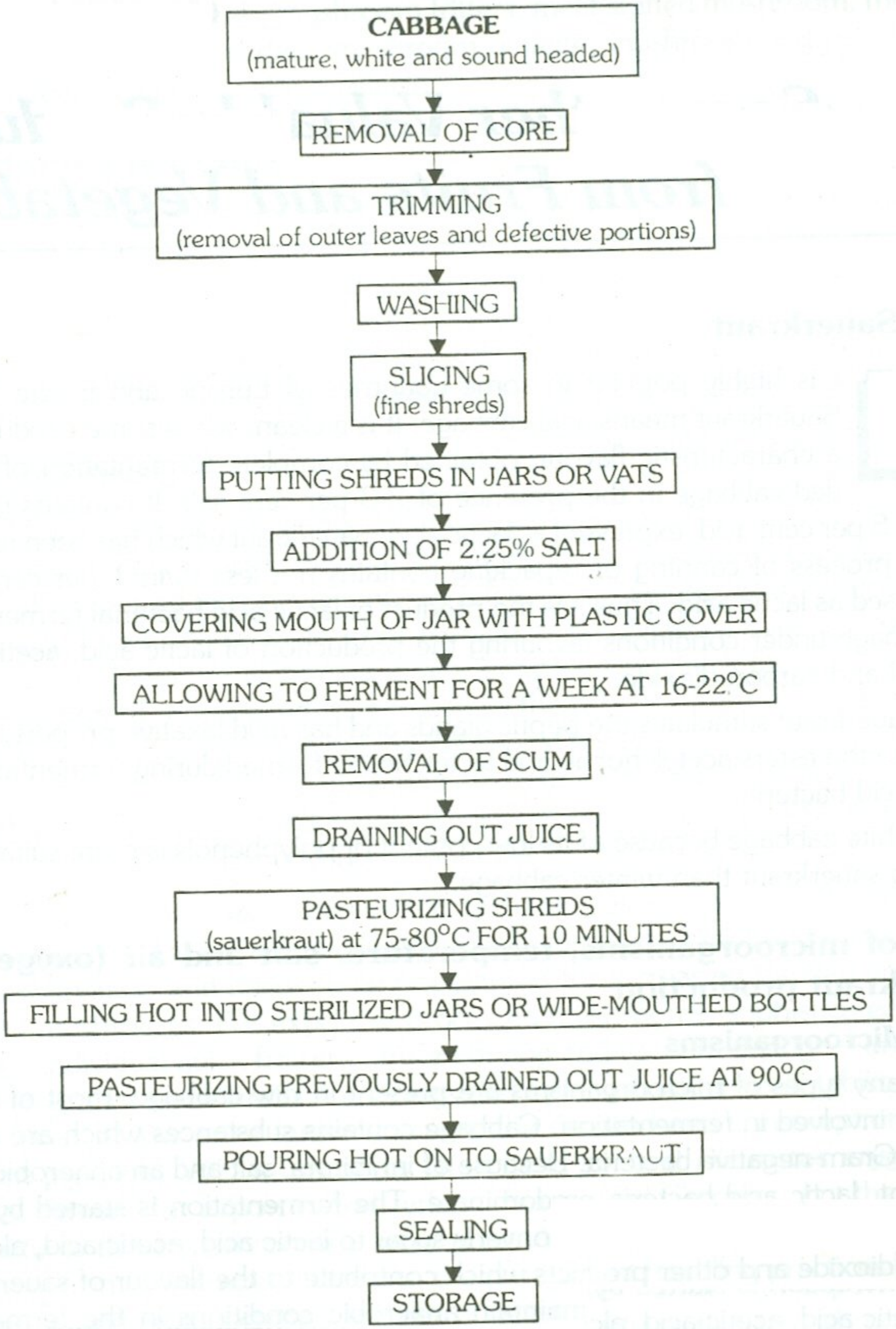
Cauliflower pickle : Cauliflower (pieces) 1 kg, salt 150 g, ginger (chopped) 25g, onion (chopped) 50 g, garlic (chopped) 10 g, red chilli, turmeric, cinnamon, black pepper, cardamom (large), cumin, aniseed (powdered) each 15 g, cloves headless) 6 numbers, tamarind pulp 50 g, mustard (ground) 50 g, vinegar 150 ml, mustard oil 400 ml.

Sauerkraut

It is highly popular in some countries of Europe and in the U.S.A. Sauerkraut means acid cabbage. It is a clean, wholesome product with a characteristic. flavour, obtained by complete fermentation of shredded cabbage in the presence of 2-3 per cent salt. It contains not less than 1.5 per cent acid, expressed as lactic acid. Sauerkraut which has been re- brined in the process of canning or repacking contains not less than 1 per cent acid, expressed as lactic acid. Thus it is the product of lactic acid bacterial fermentation of cabbage under conditions favouring the production of lactic acid, acetic acid, alcohol and carbon dioxide.

Sauerkraut stimulates the peptic glands and has mild laxative property which is due to the esters acetylcholine and lactylcholine formed during fermentation by lactic acid bacteria. White cabbage because of its low content of polyphenols is more suitable for making sauerkraut than winter cabbage.

PROCESSING FLOW-SHEET FOR CABBAGE SAUERKRAUT



Problems in pickle making

(1) **Bitter taste:** Use of strong vinegar or excess spice or prolonged cooking of spices imparts a bitter taste to the pickle.

(2) **Dull and faded product** : This is due to use of inferior quality materials or insufficient curing.

(3) **Shrivelling:** It occurs when vegetables (e.g., cucumber) are placed directly in a very strong solution of sait or sugar or vinegar. Hence, a dilute solution should be used initially and its strength gradually increased.

(4) **Scum formation:** When vegetables are cured in brine, a white scum always form on the surface due to the growth of wild yeast. This delays the formation of lactic acid and also helps the growth of putrefactive bacteria which cause softness and slipperiness. Hence, it is advisable to remove scum as soon as it is formed. Addition of one per cent acetic acid helps to prevent the growth of wild yeast in brine, without affecting lactic acid formation.

(5) **Softness and slipperiness:** This very common problem is due to inadequate covering with brine or the use of weak brine: The problem can be solved by using a brine of proper strength and keeping the pickles well below the surface of the brine.

(6) **Cloudiness:** When the structure of the vegetable used in pickling, e.g., onion, is such that the acetic acid (vinegar) cannot penetrate deep enough into its tissues to inhibit the activity of bacteria and other microorganisms present in them, fermentation starts from inside the tissues; rendering the vinegar cloudy. This microbial activity can only be checked by proper brining. Cloudiness may also be caused by use of inferior quality vinegar or chemical reaction between vinegar and minerals.

(7) **Blackening:** It is due to the iron in the brine or in the process equipment reacting with the ingredients used in pickling. Certain microorganisms also cause blackening.

LECTURE-16

Sauces and Ketchups- what are sauces –difference between sauce and a ketchup-classification of sauces-thick and thin sauces-processing of Tomato sauce/ketchup-Preparation of soya sauce(thin sauce)-problems in making of sauces.

Sauces and Ketchups

There is no essential difference between sauce and ketchup. However, sauces are generally thinner and contain more total solids (minimum 30%) than ketchups (minimum 28%). Tomato, apple, papaya, walnut, soybean, mushroom, etc., are used for making sauces.

Sauces are of two kinds: (i) *Thin* sauces of low viscosity consisting mainly of vinegar extract of flavouring materials like herbs and spices, and (ii) *Thick sauces* that are highly viscous.

Sauces/ketchups are prepared from more or less the same ingredients and in the same manner as chutney, except that the fruit or vegetable pulp or juice used is sieved after cooking to remove the skin, seeds and stalks of fruits, vegetables and spices and to give a smooth consistency to the final product. However, cooking takes longer because fine pulp or juice is used.

Some sauces develop a characteristics flavour and aroma on storing in wooden barrels. Freshly prepared products often have a raw and harsh taste and have, therefore, to be matured by storage. High quality sauces are prepared by maceration of spices, herbs, fruits and vegetables in cold vinegar or by boiling them in vinegar. The usual commercial practice is to prepare cold or hot vinegar extracts of each kind of spice and fruit separately, and then blend these extracts suitably to obtain the sauces which are then matured. Thickening agents are also added to the sauce to prevent sedimentation of solid particles. Apple pulp is commonly used for this purpose in India but starch from potato, maize, arrowroot (cassava) and sago are also used. A fruit sauce should be cooked to such a consistency that it can be freely poured without the fruit tissues separating out in the bottle. The colour of the sauce should be bright. Sauces usually thicken slightly on cooling. By using a funnel hot ketchup is filled in bottles leaving a 2 cm head space at the top and the bottles are sealed or corked at once. The necks of the bottles, when cold, are dipped in paraffin wax for airtight sealing. It is advisable to pasteurize sauces after bottling since there is always a danger of fermentation, especially in tomato and mushroom-based sauces. Other sauces are more acidic and less likely to ferment but should be pasteurized all the same. For this the bottles are kept in boiling water for about 30 minutes.

Recipes for sauces (ketchups)

(1) Tomato sauce: See chapter on 'Tomato Processing'.

(2) Apple sauce

Apple pulp 1 kg, sugar 250 g, salt 10 g, onion (chopped) 200 g, ginger (chopped) 100 g, garlic (chopped) 50 g, red chilli powder 10 g, clove (headless) 5 numbers, cinnamon, cardamom (large), aniseed (powdered) 15 g each, vinegar/ acetic acid 50 ml and sodium benzoate 0.7 g per kg finished product.

(3) Plum sauce

Plum pulp 1 kg, sugar 100 g, salt 20 g, onion (chopped) 50 g, ginger (chopped) 25 g, garlic (chopped) 10 g, red chilli powder 10 g, clove (headless) 5 numbers, black pepper, cardamom (large), cinnamon (powdered) 10 g, each, vinegar 40 ml and sodium benzoate 0.7 g per kg sauce.

Black neck: Formation of a black ring in the neck of bottles is known as black neck. It is caused by the iron which gets into the product from the metal of the equipment and the cap/crown cork through the action of acetic acid. This iron coming into contact with tannins in spice forms ferrous tannate which is oxidized to black ferric tannate. Black neck can be prevented by:

(i) Filling hot sauce at a temperature not less than 85°C;

(ii) Leaving very little head space in bottles (the more the air the greater is the blackening);

(iii) Reducing contamination by iron, sources of iron being salt and metal equipment;

(iv) Partial replacement of sugar by corn syrup or glucose syrup which contain sulphur and prevent blackening;

(v) Addition of 100 ppm sulphur dioxide or 100 mg ascorbic acid;

(vi) Storing bottles in horizontal or inverted position to diffuse the entrapped air (02) throughout the bottle thus reducing its concentration in the neck sufficiently to prevent blackening;

(vii) Using cloves only after removing the flower/head.

Tomatoes can be processed into a number of products:

(1) Tomato juice: Plant-ripened, fully red fruits are selected, discarding all green, blemished and over-ripe fruits. A good quality juice should be of deep red colour, possess the characteristic taste and flavour of tomato, contain about 0.4 per cent acid (in terms of citric acid), be uniform in appearance and, have high nutritive value. In addition the juice should contain 0.5% salt, 1% sugar and 0.4% acids. In the home it is prepared qy using 1 litre of juice, 109 of sugar, 5 g of salt, 1 g of citric acid and 1 g of sodium benzoate. Tomato juice/pulp can be extracted by hot or cold pulping. Hot pulping is superior to cold pulping because in the latter case, extraction of juice is somewhat difficult and its yield is less, vitamin C is oxidized more rapidly, the juice is lighter in colour and there are chances of microbial spoilage. On commercial scale, a pulper or continuous spiral press is used for juice extraction but in homes tomatoes are strained through a steel sieve.

(2) Tomato puree and paste: Tomato pulp without skin or seeds, with or without added salt, and containing not less than 9.0 per cent of salt-free tomato solids, is known as 'medium tomato puree'. It can be concentrated further to 'heavy tomato puree' which contains not less than 12 per cent solids. If this is further concentrated so that it contains not less than 25 per cent tomato solids, it is known as tomato paste. On further concentration to33 per cent or more of solids, it is called concentrated tomato paste. Tomato pulp is prepared from ripe tomatoes in the same manner as tomato juice. Cooking for concentration of the pulp can be done either in an open cooker or a vacuum pan. In the former most of the vitamins are destroyed and the product become brown. On the other hand, use of vacuum pans, which are expensive, help to preserve the nutrients and also reduce the browning to a great extent. In vacuum pans the juice is boiled at about 71°C only. Ordinarily tomato juice can be concentrated to 14-15 per cent solids in an open cooker, but for obtaining higher concentrations a vacuum pan is required. Moreover, sterilization of the product is also possible in a vacuum pan. While cooking in an open cooker, a little butter or edible oil is added to prevent foaming, burning and sticking.

If, after cooking, the total solids content of the juice is higher. Than required, more juice is added to lower it, if it is lower, cooking is continued till the desired concentration is reached. The end-point of cooking puree and paste can be determined either with a hand refractometer or by measuring the volume (a known volume of juice is concentrated to a known volume of final product) with the help of a measuring stick.

(3) Tomato sauce/ketchup: It is made from strained tomato juice or pulp and spices, salt, sugar and vinegar, with or without onion and garlic, and contains not less than 12 per cent tomato solids and 25 per cent total solids.

(4) Tomato chutney: Tomato 1 kg, sugar 500 g, salt 25 g, onion (chopped)100 g, ginger (chopped) 10 g, garlic (chopped) 5 g, red chilli powder 10 g, cinnamon, black pepper, cardamom (large), aniseed, cumin (powdered) 10 g each, vinegar 100 ml and sodium benzoate 0.5 g per kg final product.

(5) Tomato cocktail: It is prepared just before serving or served from stock.

Recipe: Tomato juice 5litres, salt 45 g, lime juice 60 ml, red chilli powder 0.25 g, clove (headless) 5 numbers, cumin, black pepper, coriander seed, cardamom (large), cinnamon (powdered) 1.5 g each and vinegar (10% acetic acid) 300 ml.

(6) Tomato soup: Soup is becoming very popular in homes. Stored soup is warmed at the time of serving.

Recipe: Tomato pulp 1 kg, salt 20 g, sugar 20 g, butter or cream 20 g, flour/starch 10 g, onion (chopped) 20 g, garlic (chopped) 5 g, clove (headless) 5 numbers, cumin, cardamom (large), black pepper, cinnamon (powdered) 1 g each and water 350 ml.

(7) Canned tomatoes: See chapter on "Canning and Bottling of Fruits and Vegetables"

(8) Tomato pickle: See chapter on "Pickles."

(9) Tomato chilli sauce: It is highly spiced product made from ripe, peeled and crushed tomatoes and salt, sugar, spices, vinegar, with or without onion and garlic. The method of preparation is similar to that for tomato sauce.

LECTURE-17, 18 & 19

Processing Technology of Fruit Beverage-Unit operations involved in preparation of fruit beverage.

&

Equipment used in the preparation of beverages – pulping-Screw type juice extractors-Burning machines-rollers-Taglith press by CFTRI.

&

Basket press-Rack and cloth press-Hydraulic press-Deaerators-Sietz filters-Flash pasteurizers.

1.1 Unit operations applied to juice

There are a number of unit operations involved in converting whole fruit to the desired juice, puree, or pulp product (Table 1.1). Fruit handling depends upon the process design. If the raw material is destined for multiple uses such as fresh market, whole piece processing, additional products and juice, the flow scheme will differ greatly from one for a juice-only plant. In some circumstances, cleaning, sorting and inspection precede in-plant storage or the operations can be reversed or repeated immediately prior to juicing. As indicated, an ounce of prevention (preventing/removing contaminants from raw material) is worth a pound of cure (trying to clean up contaminated juice).

Table 1.1: Unit operation involved in juice manufacture.

Unit Operation	Result
Mass transfer	Fruit delivered, dry cleaned
Extraction	Washed
Separation	Sized, graded
Separation	Peeled, cored and deseed
Size reduction	Crushed, comminuted
Pressure application	Juice extracted
Separation	Solids screened
Deaeration	Oxygen removed
Centrifugation	Solids separated
Filtration	Clarification

Fluid flow	Juice transferred, pumped
Heat transfer	Enzymes inactivated, juice pasteurized and cooled
Concentration/evaporation	Volume reduction, stability
Mass transfer	Packaging, shipping

Although there are key differences in the handling of each type of fruit destined for juice (Table 1.2) and important varietal and seasonal adjustments, the generalized flow scheme in Figure 1.1 puts the operations in perspective. Normally, juice fruit does not receive the care in packing, transport or postharvest treatment reserved for fresh market and solid pack fruit (Fellows, 1997; Arthey and Ashurst, 1996). Operations such as cooling, washing, sorting and inspecting require attention to mass and heat transfer. Cooling depends upon heat transfer from fruit to air (possibly water). Cooling and cleaning can involve physical removal of surface debris by brushes or air jet separation prior to washing with water. These steps substantially decrease water use and speed up product flow. Efficient equipment minimizes cooling/heating energy and wash water use. When performed improperly the contamination level can actually be increased. Thus equipment and water sanitation is critical with chlorination and recycling usually necessary.

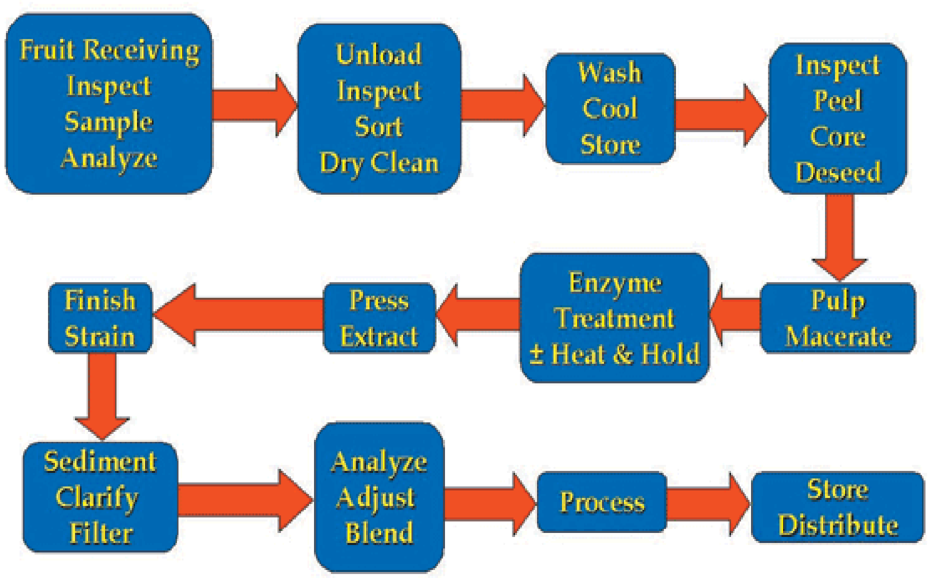


Figure 1.1: Generalized juice flow scheme.

Table 1.2: Fruit characteristics affecting juicing.

Type	**Procedure**	**Example**
Soft, all edible	Comminute, grind, press	Berry
Soft, seed inedible	Crush, press	Grape
Firm, seed inedible	Grind coarse, press	Apple
Firm, inedible skin + seeds	Ream, press flesh	Citrus
Soft inedible skin + seeds	Pre-peel, gently pulp flesh	Mango
Brittle inedible skin + seeds	Slice, gently press flesh	Passion fruit, lychee
Tough adhering skin, + seeds	Hand or contour peeling	Guanabana, pineapple
Soft, inedible skin	Roller/squeeze peel	Banana

1.1.1 Pre-process storage

The logistics of production, harvest, transport and ripening dictate that many fruits must be held prior to juicing. The seasonal harvest window may be much shorter than the time required processing the entire annual crop and stabilizing the resulting juice and finished products. As with the aforementioned steps, careful holding is necessary to allow optimum ripening to occur or prevent spoilage and contamination. Producers and processors should have a good understanding of postharvest physiology, particularly as it relates to the species and cultivars in question.

With certain climacteric fruit, ripening and senescence can be controlled (delayed, maintained constant, accelerated, or promoted uniformly) by the judicious use of low temperature, moderate humidity and adjustment of oxygen, carbon dioxide and ethylene levels (Table 5.4). These practices termed controlled or modified atmosphere storage can greatly extend the storage life of some fruits and vegetables (Arthey and Ashurst, 1996).

With other fruit, holding is short term and serves only temporarily to prevent contamination and damage while accommodating processing flow. Some fruit can be frozen and stored for long periods. Freezing is costly, but promotes cellular breakdown and facilitates shipping and juicing. In hot climates where refrigeration or freezing facilities may be neither available nor practical for juice fruit, strategies such as just-in-time harvest, cooler night time harvest operations, rapid transportation and shady, well ventilated storage can help balance the processing load and stave off deterioration for a few critical hours. Many processors are disturbingly unaware of the importance of these procedures; but every little bit helps and the benefits add up.

Packing for transport should be gentle and sanitary. Simply throwing fruit into a bulk container and travel over rough terrain guarantees partial, unacceptable juicing during transit, prior to delivery. Moreover, if the delivery time is lengthy or if the lot must be held for more than a few hours at elevated temperature, incipient fermentation will follow. A major problem in handling and storage of fruit destined for juice is the relatively low value of the crop. Thus all post-harvest operations up to and including juicing often do not receive the attention they merit. Such produce failing to meet GAPs represents a safety as well as a quality hazard and is soon eliminated from trade in all but the poorest markets. Food safety regulations and quality standards continue to eliminate businesses employing such poor agricultural and manufacturing practices.

In some regions local processors stated this chauvinistic line, "We're doing fine, our products are inexpensive and are the consumer's only alternative." The result has been responsible for the dramatic increase in alternative beverages such as imported juices, carbonated soft drinks and other beverages. Most seriously, local fruit juices and all locally processed products have received an undeserved poor quality image. Consumers do not make subtle distinctions as an entire industry can be "tarred with the same brush".

1.1.2 Cleaning, sorting and inspection

If the fruit producer has followed GAPs and the harvest and handling have been accomplished effectively, fruit arriving at the processing plant should be reasonably sanitary and of optimum quality, thus simplifying succeeding operations. Nevertheless, quality cannot be taken for granted. In many cases the basis for payment is the condition of the fruit as received. Hence sampling and analysis for composition and quality are mandatory.

Government norms, an industry association, or agreement between producer and processor in advance of the crop purchase can dictate applicable quality standards. Some agreements are seasonal or even ready before planting or harvest. A representative sample of the shipment may be drawn according to statistical procedures, inspected for visible defects and foreign matter and then analyzed for microbial load, pathogens, pesticide residues, aflatoxin level, colour, sugar, acid, flavour, or other important safety and quality attributes.(Table 1.3). Figure 1.2a and b illustrate raw material delivery inspection procedures for apples and grapes.

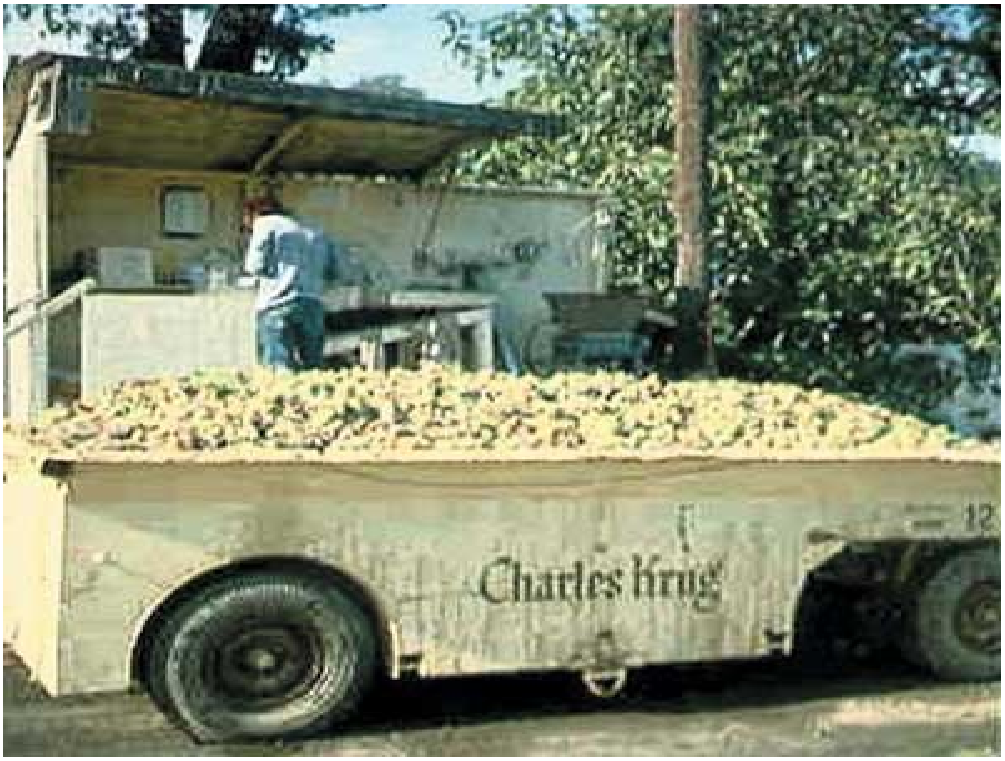


Figure 1.2a and b: Delivery inspection of apples and grapes. Analysis upon delivery is the basis for payment

Table 1.3: Some quality criteria for juicing.

Factor	Criteria	Rationale
Maturity	Ripeness	Optimum quality
Solids	Adequate level	Affects yield, flavour
Acidity	Appropriate pH level	Flavour, sugar/acid ratio
Colour	Fully developed	Juice appearance
Defects	Appropriate level	A few can be tolerated
Size/shape	Uniform	Ease of handling/juicing
Specific chemicals	Past analyses	Reflect handling/quality
Pesticide residues	Regulatory control	Legality of product
Foreign matter	Appropriate level	Reasonable limits
Microbial count	Low total, no or few pathogens	Safety/stability of juice
Aflatoxin level	Below proscribed limits	Juice safety

Rejection at this stage is a serious matter, since considerable time, effort and expense has already been invested in the suspect lot. If the defect is correctable (cleanup, resorting and inspection) a price penalty may be imposed or alternate processing required. However, if the lot cannot be corrected, contamination (microbial or chemical) or far off-standard composition/quality disposal costs and reputation damages, result. In either circumstance process flow is disrupted and plant operations suffer.

Thus for reasons of quality and safety it is important that GAPs be in place before the harvest season, agreed to by all parties, followed strictly and documented throughout the production and delivery chain. At the juice processing facility, the GAPs interface with the processor's system (GMPs), which should be equally well designed and practiced. It is inefficient and illogical to take fruit that has been well handled up to this point and then subject it to inferior juice manufacture operations. The components of GAP and GMP systems are emphasized throughout this text.

Prior to juicing, the fruit can be washed, thoroughly inspected and sometimes sized (fruit-dependent). Inspection and removal of unsound fruit is very important, more so than in whole fruit processing. In solid packs one bad piece of fruit can cause a defect in one container, but after juicing that same piece of defective fruit can end up contaminating an entire lot of juice. In the same context, a few pieces containing microbial pathogens or toxic chemicals can and do raise havoc when juiced.

Dry pre-cleaning steps and water recycling systems may be required depending upon the availability and sanitary quality of water. GAPs should insure that dirty fruit is not delivered for processing. However, weather and delivery conditions may require the removal of dust, mud or transport-induced foreign matter. Water dumping/transport can serve to gently convey the fruit, but this is a dangerous practice, if dump water is not adequately chlorinated or otherwise treated. Maintenance of water quality is an expensive but essential feature of any quality juice processing facility. A screen shaker in conjunction with air jets and dry brushes can effectively reduce water usage, provided that the fruit can tolerate such mechanical handling.

Inspection can be manual, contingent upon workers observing and removing defects or automatic, effected by computer controlled sensors to detect off colour, shape or size (Figure 1.3). Sophisticated instrumentation operating at high speed is being increasingly employed in modern processing facilities, although the human eye, hand and mind still commonly make the final decision.

1.1.3 Crushing and juicing

There are many fruit-specific ways to extract juice. Some are well-established, large-scale procedures for commercial fruits and will be explained in detailed for those fruits. Operations range from kitchen to industrial scale depending upon volume, end use and raw material. Table 1.2 provides some general guidelines for various fruit types. The goal in juice manufacture is to remove as much of the desirable components from the fruit as possible without also extracting the undesirables. Thorough comminution maximizes the yield, but by so doing extracts substances from everything, i.e. seed, skin, core, etc.

Thus the compromise between juice yield and quality dictates the juicing and subsequent steps. Fruit with unpalatable skin and seeds must be treated more cautiously than one that can be completely pulverized. It is possible to minimize extraction of skin and seed components by a crushing regime that mashes or removes edible flesh, while sparing other portions. However, some fruit must be carefully peeled and deseeded or cored prior to juicing. Hand labour is the current alternative with many minor fruits, although there is an economic incentive to mechanize if possible.

Contour peelers, such as used with apples (Figure 1.4) can be adapted to a range of fruits that are sufficiently firm and uniform to facilitate the rotary peeling action. A battery of analogous units was the precursor of the Ginaca, used successfully for pineapple (Section 15.1). Peeling systems that are effective with some vegetables such as lye, abrasion, enzymatic, explosive, are less satisfactory with delicate fruit flesh. Nevertheless, cleverly designed machinery can greatly facilitate these labour-intensive operations. Under all circumstances, a final human inspection and piece selection/rejection step is mandatory.

Generally a whole fruit is more stable than the juice, unless rapidly preserved after extraction. So fruit should not be committed to juice until the material can rapidly be stabilized or the process go to completion. Attention to quality at the prejuicing step is extremely critical. Otherwise surface debris and portions of skin or seed can easily ruin the colour or flavour of an entire batch of juice. Of course, in a similar sense, microbial and chemical contaminants at juicing can and have caused disastrous public health consequences.

Figure 1.3: Automatic inspection/grading system.
Courtesy Key Technology, Inc. (Key, 2000)

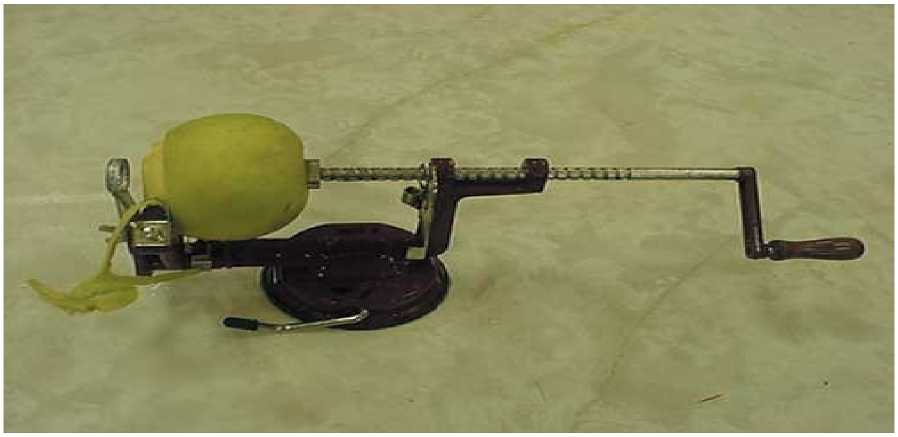
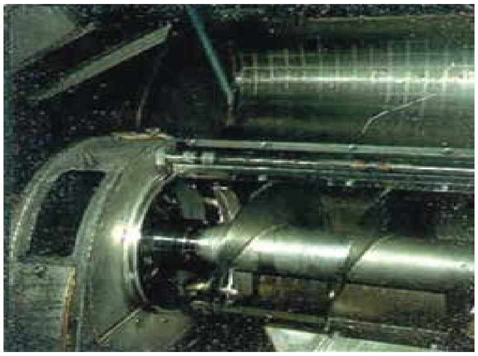


Figure 1.4: Apple peeler/corer.
Courtesy of Basics Products, Inc. (Back to Basics Products, 2000)

a.


b.


Figures 1.5a and 1.5b: Small and large fruit crushers.
Capacity ~100 kg to 40 MT/hr.



a. **b.**

c. **d.**

Figure 1.6a. b., c. and d: Fruit pulper screw finisher, paddle pulper, paddle pulper with coarse screen, paddle pulper with brushes for soft fruit.

Juice extraction equipment ranges from hand operated crushers to tonnes/hour mechanical extractors (Figure 1.5). With soft or comminuted fruit a cone screw expresser or paddle pulper fitted with appropriate screens serves to separate the juice from particulate matter (Figure 1.6). Where skin or seed shattering is a problem, brush paddles can replace metal bars. Two pulpers in series with screens of ~1 to 0.2 mm can effectively clean up many juices and often yield a usable thick pulp by-product. With thicker purees a pressing step may be needed and several options are available. For refractory material, pretreatment with a macerating enzyme with or without heating to ~60ºC and holding up to ~40 minutes can greatly increase yield and subsequent pressing/clarification steps. Enzyme suppliers have selections of enzyme blends with hydrolytic activity against fibrous plant materials such as pectin, hemicellulose and cellulose to match the composition of most plant material (Hohn, Somogyi, et al., 1996).

Even without macerating enzyme addition, heating to ~70ºC softens the fruit, inactivates native enzymes, reduces microbial load and affects an increase in juice yield. However, delicate flavours can be destroyed and unacceptable darkening due to enzymatic and non-enzymatic browning can occur. Rapid heating and cooling prior to juicing can overcome some of these quality problems. Traditionally mashed fruit and purees were batch heated to optimum macerating enzyme temperature (~55 to 60ºC) in open steam-jacketed kettles with stirring. This step and subsequent cooling can be accomplished by swept surface heat exchangers (Figure 8.4) or thermal screws (a hollow steam-heated auger in a steam-jacketed trough). Steam or cooling fluid flowing through both auger and trough effectively and continuously heats or cools the material. Pulpy, viscous puree cannot be passed through a plate or tube heat exchanger due to clogging problems, although, after solids reduction, these units are appropriate.

A thermal screw is a continuous system for both transporting and heating or cooling crushed fruit or whole small fruit. In a hot press regimen, the material passes directly from the crusher to the press holding tank via the screw, adjusted to deliver the crush at the proper temperature for enzyme activity, ~60ºC. In continuous pressing, the screw can even be slowed down enough to accomplish the holding time and then feed directly to the press (or to another feed/holding screw). Only reasonably small particles can be so treated and care must be taken to insure even heating and avoid scorching of the crush.Macerating enzymes also facilitate juice clarification steps. In some cases the naturally present enzymes (primarily pectinases) can be allowed to act at ambient temperature prior to pressing. However lengthy holding may favour spoilage organisms and the natural hydrolytic activity is apt to be slower than with added industrial enzymes. For fruits with delicate flavour or those where colour extraction from seed or skin is not desired, an immediate press at ambient temperature (referred to as a cold press) with or without enzymes is favoured. Juice yield will thereby be lowered; a compromise dictated to avoid undesirable heat-induced darkening.

A word of caution regarding commercial enzymes, enzyme preparations available in powder or liquid form, have a finite shelf life and should be refrigerated, since activity decreases rapidly at ambient temperature. These processing aids are fairly expensive and should be used sparingly. The solutions and powders are warranted only when the value of the additional juice yield and its quality exceeds enzyme cost. Also, they are mixtures containing individual enzymes, some of which may promote undesirable reactions, so consultation with suppliers and pilot testing is advised.

Another means of extracting water-soluble components from fruits and plant material is infusion extraction. The flesh is comminuted with added water to dissolve solids that are then separated from the pulp as described. Multiple extractions with temperature and pH adjustment and enzyme treatment can extract practically all-soluble solids. A countercurrent flow where fresh solvent (usually water) contacts the last stage of spent pulp is quite efficient (Figure 1.7) and used widely in the Citrus Industry (Section 11.3.4). In this case, subsequent concentration of the extract is necessary to return to the initial fruit ºBrix. With soft, readily extractable fruits a steam extraction system has promise. An early example is a home extraction unit of Scandinavian origin (Figure 1.8). The fruit is in a strainer that drains concentrically away from an inner container with boiling water. Rising steam condenses in the fruit compartment or on the fruit, heating it and leaching out soluble that drain away from the pulp. A larger scale semi-continuous unit of French design is shown in Figure 1.8. Despite the use of high temperature, this system steam inactivates enzymes (blanches) and pasteurizes the fruit and excludes oxygen during extraction. Thus the juice has unusually good colour and flavour retention.

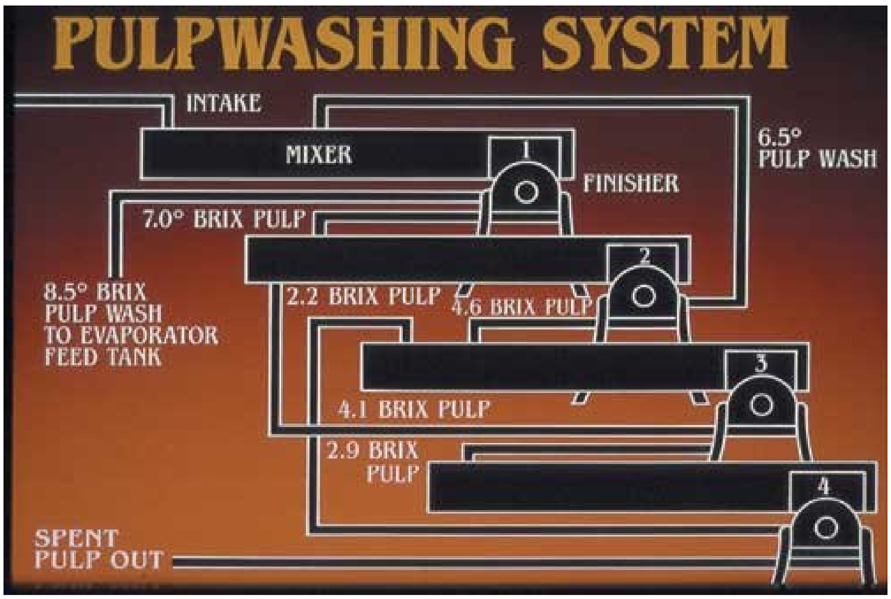


Figure 1.7: Pulp wash extraction schematic.

a

b

Figure 1.8 a. and b: Steam extractors. Kitchen and pilot plant models.

Independent of the system used, if the extract is then concentrated back to the original solids level, it is technically juice. However, labelling as juice depends on specific country regulations. The pulp or press residue of high value fruits can be extracted in this manner with water or other solvents to yield extracts containing pigments, nutrients, nutraceuticals, essences, or other useful by-products.

1.1.4 Pressing

The pressing operation can also range from manual to mechanical (Figure 1.9) with complete automated systems common in the juice industry. Kitchen-scale juicers or food processors are effective for small quantities, but for larger multi-kilogram amounts, flow resistance and distance the expressed juice must travel to the press surface complicate pressing. The rack and cloth press increases the surface area to volume ratio and is quite effective, albeit labour intensive. Figure 1.10 shows a simple press based on a hydraulic truck jack developed by Cornell University (Downing, 1972). All supports are wood, including the racks. Tough cottons or synthetic cloths provide an inexpensive, durable batch press, albeit difficult to clean and sanitize.

Figure 1.10: Simple hydraulic rack and cloth press.
(Downing, 1972)

Figure 1.11: Bladder press, 100L capacity.

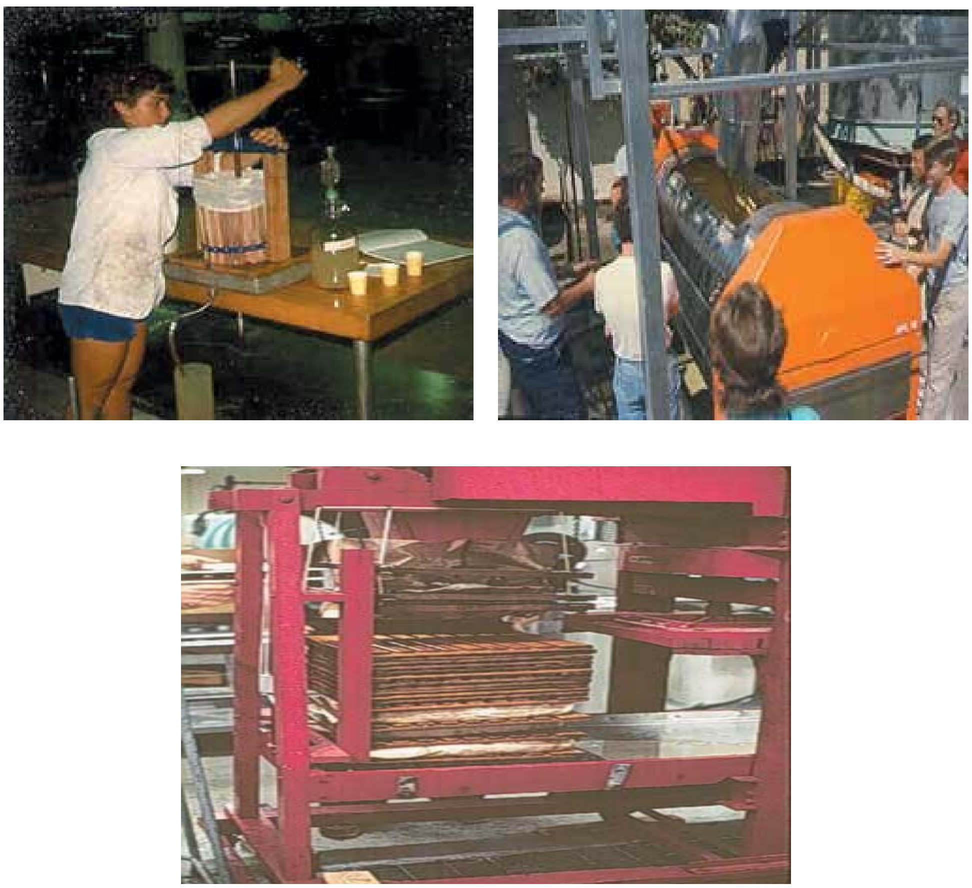


Figure 1.9: Juice presses - hand basket, rack and cloth and pneumatic bladder.

Other batch systems involve hydraulic basket presses where pistons move down into a press sack containing the crush. Better extraction is obtained by mixing the crush between multiple pressings to expose fresh surface near the cloth. This mixing step is accomplished in bladder presses by rotating a horizontal basket fitted with a chain or internal mechanism to redistribute the cake and reinflating the bladder to provide pressure on the crush (Figure 1.11). Vertical bladder presses inflated by air or water pressure are also in use. Periodic deflation of the bladder and manual cake redistribution is necessary to insure a fresh press surface.

At the other extreme are continuous screw presses capable of handling many tonnes/hour of crushed fruit. Care must be taken not to subject the press cake to excessive shear; or else seeds and other solids will contribute undesirable components to the juice. A more expensive continuous yet gentle system is a belt press where the pulp is pressed between porous belts by rollers. In most press configurations, adding several percent of a press aid to the crushed fruit can increase yield. Press aids consist of clean rice hulls or cellulose fibre that provide drain channels for the expressed juice. Multiple pressings or rotations (in bladder presses) further increase yield, but require more time and can extract undesirables if overdone. The press aid also serves to strain out particulates; juice expressed late in the cycle tends to be clearer (and darker, if browning has occurred). However, press aids can present a disposal problem, may be expensive and unless well refined, can contribute off flavours.

With some fruits allowing the crush to settle provides natural drainage. The pulpy fraction either floats or sinks for easy separation and greatly reduces the volume needing pressing. Fining with the use of bentonnesite or highly adsorbtive powder capable of flocculating colloidal material from the juice speeds up settling and is commonly used in wine clarification. Similarly, addition of protein or tannins as fining agents can not only remove suspended solid, but also form complexes with macromolecules that, if not removed, can cause haze formation in finished juice (Chapter 13).

Figure 1.12: Juice sampling after manual crushing through a nylon bag.

Table 1.4: Press factors influencing juice yield and quality.

Factor	Effect
Fruit immature	Resistance to juicing, low yield
Fruit inadequately crushed	Resistance to juicing, low yield
Fruit over mature	Undesirables extracted, poor quality
Fruit over comminuted	Undesirables extracted, poor quality
Excessive pressure	Undesirables extracted, dark juice
Excessive time in press	Dark, over extracted juice
Short press cycle	Low yield, lighter juice character
Long press cycle	Low throughput, over extraction
Cold Press	Lower yield, lighter character
Hot press	Higher yield, stronger, darker character
Enzyme treatment	Higher yield, stronger character
Pressing aid added	Higher yield
Press cake redistributed	Increased yield
Delayed or extended pressing	Dark juice, incipient spoilage

1.1.5 Juice clarification

For more fluid juices where cloud or turbidity is not acceptable primary extracted juice must be treated further. A settling step can help, if the juice can be held refrigerated for a few hours. At ambient tropical temperatures holding is not recommended. Rapid methods such as centrifugation and filtration can produce a clear juice. A continuous or a decanting centrifuge with automatic desludging to produce a clear or nearly clear juice is quite effective. (Juices where a cloud is desired generally do not require filtration; centrifugation is adequate.) The stream should be settled or coarse strained prior to centrifugation in order to reduce the sludge load in the feed going to the centrifuge. A fine mesh shaker screen can further remove particulates (Figure 1.13). A centrifuge is a very costly item; however, it greatly simplifies subsequent filtration steps and is an essential component in many juice processing operations (Figure 1.14).

Figure 1.13a: Shaker separating screen.
Mesh size and vibration frequency can be varied to accommodate feed viscosity

	
Figure 1.13b: Shaker separating screen used in conjunction with a continuous centrifuge.	**Figure 1.13c: Commercial dewaterer/dejuicer. Courtesy Keys Technology, Inc.**

Figure 1.14: Continuous centrifuges.
Commercial ~200-1 000 L/hr, Pilot plant ~ 5 to 20 L/hr

1.1.6 Filtration

As with pre-centrifugation, the juice stream should be cleaned up as much as possible to reduce treated volume and increase throughput. There are many filtration systems well suited to various juices. These range from plate and frame filters, fitted with porous cellulose pads, (Figure 1.15) to plastic, ceramic, or metal membranes. Diatomaceous earth mixed with the liquid serves to greatly increase the surface area and porosity of the filter bed and hence the particulate absorbing capacity of the filter.

Figure 1.15: Plate and frame and vacuum filter.

In the extreme case a filter can have small enough pores to physically remove microorganisms from the juice (sterile filtration) or even remove macromolecules such as proteins and carbohydrate polymers (ultrafiltration). These processing steps will be considered later. The production of a clear or brilliantly clear juice and the prevention of post filtration turbidity are the normal goals. Membrane clogging is a concern in any filter, so pretreatment to minimize particulates and flow patterns that self clean the membrane are essential.

The system can be made continuous by a rotary vacuum filter (Figure 1.15). A vacuum deposits fresh filter aid suspended in the juice on the drum surface. The juice passes into the rotating drum through the filter bed that is constantly renewed by scraping the spent material off the surface after a rotation. Various other filters use durable ceramic or metal porous membranes with backflush capabilities and flow patterns that minimize clogging. These systems operate in parallel to insure continuous operation and can reduce or eliminate the need for filter aid; a purchase and disposal expense.

1.1.7 Deaeration

In the operations described crushing, comminution, pressing, shaker separation, centrifugation and filtration, the fruit and juice are subjected to considerable aeration. The inclusion of oxygen can promote enzymatic browning, destroy nutrients, modify flavour and otherwise damage quality. Therefore, care should be taken to perform these steps rapidly, at low temperature and/or protect the material from oxygen, if possible. Sometimes preheating to inactivate natural and/or added enzymes is useful, provided rapid cooling follows.

Deaeration can be accomplished by either flashing the heated juice into a vacuum chamber or saturating the juice with an inert gas. Nitrogen or carbon dioxide is bubbled through the juice prior to storing under an inert atmosphere. Clearly, once air is removed or replaced by inert gas, the juice must be protected from the atmosphere in all subsequent processing steps. Deaeration, especially flashing off at high temperature, can also remove some desirable volatile aroma, another compromise facing the juice technologist.

1.1.8 A word of caution regarding processing systems

The excellent research reporting juice details - preparation, processing, composition, storage quality, etc. most likely came from academic or institutional research labs working with small, albeit representative samples of fruit. Handling is usually ideal with the major emphases on repeatability, speed and attention to detail. Rarely are the studies concerned with the logistics of handling large, i.e. commercial quantities, under industrial conditions.Thus scale-up and the attendant difficulties are not stressed. Just because a fruit can yield an outstanding juice in the lab doesn't mean it is commercially viable. Equipment from harvest to storage must be developed to efficiently perform the myriad of operations under varying and often vastly different and difficult operating conditions. Furthermore, these operations must match reasonably well the process flow scheme. Incompatibility in throughput, or highly sensitive procedures with excessive down time raise havoc with production flow and cannot be tolerated. Ingenuity and/or technology can eventually overcome these hurdles, but only with considerable patience and time.

Hand labour and care can represent a first step in scale-up and produce juice products for local niche markets. However, this is no substitute for well-designed mechanization, to replace or at least supplement human labour. Thousands of labourers cannot match several high-speed extractors for long. Some fruits mentioned here have superb eating quality, but will have scant juice (or solid pack) potential, until some degree of cost-reducing mechanization is introduced into the system.

Generally it is the inspection, cleaning, sorting peeling/coring/pulping operations that cause the greatest problem. (Once the flesh is isolated in a reasonably clean form, subsequent operations scale up fairly easily.) This is a major challenge for small processors. If they don't continually strive to improve juice manufacture efficiency, somebody else will or the fruit will remain under exploited to the detriment of the growing region and consumers.

Curiously, the awesome ingenuity and craftsmanship demonstrated by third world mechanics in repairing and maintaining complicated machinery and equipment (automotive, refrigeration, electrical) with little training or parts inventory has not been extended to food processing equipment design and development. Of course, all such equipment is kept running long after the anticipated design life, past zero depreciation. New and innovative mechanical solutions to tedious processing steps are either conspicuously absent or not shared within the local food industry. There is a critical need for such innovation, especially since existing (large scale/multinational) equipment manufacturers with the experience and talent view this as a niche market not worthy of the investment. Conversely, if appropriate small/medium scale equipment does exist, it is atrociously expensive and/or complicated to operate and maintain.

Lecture 20, 21, 22 and 23

Types of Beverages-Processing technology of Beverages-Flow charts of Juice-examples-RTS –Nectar.

&

Processing of Beverages like Cordial-flow chart; Squash-flow chart; Crush-flow chart.

&

Processing of Syrups- natural and synthetic- rose syrup -almond syrup- fruit syrup. Fruit juice concentrate.

&

Fruit juice concentrate -Fruit juice powder- Lemon Barley water- Carbonated beverages.

Beverages

Production of fruit beverages on a commercial scale was practically unknown till about 1930, but since then it has gradually become an important industry. In tropical countries like India, fruit beverages provide delicious cold drinks during the hot summer. Due to their nutritive value they are becoming more popular than synthetic drinks which at present have a very large market in our country.

Synthetic drinks contain only water (about 88%) and total carbohydrates (about 12%) and provide about 48 K-cal, whereas fruit based drinks contain vitamins (A, B and C:) and minerals (iron, calcium, etc.) and provide more calories. Thus, fruit-based drinks are far superior to many synthetic drinks. If synthetic preparations are replaced by fruit beverages, it would be a boon to the consumers as well as to the fruit growers.

Fruit beverages

Fruit beverages are easily digestible, highly refreshing, thirst-quenching, appetizing and nutritionally far superior to many synthetic and aerated drinks. They can be classified into two groups:

(A) Unfermented beverages: Fruit juices which do not undergo alcoholic fermentation are termed as unfermented beverages. They include natural and sweetened juices, RTS (ready-to-serve), nectar, cordial, squash, crush. syrup, fruit juice concentrate and fruit juice powder. Barley waters and carbonated beverages are also included in this group.

(8) Fermented beverages: Fruit juices which have undergone alcoholic fermentation by yeasts include wine, champaigne, port, sherry, tokay, muscat, perry, orange wine, berry wine, nira, and cider.

Preparation and preservation of unfermented fruit beverages:

The general process for the preparation and preservation of unfermented fruit beverages is as under:

(i) Selection of fruit: All fruits are not suitable because of difficulties in extracting the juice or because the juice is of poor quality. The variety and maturity of the fruit and locality of cultivation influence the flavour and keeping quality of its juice. Only fully ripe fruits are selected. Over ripe and green fruits. if used, adversely affect the quality of the juice.

(ii) Sorting and washing: Diseased, damaged or decayed fruits are rejected or trimmed. Dirt and spray residues of arsenic, lead, etc., are removed by washing with water or dilute hydrochloric acid (1 part acid: 20 parts water).

(iii) Juice extraction: Generally juice is extracted from fresh fruit by crushing and pressing them. Screw-type juice extractors, basket presses or fruit pulpers are mostly-used.

The method of extraction differs from fruit to fruit because of differences in their structure and composition. Before prersinq most fruits are crushed to facilitate the extraction. Some require heat processing for breaking up the juice-containing tissues. In case of citrus fruits, the fruit is cut into halves and the juice extracted by light pressure in a juice extractor or by pressing the halves in a small wooden juice extractor. Care should be taken to remove the rind of citrus fruits completely otherwise it makes the juice bitter. Finally, the juice is strained through a thick cloth or a sieve to remove seeds. All equipment used in the preparation of fruit juices and squashes should be rust and acid proof. Copper and iron vessels should be strictly avoided as these metals react with fruit acids and cause blackening of the product. Machines and equipments made of aluminium, stainless steel, etc., can be used. During extraction juices should not be unnecessarily exposed to air as it will spoil the colour, taste and aroma and also reduce the vitamin content.

(iv) Deaeration: Fruit juices contain some air, most of which is present on the surface of the juice and some is dissolved in it. Most of the air as well as other gases are removed by subjecting the fresh juice to a high vacuum. This process is called deaeration and the equipment used for the purpose is called a deaerator. Being a very expensive method, it is not used in India at present.

(v) Straining or filtration: Fruit juices always. contain varying amounts of suspended matter consisting of broken fruit tissue, seed, skin, gums, pectic substances and protein in colloidal suspension: Seeds and pieces of pulp and skin which adversely affect the quality of juice, are removed by straining through a thick cloth or sieve. Removal of all suspended matter improves the appearance but often results in disappearance of fruity character and flavour. The present practice is to let fruit juices and beverages retain a cloudy or pulpy appearance to some extent. In case or grape juice, apple juice and lime juice cordial, however, a brilliantly clear appearance is preferred.

(vi) Clarification: Complete removal of all suspended material from juice, as in lime juice cordial, is known as clarification which is closely related to the quality, appearance and flavour of the juice. The following methods of clarification are used:

(A) Settling: The juice is stored in a carboy or barrel, after adding a chemical preservative to ensure that it does not undergo fermentation, e.g., lime juice is stored for 3 to 6 months for settling with the addition of 700 ppm sulphur dioxide. Colloidal pectins, gums, proteins, mucilaginous solids settle down and the juice is syphoned off for further treatment. However, the process is very slow.

(8) Filtration: Filtration is necessary to remove completely all fine and colloidal suspensions. In this process, the juice, after straining, is forced through a filtering medium which may be cotton pulp, wood pulp, woven fibre cloth, etc. The colloidal suspension tends to clog the filter, hence a filter aid is used to reduce clogging. The most important filter aids are supercel, kieselguhr, spanish clay and bentonite, which are added to the extent of 0.1-0.2 per cent. However, a filter aid may impart an unpleasant taste to the juice, therefore, these should be used with caution. Recently, china clay has been demonstrated to be a good filter aid.

(C) Freezing : The pasteurized juice kept in a carboy is frozen at -18°C and thereafter stored for 4 to 7 days at room temperature. This is a costly method and is used to some extent only for clarification of grape juice.

(D) Cold storage : This is generally used for grape juice. The juice is stored at -2 to -3°C for one month during which the suspended matter settles down and clear juice can then be taken out.

(E) High temperature : The juice is heated at 82°C for about a minute when the colloidal material coagulates and settles down. After cooling rapidly, the juice is mixed with a filter aid and passed through a filter press. Pomegranate juice is prepared by this method.

(F) Chemicals: Fining agents such as gelatin, albumen, casein, and a mixture of tannin and gelatin, are also used for clarification.

7. **(a) Gelatin:** It is used for apple and cashew apple juices. On addition of gelatin solution, the colloids present in the juice coagulate and form a flocculent precipitate which settles down. The precipitation is due to electrostatic action between the positively charged gelatin particles and Negatively charged colloids in the juice.

(b) Albumen: Solid albumen available in the market is dissolved in warm water to make a 2 per cent solution. A solution of egg-white may also be used. The albumen solution is mixed with the juice, which is heated to about 91°C to ensure complete coagulation of albumen.

(e) Casein: Addition of hydrochloric acid to skimmed milk precipitates casein which is thoroughly washed with water to remove traces of acid, dried and powdered. It is then dissolved in a little liquor ammonia and the solution diluted 10 to 20 times with water and then boiled to re- move all traces of ammonia. It is again diluted with water to give a 2 per cent solution which is mixed with the juice. In 24 hours the acids in the juice precipitate the casein which settles down along with other colloidal particles.

(d) Mixture of tannin and gelatin: The tannin-gelatin method is very widely used for clarifying fruit juices. The quality of gelatin to be added is determined by carrying out a preliminary laboratory test. Sufficient tannin is added to minimize the bleaching action of gelatin. About 42 g of tannin and 85 g of gelatin are generally required for every 455 litres of juice. The juice is well stirred, the tannin solution is added to it with stirring and the gelatin solution is then added. The treated juice is allowed to stand undisturbed for 18 to 24 hours to let the suspended matter coagulate and settle down. The clear juice is then syphoned off carefully without disturbing the sediment. In case of lime juice addition of 213 g of tannin and 283 g of gelatin)er 2500 litres of juice, preserved by the addition of about 350 ppm of sulphur dioxide, immediately after extraction, gives a sparkling clear product. The colloidal matter settles down completely in 4 to 6 days and the clear supernatant juice can be syphoned off and used for preparation of cordial.

(G) Enzymes: Soluble pectins in the juice are responsible for keeping in suspension other materials such as hemicellulose. When the pectin is destroyed by adding pectic enzyme preparations, e.g., Pectinol and Filtragol, it settles down and during this process also carries down other materials. After filtering, the clear juice is heated to about 77°C for 30 minutes to stop the enzymatic action otherwise the juice becomes cloudy again.

(vii) Addition of sugar : All juices are sweetened by adding sugar, except those of grape and apple. Sugar also acts as preservative for the flavor and colour and prolongs the keeping quality. Sugar-based products can be divided into three groups on the basis of sugar content:

(a) Low Sugar - 30 per cent sugar or below,
(b) Medium sugar - Sugar above 30 and below 50 per cent,
(c) High Sugar - 50 per cent sugar and above.

Sugar can be added directly to the juice or as a syrup made by dissolving it in hot water, clarifying by addition/ of a small quantity of citric acid or few drops of lime juice and filtering.

(viii) Fortification: Juices, squashes, syrups, etc., are sometimes fortified with vitamins to enhance their nutritive value, to improve taste, texture or colour and to replace nutrients lost in processing. Usually ascorbic acid and beta-carotene (water-soluble form) are added at the rate of 250 to 500 mg and 7 to 10 mg per litre, respectively. Ascorbic acid acts as an antioxidant and beta-carotene imparts an attractive orange colour. For a balanced taste some acids are added. Citric acid is often used for all types of beverages and phosphoric acid for cola type of drinks.

(ix) Preservation: Fruit juices, RTS and nectars are preserved by pasteurization but sometimes chemical preservatives are used. Squashes, crushes and cordials are preserved only by adding chemicals. In the case of syrup, the sugar concentration is sufficient to prevent spoilage. Fruit juice concentrates are preserved by heating, freezing or adding chemicals. The details regarding methods or preservation are given in the chapter on 'Principles and Methods of Preservation'.

(x) Bottling : Bottles are thoroughly washed with hot water and filled leaving 1.5-2.5 cm head space. They are then sealed either with crown corks (by crown corking machine) or with caps (by capping machine).

Unfermented Beverages

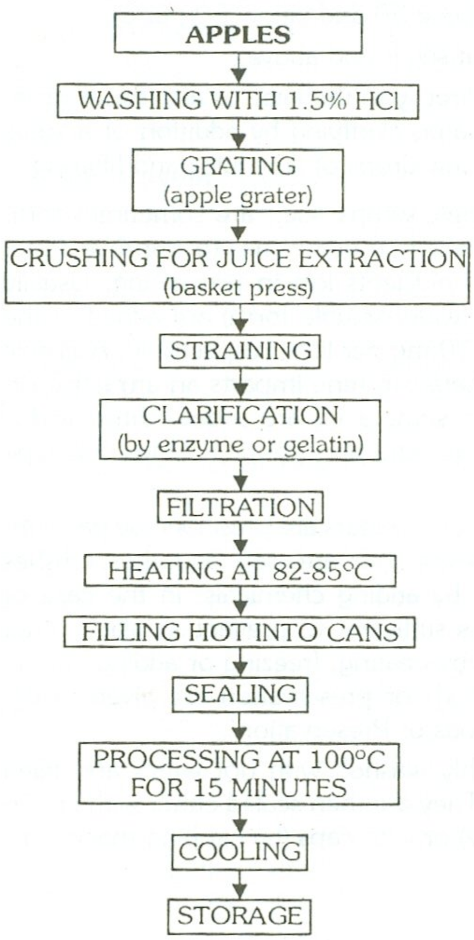
(1) Juices: Juices are of two types -

(a) Natural juice (pure juice): It is the juice, as extracted from ripe fruits, and contains only natural sugars.

(b) Sweetened juice: It is a liquid product which contains at least 85 per cent juice and 10 per cent total soluble solids. Pure fruit juices, such as apple juice and orange juice are commercially manufactured in several countries. Apple juice is generally bottled while other juices are canned. The techniques for preparation of various fruit juices are given as follows:

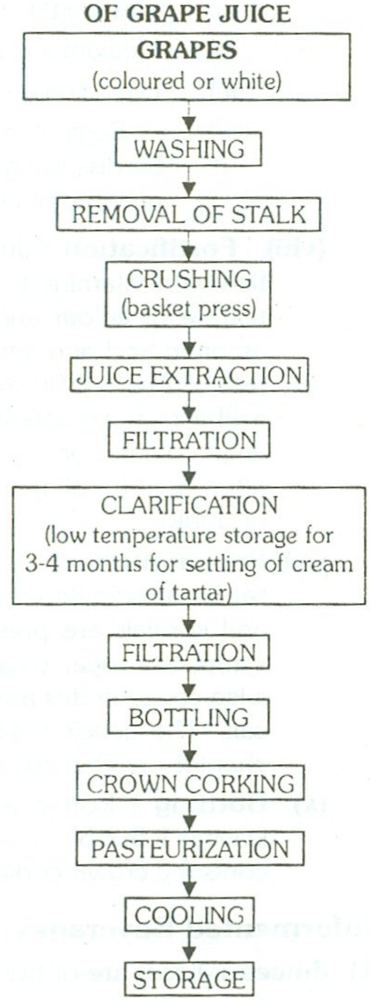
(i) Apple juice

FLOW-SHEET FOR PROCESSING OF APPLE JUICE



(ii) Grape juice

FLOW-SHEET FOR PROCESSING OF GRAPE JUICE



(ii) Blended juices

Sometimes two or more juices are mixed to yield a well-balanced, rightly flavoured, highly palatable and refreshing drink. Juices are blended so as to utilize a too sweet fruit (grape), a bitter fruit (grapefruit), too acidic or tart fruits (sour lime, sour plum, galgal, sour cherry, etc.), bland and insipid tasting fruits like pear or apple, and strongly flavoured fruits (guava and banana). Some of the common commercial blends of juice are:

(1) Grape (97%) and lime (3%)
(2) Grape (50%) and orange (50%}
(3)Orange (50-75%) and grapefruit (25-50%)
(4) Apple (97%) and lime (3%)
(5) Apple (74%) and grapefruit (25%) + 1% sugar
(6) Apple (50-75%) and pineapple (25-50%) + 1% sugar
(7) Apple (37%) and plum (62%) + 1% sugar

(2) Ready-to-serve (RTS)

This is a type of fruit beverage which contains at least 10 per cent fruit juice and 10 per cent total soluble solids besides about 0.3 per cent acid. It is not diluted before serving, hence it is known as ready-to-serve (RTS).

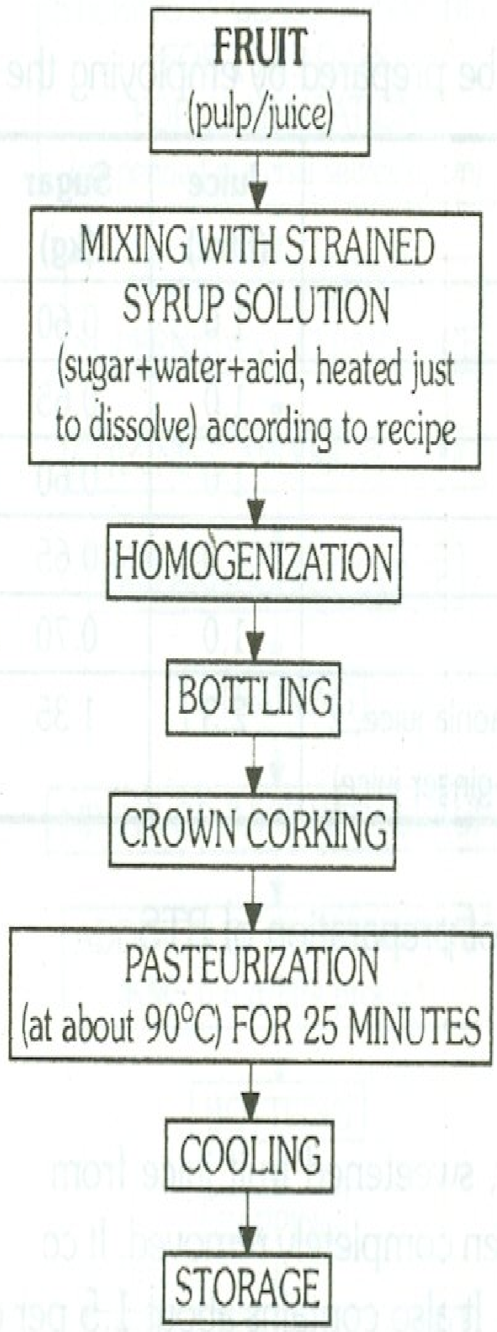
Before undertaking the preparation of beverages, it is necessary to know the techniques of extraction of pulp/juice from various fruits used for RTS, nectar. squash, syrup, etc. The extraction techniques for some fruits have been described earlier and for some other fruits are as under.

For preparing the beverages the total soluble solids in the pulp/juice and its acidity are first determined and then requisite amounts of sugar and citric acid dissolved in water are added for adjustment of TSS and acidity.

In homes, RTS can be prepared by using the following recipes:

S. No.	Fruit	Juice (litre)	Suga (kg)	Citric acid (g)	Water (litre)
1	Bael	I.0	I.20	28	7.7
2	Lemon/Lime	0.5	I.30		8.2
3.	Guava	I.0	I.25	28	7.7
4.	Aonla blend (10 part aonla juice : 2	I.3	I.60	22	10.0
5	Mango	I.0	1.,25	28	7,7
6	Ginger	0.25	I.30	30	8.4

FLOW-SHEET FOR PROCESSING OF RTS BEVERAGES



(3) Nectar

This type of fruit beverage contains at least 20 per cent fruit juice/pulp and 15 per cent total soluble solids and also about 0.3 per cent acid. It is not diluted before serving.

Commercially, nectar (with 13% TSS and 0.3% acid) can be prepared by using the following recipes standardized by Department of Horticulture, N.D. University of Agriculture and Technology, Faizabad.

s. No.	Fruit	Juice/pulp (%)	Quantity of water (litre)
1	Mango	20	Quantity of finished product (litre)--Quantity of juice (litre) + sugar (kg) + acid (kg)J used
2	Papaya	20	
3	Guava	20	
4	Bael	20	
5	Jamun	20	
6	Aonla (blend)	Aonla pulp 20 Ume juice 2 Ginger juice 1	

For preparing the above beverages the total soluble solids and total acid present in the pulp/juice are first determined and then the requisite amounts of sugar and citric acid dissolved in water are added for adjustment of TSS and acidity.

In homes, nectar can be prepared by employing the following recipes:

s. No.	Fruit	Juice (litre)	Sugar (kg)	Citric acid (g)	Water (litre)
1	Mango	1.0	0.60	13	3.3
2	Papaya	1.0	0.65	13	3.3
3	Guava	1.0	0.60	13	3.3
4	Bael	1.0	0.65	15	3.3
5	Jamun	1.0	0.70	7	3.3
6	Aonla blend (20 part part lime juice, 1 part	2.3	1.35	4	7.8

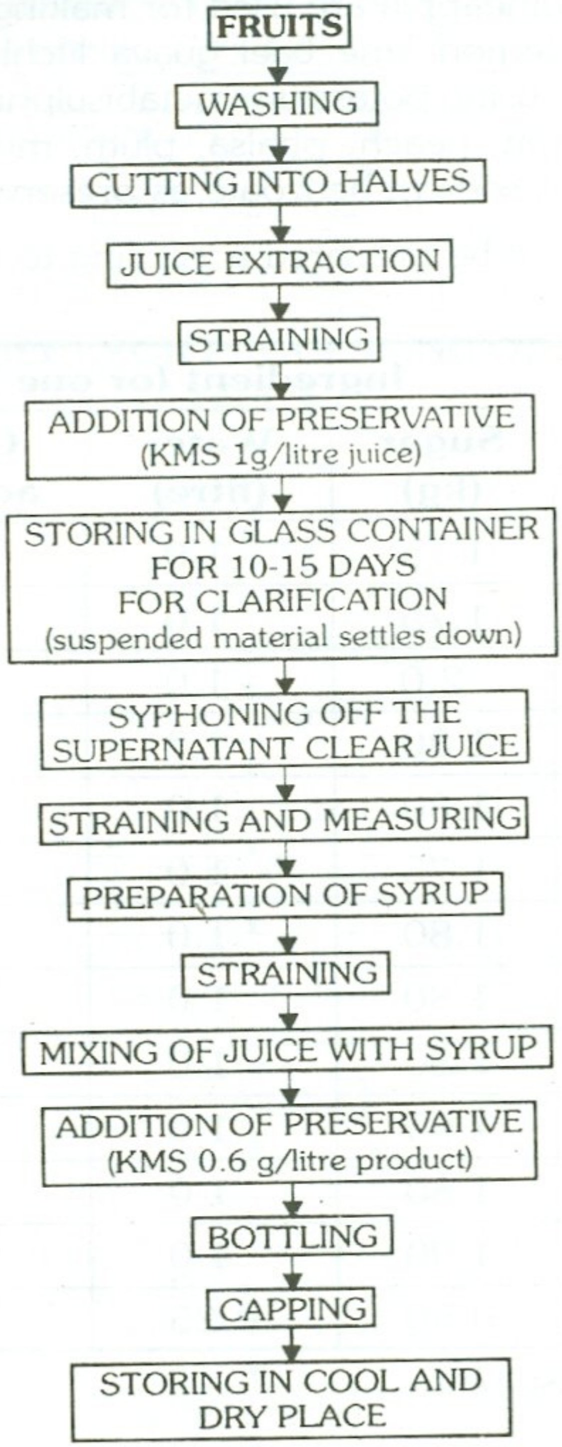
Process: Similar to that of preparation of RTS.

(4) Cordial

It is a sparkling, clear, sweetened fruit juice from which pulp and other insoluble. Substances have been completely removed. It contains at least 25 per cent juice and 30 per cent TSS. It also contains about 1.5 per cent acid and 350 ppm of sulphur dioxide. This is very suitable for blending with wines. Lime and lemon are suitable for making cordial. In homes, cordial can be prepared using the following recipe:

Lime/Lemon juice - 1.0 litre
Sugar - 1. 25 kg
Water - 1.0 litre
Potassium metabisulphite - 2.0 g

FLOW-SHEET FOR PROCESSING OF CORDIAL



This is a type of fruit beverage containing at least 25 per cent fruit juice or pulp and 40 to 50 per cent total soluble solids, commercially. It also contains about 1.0 per cent acid and 350 ppm sulphur dioxide or 600 ppm sodium benzoate. It is diluted before serving.

Mango, orange and pineapple are used for making squash commercially. It can also be prepared from lemon, lime, bael, guava, litchi, pear, apricot, pummelo, musk melon, papaya, etc., using potassium metabisulphite (KMS) as preservative, or from jamun, passion-fruit, peach, phalsa, plum, mulberry, raspberry, strawberry, grapefruit, etc., with sodium benzoate as preservative.

In homes, squashes can be prepared according to the following recipes:

S. No.	Fruit	Ingredient for one litre pulp/juice			
		Sugar (kg)	Water (litre)	Citric acid (g)	Preservative (g)
1	Orange*	1.75	1.0	20	2.5 KMS
2	Mango	1.75	1.0	20	2.5 KMS
3	lime, Lemon	2.0	1.0	-	2.5 KMS
4	Bael	1.80	1.0	25	2.5 KMS
5	litchi	1.80	1.0	25	2.25 KMS
6	Pineapple	1.75	1.0	20	1.9 KMS
7	Guava	1.80	1.0	20	2.0 KMS
8	Papaya	1.80	1.0	25	2.5 KMS
9	Karonda	1.80	1.0	5	4.0SB
10	Phalsa	1.80	1.0	5	4.0SB
11	Jamun	1.80	1.0	15	3.0SB
12	Plum	1.90	1.0	10	4.0SB
13	Water melon	0.50	0.25	10	1.5 SB
KMS= Potassium metabisulphite SB= Sodium					

TECHNOLOGICAL FLOW-SHEET FOR REMOVAL OF ASTRINGENCY FROM ORANGE JUICE

ORANGES
↓
PEELING
↓
DIPPING SEGMENTS IN HOT 2% NaOH FOR 2-3 MINUTES
↓
DIPPING IN 0.5% CITRIC ACID SOLUTION (to Neutralize Alkali)
↓
USE FOR JUICE EXTRACTION

FLOW-SHEET FOR PROCESSING OF SQUASH

FRUITS
↓
WASHING
↓
TRIMMING
↓
CUTTING OR GRATING
↓
JUICE EXTRACTION
↓
STRAINING
↓
JUICE MEASURING
↓
PREPARATION OF SYRUP (sugar+water+acid, heating just to dissolve)
↓
STRAINING
↓
MIXING WITH JUICE
↓
ADDITION OF PRESERVATIVE (0.6 g KMS or 1.0 g sodium benzoate/litre squash)
↓
BOTTLING
↓
CAPPING
↓
STORAGE

(6) Crush

This type of fruit beverage contains at least 25 per cent fruit juice or pulp and 55 per cent total soluble solids. It is more or less similar to squash, contains about 1.0 per cent acid and is diluted before serving.

(7) Syrup

This type of fruit beverage contains at least 25 per cent fruit juice or pulp and 65 per cent total soluble solids. It also contains 1.3-1.5 per cent acid and is diluted before serving.

Fruits like phalsa, aonla, jamun, pomegranate, grape, lemon, orange and sometimes ginger can be used for the preparation of syrup. It is also prepared from extracts of rose, sandal, almond, etc.

Syrups (with 68% TSS and 1.3% acid) can be prepared commercially by using the following recipes:

S.	Fruit	Juice/Pulp (%)	Quantity of water required (litre)
1	Phalsa	25	Quantity of finished product (litre) - Quantity of [Juice (litre) + sugar (kg) + acid (kg)] used
2	Jamun	25	
3	Aonla (blend)	50% aonla pulp + 5% juice + 2% Qinger juice	
4	Grape	25	
5	Pomegranate	25	
6	Lemon	25	
7	Orange	25	
8	Ginaer	10	
9	Rose extract	10	

In homes, syrup can be prepared according to the following recipes:

S. No.	Fruit	Juice/Pulp (litre)	S	Water	Citric acid (g)
1	Phalsa	1.0		0.50	10
2	Jamun	1.0		0.50	15
3	Aonla (blend)	Aonla juice - 1.00 Lime juice - 0.10 Gingr juice - 0.04		0.50	5
4	Grape	1.0		0.50	5
5	Pomegranate	1.0		0.50	5
6	Lemon	1.0		0.50	-
7	Orange	l.0		0.50	10
8	Ginger	0.10		0.20	15

Syrup from extracts

Syrups containing extracts of rose, sandal, kewra, mint, khus, almond, etc. are very popular. The preparation of some of these syrups is described below

(i) **Rose syrup:** Clean rose petals (100 g) are soaked overnight in about 200 mi. of water, then well rubbed, heated for about 5 minutes and strained. The syrup is prepared by using 100 ml of rose extract, 700 g of sugar, 10 g of citric acid and 250 ml of water. Sometimes raspberry red colour and rose water are also added.

(ii) **Sandal syrup:** Sandalwood powder (50 g) is soaked overnight in about 250 ml of water, then heated for about 5 minutes and strained. The syrup is prepared by using the extract, 1.3 kg of sugar, 400 ml of water, and 10 g of citric acid. Sometimes Kewra essence is also added.

(iii) **Almond syrup:** Almond kernels (50 g) are soaked in 200 ml of hot water for some time, the loosened skin is removed and the kernels are ground with 10 g of cardamom (small) and the juice is strained. Syrup is prepared by using above extract, 1.3 kg of sugar, 10 g of citric acid and 350 ml of water. Sometimes kewra or rose essence is added as re- quired.

Synthetic syrups

Heavy sugar syrup of 70-75 per cent strength is used as the base of all synthetic syrups and they are flavoured and coloured with artificial essence/flavours and colours. They never contain fruit pulp/juice. A large proportion of these syrups can, however, be replaced by real fruit juices, squashes and syrups which are more nutritious.

Large quantities of synthetic syrups (orange, lemon, pineapple, raspberry,strawberry, khus, kewra, etc.) are manufactured and sold in various countries. These can be prepared by using 1.5 kg of sugar, 500 ml of water and 15 g of citric acid. Different colours and flavours are added as required. Among colours, orange red, lemon yellow, green, raspberry red, etc., are mostly used, while artificial essence/flavours of rose, kewra, orange, pineapple, strawberry, lemon etc are added as flavouring substances.

Fruit Juice Concentrates

A fruit juice from which water has been mostly removed by heating or freezing is known as concentrate. Carbonated beverages are prepared from this. They contain pure juice with at least 32 per cent total soluble solids. The major advantages of concentrates are :

(i) Reduced weight and bulk compared to juice result in economy in packaging, storage and transport.

(ii) The whole crop of fruits is fully utilized during peak season, thus helping to stabilize the price.

(iii) The product can be used as base material for making various food and beverage formulations.

Problems with concentrates

(i) Fermentation is not prevented,

(ii) Non-enzymatic browning occurs, and

(iil] Gel formation takes place.

In some countries, concentrates of pure fruit juices particularly of orange, apple, pineapple and grape are highly popular. The major methods deployed for production of fruit and vegetable concentrates are : (i) freezing and mechanical evaporation: (ii) low-temperature vacuum evaporation; and (iii) high-speed high temperature evaporation.

(9) Fruit juice powder

Fruit juice can be converted into a free-flowing, highly hygroscopic powder by puff-drying, freeze drying, vacuum drying, spray drying or drum drying. The powder has the advantage of long shelf-life and is soluble in cold water. But during the drying process much of the characteristic fresh flavour is lost, which is compensated for by adding to the juice powder natural fruit flavour in powder form. Reconstitution of the powder mixture yields full strength fruit juice drink. Techniques have been standardized by Central Food Technological Research Institute, Mysore, for preparation of powder from mango, orange, lemon, guava, passion-fruit, banana, avocado, tomato, etc.

(10) Barley water

Fruit beverage which contains at least 25 per cent fruit juice, 30 per cent total soluble solids and 0.25 per cent barley starch is known as barley water. It also contains about 1.0 per cent acid.

Barley water is prepared from citrus fruits such as lime, lemon, grapefruit and orange and of these lime and lemon are mostly used.

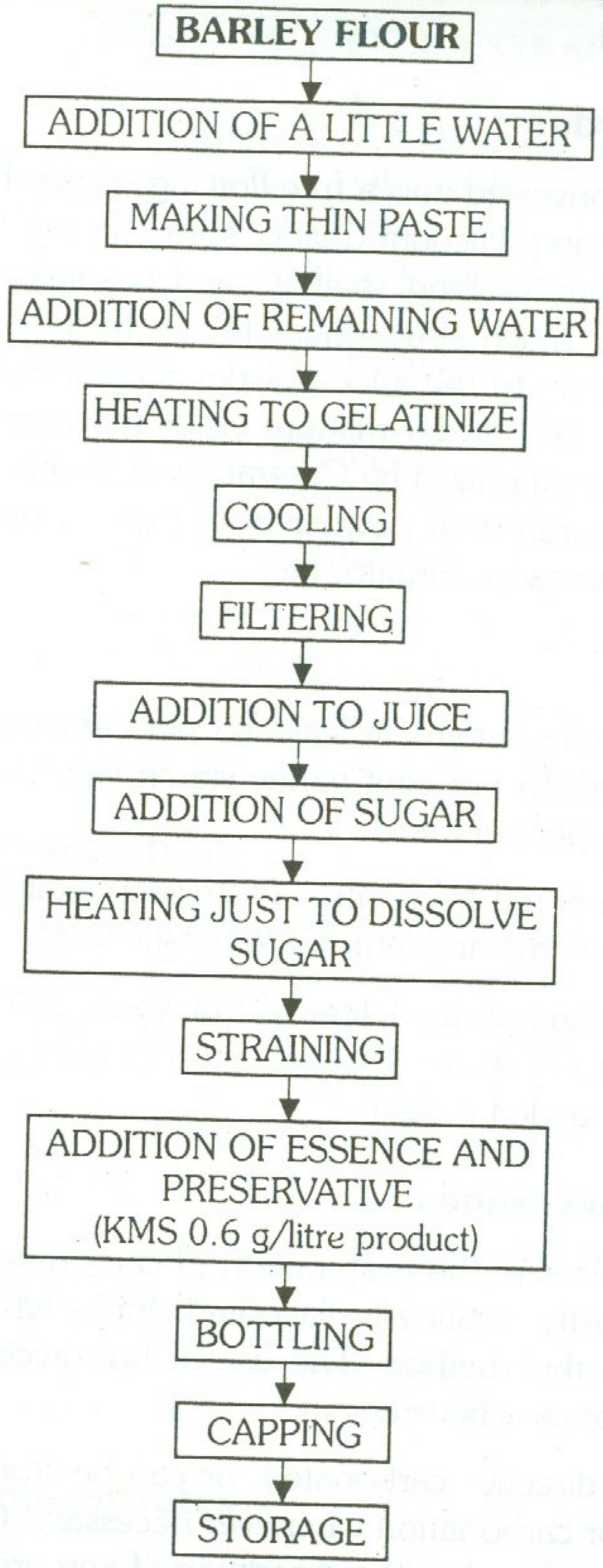
It is prepared by using about 1 litre of fruit juice, 2.0 kg of sugar, 15 g of barley flour and 1.3 litre of water. Essence and potassium metabisulphite (as in case of cordial) may be added if desired.

(11) Carbonated beverages

The use of fruit juices in the preparation of carbonated drinks is practically unknown in India. Mostly, artificially flavoured drinks which have no nutritive value are prepared by this method. The use of fruit juices would increase the nutritive value of carbonated beverages.

The juice can be directly carbonated, or can be stored as such, or in the form of concentrate for carbonation whenever necessary. Carbonated beverages can keep well for about a week without addition of any preservative. If the products are to be kept for a longer period, 0.05 per cent sodium benzoate must be added. For example, while preparing carbonated orange syrup; juice, sugar and citric acid in the ratio of 1: 1.55:0.044 should be used. For carbonation, 42 to 56 g of this prepared syrup is filled in 285 to 340 g bottles. In the same manner syrups of pineapple, lime, lemon, etc. can be prepared. Lemonade, orangeade, ginger, strawberry, lime juice, are examples of carbonated beverages.

FLOW-SHEET FOR PROCESSING OF BARLEY WATER



LECTURE-24 & 25

Processing technology of Fruit Cheese- Processing of fruit cheese-guava cheese- Processing of Fruit leather- mango leather.

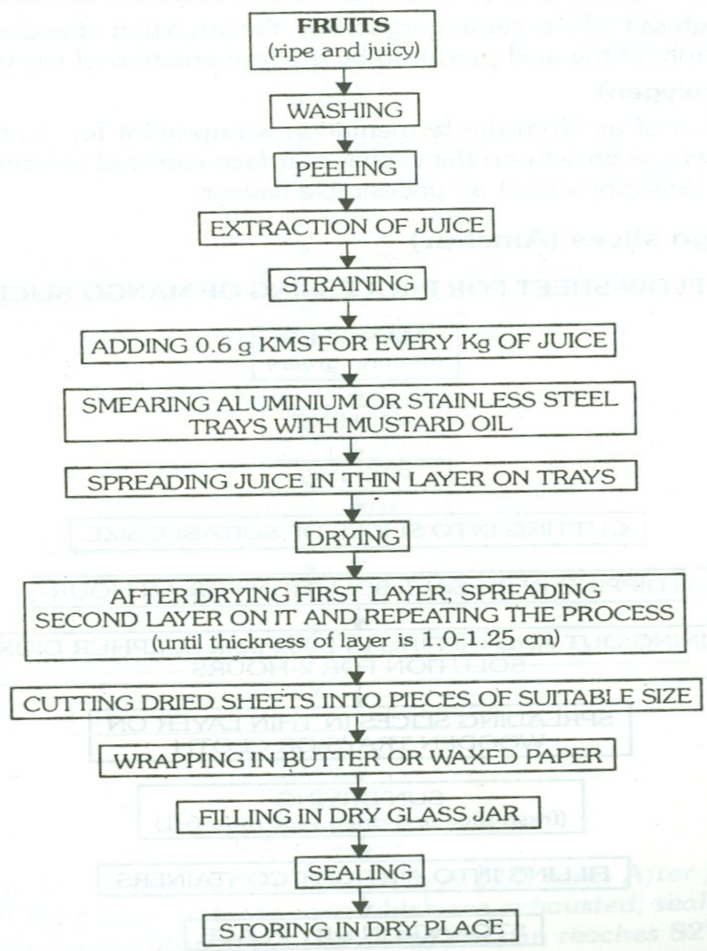
&

Fruit toffee- preparation of banana toffee-Processing of Fruit Butter.

Mango leather

It is also known as mango slab, amawat and ampapar. Ripe fruits are used in its preparation.

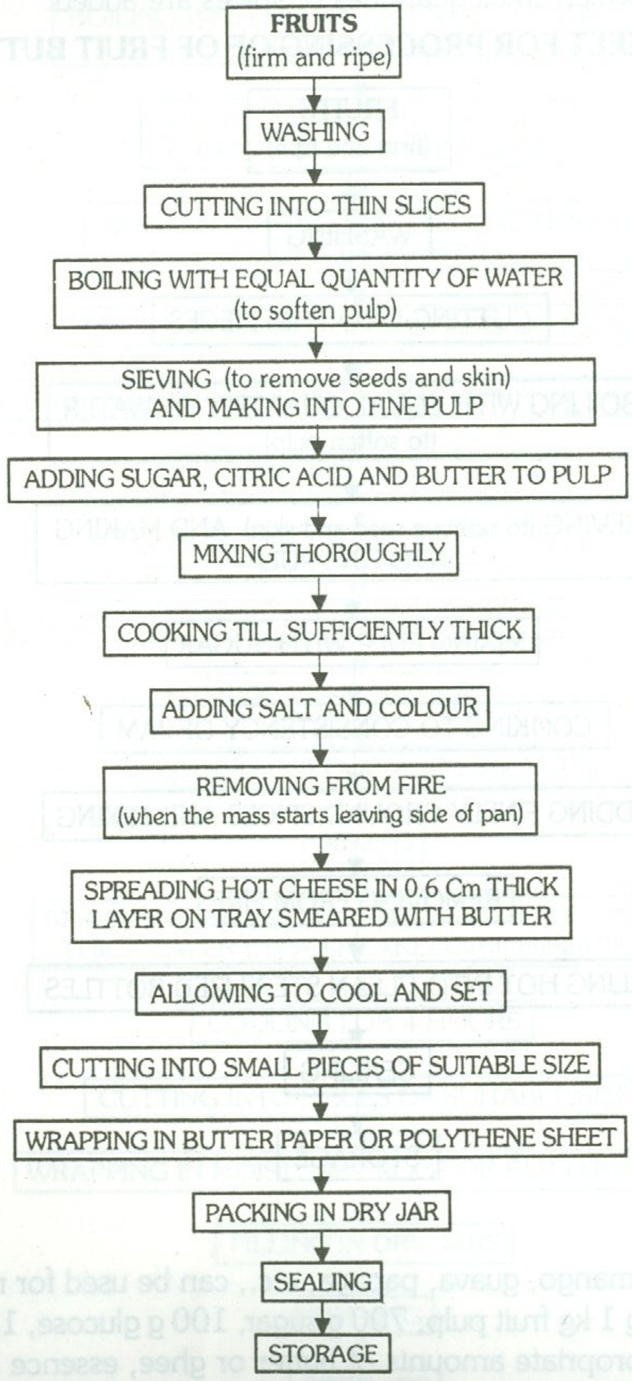
FLOW-SHEET FOR PROCESSING OF MANGO LEATHER



Fruit Cheese

Fruit cheese has recently become very popular. It is a confection of the type of Karachi Halwa and is prepared from fruits like guava, apple, pear and plum. Fruit cheeses have a long shelf-life and are at their best after 3 to 6 months storage. They can be prepared by using fruit pulp 1 kg, sugar 1.25 gk, butter 70 g, citric acid 3 g, salt 2 g and appropriate amount of colour.

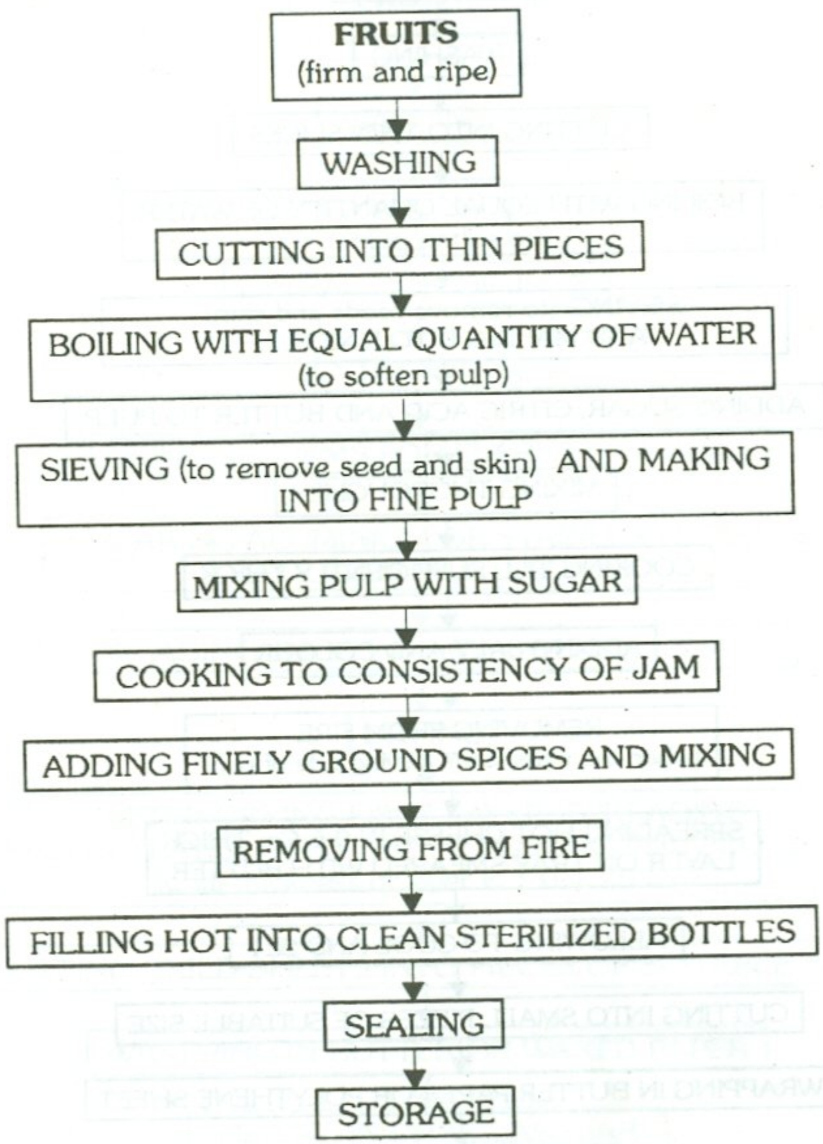
FLOW-SHEET FOR PROCESSING OF FRUIT CHEESE



Fruit butter

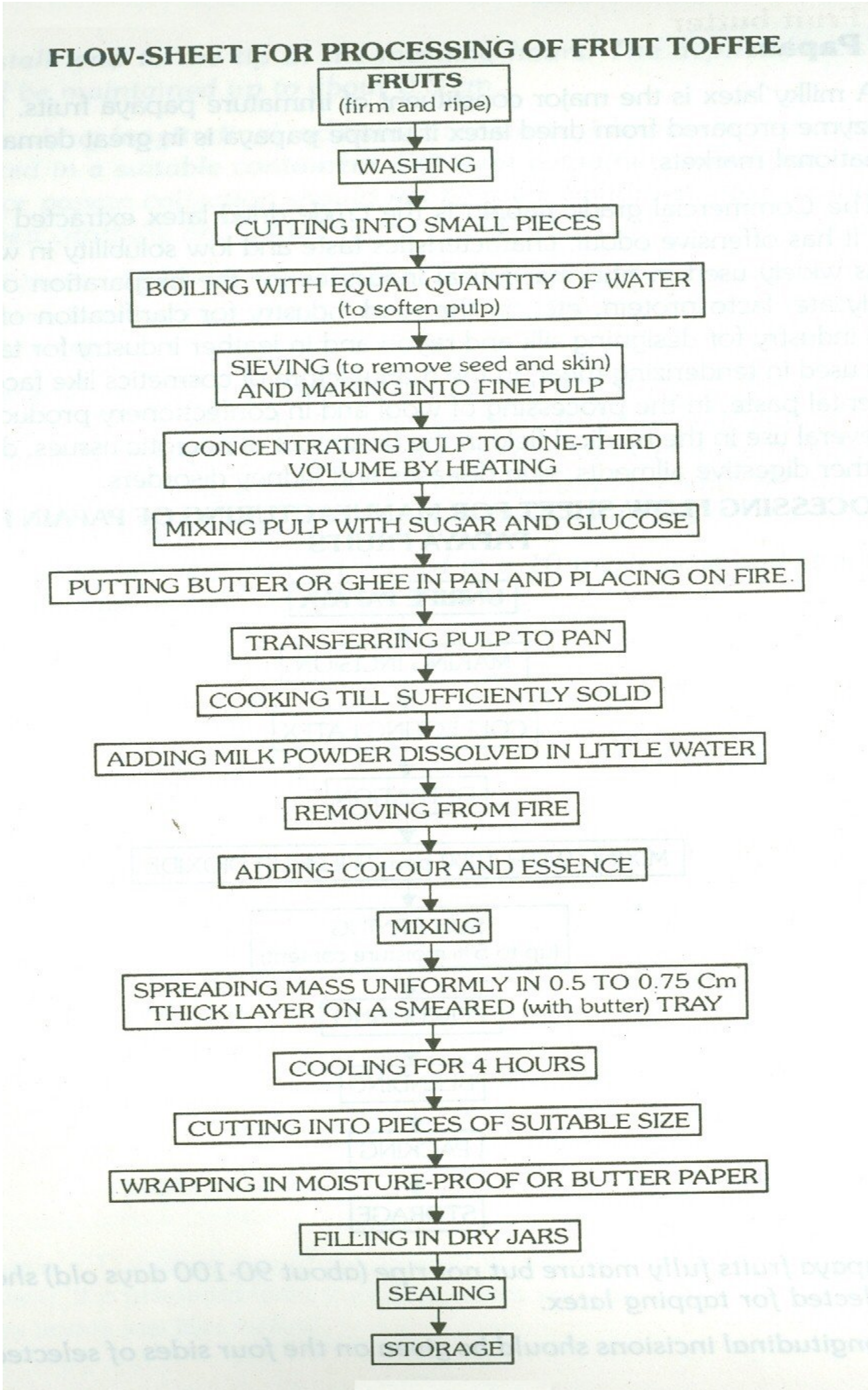
Fruit butters are prepared from apples, peaches, pears, apricots, plums, grapes, etc., or a combination of these fruits. They have a soft butter-like consistency and can be spread easily on breads. They are made by cooking 750 g of sugar with 1 kg of pulp and adding spices like nutmeg, cinnamon, clove, etc. On account of mild spicy taste and flavour fruit butters, specially apple butter, are very popular. The preparation of fruit butter is similar to that of jam except that fine pulp is used to which small quantities of spices are added.

FLOW-SHEET FOR PROCESSING OF OF FRUIT BUTTER



Fruit toffee

Pulpy fruit~ like mango, guava, papaya, etc., can be used for making toffee. It is prepared by using 1 kg fruit pulp, 700 g sugar, 100 g glucose, 150 g skimmed milk powder and appropriate amounts of butter or ghee, essence and colour.



LECTURE-26

Processing technology of vegetable wafers- potato wafers- preparation- types of peeling- discolorations- slicing-Drying-Frying-Salting-packing.

Potato is semi-perishable i.e nature because i.e contains .about 80% water Therefore, post-production management In potato is as Important as the production management. Under tropical and subtropical conditions, 40-50% losses occur due to poor handling and storage. Therefore, it is of utmost importance, to minimize postharvest losses. For successful postharvest management of potato, the farmers should have a better understanding of the production-storage-demand system. Good postharvest management increases returns to the growers. Therefore, the farmers should have access to market information and the ability to take advantage of the market needs. For this access to efficient transport system is very important. Whether to sell the potatoes immediately after harvesting or to store them and, if the potatoes are to be stored, how to store them, and how long to store them are commercial decisions which the potato-growers have to take. Postharvest losses cannot be avoided completely. Good postharvest management minimizes losses, while bad post-harvest management results in high storage losses.

Processing of potatoes 'is advantageous, because is makes storage easier due to reduction in bulkiness and increase in shelf-life. It adds value to potatoes and, therefore, gives better returns. From the consumer point of view, all processed products should have an attractive colour, acceptable texture and good flavour. Generally, use of high quality potatoes will help to obtain and maintain good quality of the processed products. Potato processing quality, in turn, is dependent on various conditions, including cultivation and environment as well as the time of harvest. The variety of the potatoes used also is an important factor.

Potatoes are processed into many types of products, (i) fried products such as wafers/chips etc.; (ii) dehydrated products such as dice etc.; (iii) frozen products such as French fries, patties, puffs, dice etc.; and (iv) canned. For such diverse forms of products, the raw material requirements are likely to be different. The raw material requirement for some of the processed potato products are:

Quality requirements of potatoes for processing+

Characteristics	Potato Products			
	Dehydrated	French fries	Chips	Canned
Tuber shape		Long shape	Round to Round-oval	
Tubler size, mm	30	50	40-60	35
Eyes	Shallow	Shallow	Shallow	Shallow
Specific gravity	1.080	1.080	1.085	1.080
Drymatter (%)	22-25	20-24	22-25	18-20
Starch (%)	15-19	14-16	15-18	12-24
*RS (%) after 8°C	2.5	2.5	1.25	2.5
*TS (%) after 6°C storage	5.0	5.0	5.0	5.0
ACD	Slight	Slight	-	Nil
ED	Slight	-	-	-
Texture	Fairly firm to mealy	Fairly firm	Fairly firm to mealy	Firm (waxy

* On dry weight basis, RS = Reducing sugars; TS = Total sugars; ACD = After cooking discolouratio
ED = Enzymatic discolouration.

+ Source : Verma (1991).

Perhaps the first attempt at processing of potatoes in India on a commercial scale was made by one Col. Rennick, who established a factory at Narkanda in Himachal Pradesh, to produce potato 'Meal'. Dehydration of potato on commercial scale was also taken up during the Second World War to meet the demands of the defense forces. Solar dehydration of potatoes in the form of slices, shreds and *'papads'* is carried out in many households for their own use. Recently, however, there has been a lot of interest in India in processing potatoes. The installed capacity in the organized sector for processing of potatoes in India is very low as compared to the annual production. Thus, there is a considerable scope for an increase in the processing of potatoes in the country.

The situation appears to be ideal for the development of potato processing industry, but there has been hardly any progress in that direction. This is because processing plants cannot be operated economically on periodic or seasonal gluts or on unmarketable potatoes. A regular supply of raw material of the desired specific quality has to be available for a greater part of the year. Moreover, processed products will have to be priced so as to compete with fresh foods. Presently potatoes in India, as a raw material, are not cheap, except for a few weeks soon after harvest. And, the cost of the frying medium, processing and packaging etc. adds to the cost of production making the finished product beyond the reach of a common Indian.

The prospects for using potato as an industrial raw material appears to be limited at present to unmarketable potatoes, as cheaper alternative raw materials for the production of starch such as maize and tapioca are available. Similarly molasses from sugar factories is abundantly available for production of industrial and potable alcohol.

Notwithstanding the above, there are some special situations, where potato processing is extremely desirable, e.g., in the Nilgiri hills where cyst forming nematodes occur. The movement of potatoes from this area is a potential hazard. Processing *in situ* will reduce the risk. Similarly, Darjeeling district in West Bengal, where wart disease is prevalent, will benefit from potato processing. Processing is certainly an attractive proposition in areas of high production/productivity as in certain districts of UP, West Bengal and Gujarat. Some form of processing may also help the farmers in the hilly and other regions where lack of transportation is still a major constraint.

Considering that the potato products using sophisticated processing technology are at present very costly, there appears to be a limited scope in the immediate future. The cost of the products such as chips, is pushed up because of the scarcity of frying medium, which is not even sufficient for meeting the requirements of housewives.

In order to make processed potato products available to a common Indian at a reasonable price, it would be desirable to develop appropriate technology and products. In this context products like dehydrated dice (piece), flour may be desirable. Dehydrated dice or pieces can be used in the households for preparation of curries, and also by the fast food outlets for stuffing in the *Masala Dosa* or *Samosas,* while potato flour can be used to prepare *'Tikkis'* and extruded products like *'Papads'* etc.

Important considerations in Potato Processing

The quality required for processing of potatoes has been mentioned in the Table given above. However, for processors potatoes it would be desirable to identify/select/breed long dormancy varieties with round or oval tubers of medium to large size with fleet eyes and free from diseases and peeling losses. The dry matter content of the tubers should be high for greater yield of dehydrated products. The sugar and phenol content should be low and the tubers should be free from after cooking darkening. In addition to the morphological characters, some other factors determining the suitability of potatoes for processing are the specific gravity, or the dry matter content of potatoes and their sugar content.

8.

Potatoes, high in specific gravity (or dry matter) are preferred for preparation of chips, French fries or dehydrated products, whereas those of lower specific gravity .are used for canning or for such other products where a firm piece is desired. Yield of chips and flour etc. is higher from high specific gravity potatoes. Besides high yields of the product, the uptake of fat or oil during frying is lower. Moreover, relatively much less moisture has to be removed per unit of products when high specific gravity potatoes are used. However, potatoes of very high specific gravity may not be suitable for the production of French fries etc. French fries produced from potato with a specific gravity of 1.106 were too hard and biscuit like. It is also of the opinion that very high specific gravity potatoes may yield 'hard chips'.

Dry matter content (specific gravity) is vital in terms of yield, of potato chips or wafers, and the texture of potato chips and reconstituted dehydrated potatoes. Generally even small (marginal) increases in dry weight, will ensure greater yield of the product. Specific gravity of potatoes can be determined by a number of methods e.g. use of i) brine solution of known specific gravities (Burton 1989), ii) Potato Hydrometer, iii) Archemides principle (Nissen 1967), iv) variable load hydrometer (Sukumaran and Ramdass 1980), and v) ordinary scales (Misra 1983). Dry matter content of fruits and vegetables, including potatoes is determined by oven drying, but a non-destructive method is also available for potatoes and sweet potatoes. Von Schee *et al.* (1937) demonstrated that the specific gravity and dry matter content of potatoes are directly related to each other. Since then relationships have been established in other countries including India.

(8) Sugar content

Sugar content of potatoes influences the colour of the processed products and plays a very important role in determining the acceptability of fried products. Chips and French fries prepared from potatoes containing large amounts of sugars, especially reducing sugars, i.e. glucose and fructose, turn brown and black and become 'unacceptable to the consumers. This discolouration is ascribed to a reaction, between the reducing sugars and amino acids, which takes place when the moisture content is low and the temperature is high. Generally, freshly har- vested mature potatoes contain-acceptable levels of reducing sugars but when stored at low temperatures, the sugar content increases and potatoes become unfit for processing. For storage of potatoes for the processing industry, the current storage practices followed in India are not suitable, as potatoes stored below SOC are rendered unfit for processing due to an increase in reducing sugars.

One of the methods of overcoming this problem is to store the potatoes at high temperature. It has been shown that when potatoes were stored at ambient temperatures, there was very little increase in the reducing sugar content of potatoes. But under such conditions sprouting and weight loss were excessive. However, when potatoes were stored in an evaporative cooled store, similar changes in the sugar content were observed but with a lower weight loss of the potatoes, yet the problem of sprouting remained. To overcome this problem, potatoes were treated with CIPC (Isopropyl-N-chlorophenyl carbamate) and stored in an evaporatively cooled store, and also at lower temperatures recommended for storage of potatoes meant for processing. Even under such conditions of storage, potatoes became unfit for processing within a very short period. Recourse had to be taken to reconditioning another method used to overcome the problem of excess sugar in cold stored potatoes. During reconditioning, cold stored potatoes are stored at *15-20DC* for 2-3 weeks. Under such conditions a reduction in the contents of sugars take place. However, in many cases this was also not very effective and dark colored chips were produced. In an attempt to produce acceptable colour, the chips were fired at lower temperatures. While the colour of chips was acceptable the oil content of the chips so produced was about 30% higher than the oil content of chips produced by frying under the normal conditions. The discolouration of chips and French fries due to high sugar content of cold stored potatoes is a problem faced by the industry all over the world and attempts have been made to identify varieties which do not accumulate large amount of sugars during the low temperature storage. In UK, a variety Brodick has been released and in India, Kufri Sherpa has been found to accumulate much lower quantities of sugars than many other potato varieties (Kufri Badshah, Kufri Chandrarnukhi, Kufri Jyoti, and Kufri Sindhuri) examined.

(C) Discolouration

One of the problems affecting appearance and acceptability of any potato product is the tendency for discolouration of the -product or browning to occur. This is generally a result of physiological conditions, and some subsequent chemi- cal reactions. Potato and potato products are prone to three types of discolouration: i) enzymatic discolouration, ii) after cooking discolouration and iii) discolouration of fried products (Chips/Wafers/French fries) and dehydrated potatoes.

(i) Enzymatic discolouration

Discolouration of peeled or cut raw potatoes results from enzymatic oxidation and Discoloration of polyphenolic compounds in the presence of air or oxygen. The problem is encountered in sun-drying of potatoes and is due to the action of polyphenoloxidase enzyme on the phenolic compounds. Similar reaction takes place in the development of black spot in potatoes during harvesting, handling and transport, specially at low temperatures.

Exclusion of oxygen or preventing contact of the potatoes with air can prevent discolouration. Inactivating the enzyme with heat or lowering the **pH** also helps to control browning. An alternative way is to treat the whole potato with So_2 gas. Such potatoes can be stored. High concentrations of CO_2 can also be used to treat whole potatoes to prevent the accumulation of reducing sugar and to improve the colour of wafers.

Storage of potatoes also influences enzymatic browning. Generally, highertemperatures and longer storage periods has been associated with higher levels of tyrosine; thus, such potatoes tend to be more discoloured when peeled or cut.

Enzymatic discolouration and black spot in potatoes can also be prevented by the application of potassium fertilizers specially muriate of potash. But the application of muriate of potash resulted in a decrease of the dry matter content of potatoes. Therefore, the industry uses other methods to overcome the problem of enzymatic discolouration, i.e., the application of chemicals to peeled potatoes. Sulfiting, as the common procedure is known as, helps to reduce or eliminate enzymatic browning but is a potential health hazard, specially to people prone to asthmatic conditions. As such efforts have been made to select varieties which do not show any enzymatic discolouration. It has been reported that varieties 02286 and C2703 did not show much enzymatic discolouration.

(ii) After cooking discolouration (ACD)

As the term suggests, it develops in cooked potatoes and potato products after exposure to air, especially in boiled and steamed potatoes. Discoloration and / or darkening occurs after cooking due to the non enzymatic browning reactions which take place at high temperatures used in preparation of chips/wafers, French fries, canned potatoes or during dehydration. After cooking darkening is, generally, due to the formation of a dark coloured complex of ferric iron and a phenolic compound. Factors such as iron content, presence of organic acid, pH and phenolic compounds are involved in such darkening, which usually, is less in immature than in mature tubers. In solutions more acidic than the normal pH of potatoes, the darkening can be prevented; while, in contrast, it is intensified by reactions which are alkaline. The organic acid content, aspartic acid, of the tubers affects the discolouration after cooking. This has been attributed due either to the effect of pH, or the ability of the acid to chelate iron and compete with chlorogenic acid for iron, and form a colourless complex. The more the citric acid, the lesser the content of darkening. Thus, darkening is associated with low levels of organic acid, such as citric, oxalic, malic and orthophosphoric acids. It has been suggested. however, that the amount of free organic acid is a greater determinant for discolouration.

Almost all the Indian potato varieties are free from ACD, though it has been observed occasionally in Kufri Jyoti. But ACD develops in gamma irradiated potatoes stored at or below 15°C for 2.5 to 3 months. The problem could be overcome by storing potatoes at higher temperature or by reconditioning such potatoes at 30-35°C for 2 weeks.

(iii) Discolouration of fried products and dehydrated potatoes

Products made from potatoes with high sugar content are more likely to be scorched, or discoloured during dehydration and to turn dark during storage. Two methods have been suggested for overcoming the problem. In one of the methods, excess quantity of sugars is fermented to lactic acid by *Lactobacillus plantarum* L.nd it was claimed that "Satisfactory product, with respect of colour, flavour/aroma, texture and general acceptability could be produced by this method". In another method, thereactants were removed by repeated washing of the raw slices in water. It was claimed that about 50% of the reducing sugars and about 40% of the free amino acid were removed by washing the raw slices in water. It may be pointed out that these two reactants are involved in the development of the discolouration of fried products.

(D) Peeling Potatoes for Processing

After selection of raw materials, peeling is an important preliminary step in the manufacture of various potato products, since the effectiveness and efficiency of peeling determine the yield of the finished product, the amount of waste, and the cost of waste disposal.

The ideal peeling operation should only remove a very thin outer layer of the potato, leaving no eyes, blemishes, or other material for later removal by hand trimming. It should not significantly change the physical or chemical characteristics of the remaining tissue.

Preferably peeling should use small amount of water and result in minimal effluent; compromises will have to be made in all of these aspects of peeling.

9.First, the potatoes are thoroughly washed, not only for sanitary reasons, but also to prevent dirt of grit from abrading the equipment the tubers will later . contact. Washing may take place in streams, as the potatoes are being conveyed with brushes or rubber rolls.

In barrel-type washers, potatoes are cleaned by being tumbled and rubbed against each other and against the sides of the barrel while they are immersed in, or sprayed with, water.

After washing, the potatoes are allowed to drain, usually on mesh conveyors, and they travel over an inspection belt where foreign material and defective tubers are removed. The more common peeling methods are abrasion, lye immersion, and steam. Various methods used in peeling of potatoes are briefly discussed below:

(i) Abrasion Peelers : These are designed to uniformly contact the surface of the tubers with abrasive discs or rollers so that, while peeling, the losses are minimum. Abrasion peelers which may be either batch or continuous, use rollers coated with grit to grind away the potato surface. An important design feature is to ensure that all surfaces of the tuber are equally exposed to the rasping action. The peel fragments are flushed out of the unit by water sprays. During peeling, potatoes are sprayed with water in order to decrease the tendency for the tubers to darken as a result of enzymatic action.

Abrasion peelers work best with uniform, round, undamaged potatoes.' Non uniform size also results in uneven peeling. Peeling losses are, usually, greater for small than for large potatoes. Some of the advantages of abrasion peelers are their simplicity, compactness, low cost and convenience. Abrasion peeling is suitable for potatoes to be used for manufacturing chips/wafers, since other peeling processes which use heat, give a coated layer of tissue, or a visible heat ring, About 10% of the original tuber weight is lost through abrasion peeling prior to chipping.

(ii) Lye Peeling: It depends on chemical attack and thermal shock to loosen and soften the skin, eyes and blemishes of -potatoes so that they are readily worked off, or rubbed off, by pressure spray and washers. In this method lye (sodium hydroxide) solution is used at a high temperature, i.e., 160^{0}F or a lower temperature, i.e. 120^{0}F to 16QoF.

Potatoes may be pre-heated for a short time in water at temperatures ranging from 140 to 190^{o}F. This minimizes the cooling effect and help to maintain a uniform temperature that the potatoes would otherwise have on the lye solution and thus, increase the capacity of the peeler. If a heat ring or partially cooked layer of tissue remains on the peeled surface, it can be removed by immersing the potatoes again in a lye solution maintained at a low temperature (usually 70°F, and lye concentrations ranging from 10 to 40 per cent, or at 12°F with concentrations of 15 to 20 per cent).

Different types of lye peeling equipment are available. These are de- signed such that the potatoes can be submerged in heated lye solution, the temperature of which is maintained for a specific period of time. The equipment used with low or high temperature lye treatment is the same. At low temperatures, the lye is more viscous; hence, there is need for rapid circulation. Further, the viscosity is increased due to the starch, protein and other components, from the potatoes that are dissolved in the solutions. The con- tact time or dip/immersion time needs to be longer when lye concentrations are higher, probably because of increased viscosity which makes it more difficult to ensure adequate circulation of the peeling medium.

Lye peeling softens the surface of the potato and the colour changes to a deep yellow due to the reaction of the lye with constituents of the potato. After removal from a lye peeler, potatoes are washed to remove the remaining lye. Failure to remove the lye allows it to continue to react with the flavours in the potato, and results in further yellowing of the potato. Sometimes the potatoes may be sprayed with or immersed in dilute solu- tions of some acid to neutralize the lye.

(iii) Steam Peeling : In this method potatoes are subjected to high pressure steam for a short time. This treatment hydrates the potatoes and cooks their surface tissue, which softens and, consequently, lossens the peel from the underlying tissue. The softened tissue' is removed by brushes or water sprays. However, steam peeling leaves a heat ring on the peeled potato surface. In many processed products, this is not objectionable. The exception is potato chips/wafers, in which this ring is visible and has been known to affect consumer acceptance of the product.

(iv) Brine Peeling: Brine solution maintained near boiling and saturation points has been used for peeling potatoes. However, evaporation of water occurs constantly, hence, it is necessary to prevent over saturation and crystallization. Immersion time required for adequate peeling may range from 3 to 10 minutes.

Brine peeling is less expensive than lye peeling, and is also less of a hazard to the operating personnel. Another advantage with brine peeling is that any salt left on the potato surface does not need to be neutralized and may reduce enzymatic discolouration of the peeled potatoes. The only problem is that the brine solution corrodes the equipment it is in contact with Lye and brine may also be used together.

(v) Flame Peeling : Potatoes are subjected to high temperatures which lead to charring or carbonization of the skin. Potatoes are passed through a flame or a refractory oven which subjects all surfaces of the potato to approximately 200^0F for 15 to 30 seconds. Since the tubers are exposed to such an elevated temperature for a relatively short time, the depth of the heat ring formed is much less.

Peeling losses are usually less by flame peeling than by the use of abrasion peelers. The demerits of this method lie in the difficulties in controlling temperature, and noise; and considerable maintenance of the equipment is required. Flame peelers are used mostly for peeling onions and peppers than potatoes.

(vi) Oil Peeling : Oil heated at 300 to 400^0F can be used to remove the peel. Vegetable and mineral oil can be used. If the mineral oil is used, the oil must be completely removed otherwise undesirable oily odours will impair the product.

After peeling and washing, hard trimming is done to remove any residual skin, discoloured areas, disease and insect injured potatoes, black spot as well as parts of potatoes which are green. The amount of trimming required depends on how efficiently the peeling was done. Subsequent to trimming, the tubers may either be sized, or conveyed directly to the next processing operation.

It is desirable, therefore, that the potato varieties used for processing should have following characteristics:

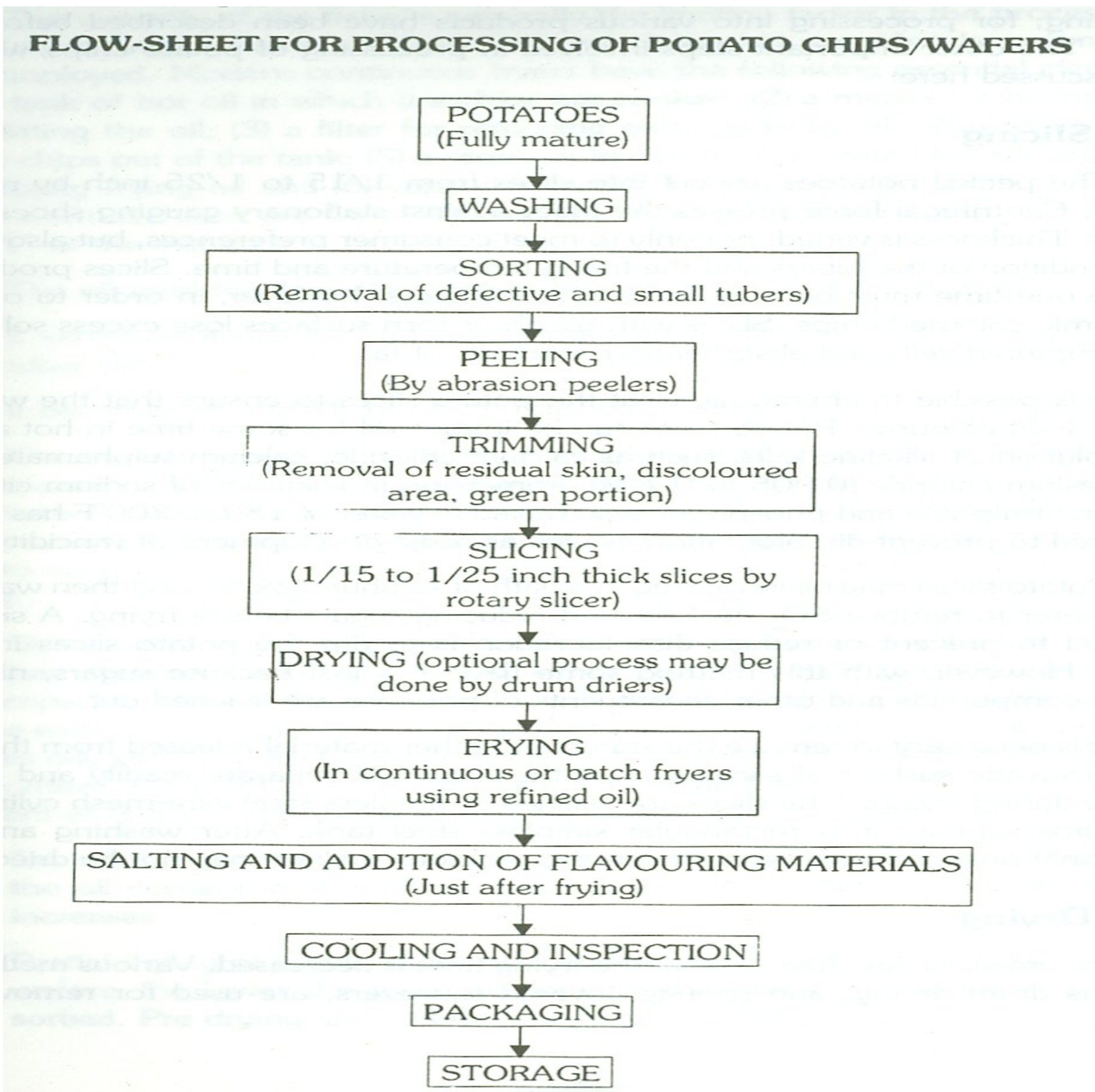
(i) Potato tubers should have high degree of maturity (fully mature), round or oval shape, medium to large size with fleet eyes, and free from diseases.

(ii) Potato tubers should have long dormancy.
(iii) Potato tubers should have high specific gravity or dry matter content.
(iv) Potato tubers should have low sugar content.
(v) Potato tubers should be free from after cooking discolouration.
(vi) Potato tubers should have low peeling losses.

Recently Kufri Chipsona-I and Kufri Chipsona-Z potato varieties, released from Central Potato Research Institute, Shimla, are free from after cooking discolouration and due to their high dry matter and low reducing sugars and phenols contents these varieties are highly suitable for making chips and French fries.

Potatoes can be processed in a number of ways as follows:

1.Potato chips/wafers



(2) French Fries (Frozen Potato Chips)

FLOW-SHEET FOR PROCESSING OF POTATO FRENCH FRIES

POTATOES (Fully mature)

↓

WASHING

↓

SORTING (Removal of defective and small tubers)

↓

PEELING

↓

TRIMMING (Removal of residual skin, discoloured area, green portion)

↓

CUTTING[1] (into strips by strips cutters)

↓

SORTING OF STRIPS (Removal of broken, discoloured and defective pieces

↓

BLANCHING[2]

↓

REMOVAL OF EXCESS MOISTURE

↓

FRYING[3]

↓

DEFATTING[4]

↓

COOLING AND INSPECTION[5]

↓

PACKAGING

↓

FREEZING[6]

↓

STORAGE (at 0°F for at least 2-4 months)

(3) Potato Drying/Dehydration

(i) Sun Drying

A home-drier for fruits and vegetables (including potatoes) was fabricated in which best dried product was obtained when the potatoes were peeled, sliced, and blanched for 3-5 min at *81-100^{0}c;* The slices could be dried in 9-11 hr. The Peeling and trimming losses were lower in 'new' potatoes but the yield of the dried product (22-29%) was higher in old potatoes.

(ii) Solar Drying

Solar energy has been used since ancient times to dehydrate potatoes in the Andes mountains to prepare *Chuno.* In India also, sun-drying of potatoes in the form of slices, shreds and *Papads* etc. is practiced by housewives. But quite often the products are varying shades of grey and therefore, unappealing. Investigations were, therefore, conducted at the Central Potato Research Institute and its regional stations to develop a procedure to prepare dehydrated potato slices of acceptable colour. Discolouration of peeled potatoes and the slices is minimized by immersing them in cold water. Blanching of slices inactivates the enzymes) responsible for browning. Use of potassium metabisulphite ensures that such slices have a long shelf life, if stored in air-tight containers or in sealed polythene bags. Such slices could be ground to prepare potato flour for use in the preparation of biscuits etc.

A number of investigations have been conducted to study factors which have a bearing in solar dehydration of potatoes, e.g. thickness of the slice, use of various surfaces for sun-drying, and evaluation of the efficiency of different types of solar dehydrators etc. It was observed that black polythene and nylon mesh was a better surface for dehydration than clear polythene. The thickness of slices affected the rate of dehydration, thinner slices dried in the sun at a faster rate than thicker ones.

A problem related to quality of sundried products is the reported occurrence of dust, and at times dead insects, when dehydration is carried out in open. A number of solar dries have been fabricated and evaluated. These not only ensure better, hygenic standards but also generally result in faster drying.

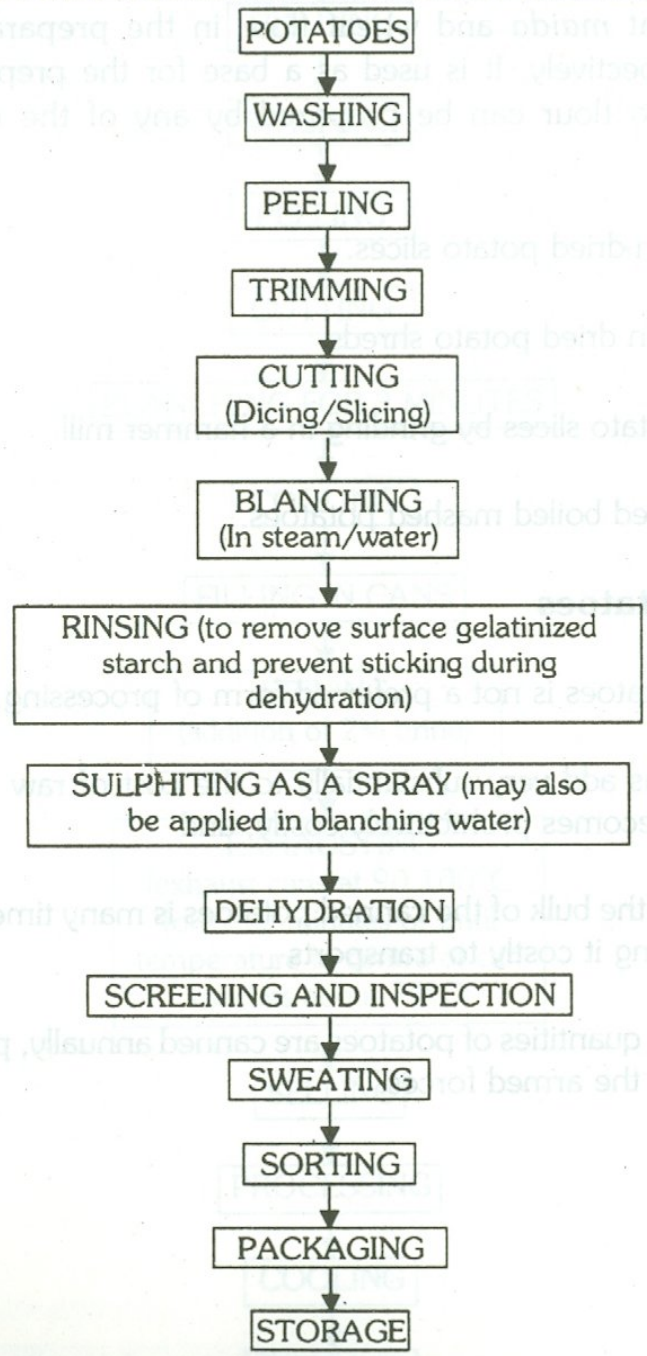
Solar dehydration of partially cooked potatoes

In some parts of our country, particularly in Gujarat and Maharashtra considerable quantities of partially cooked potatoes are dried and are consumed after deep fat frying. Such slices take up much less cooking medium during frying and are, therefore, more economical. The procedure for preparing such slices consists of cooking the potatoes in boiling water for 8 min before peeling and slicing. Slices are then allowed to dry in the sun. Dehydration of such slices take longer time and is usually accomplished in about 8-10 hours.

(iii) Dehydrated Diced Potatoes

At the Central Food Technological Research Institute, Mysore extensive investigations were carried out for evaluating different potato varieties for preparation of dehydrated dice. When all the factors viz., blanching time, cooking time, sulphite content and browning of dice during storage were taken into consideration, the varieties Kufri Chandramukhi, Kufri Kuber, C-990 and VB-8 were found to be the most suitable for processing into conventionally dehydrated dice.

FLOW-SHEET FOR PROCESSING OF DEHYDRATED DICED POTATOES



Besides above dehydrated potato cubes, vacuum-puffed dried potatoes and instant potato flakes are also being prepared by various drying/dehydration techniques.

(4) Potato Flour

Potato flour is a very important product and is used in the baking industry, mainly to reduce the protein content of the mix, but also to impart softness to bread and for better retention of moisture. Potato flour can also be used to partially replace wheat *maida* and wheat flour in the preparation of biscuits and *'Chaptai',* respectively. It is used as a base for the preparation of many soup mixes. Potato flour can be prepared by any of the under mentioned Procedures:

(i) By grinding sun-dried potato slices.

(ii) By grinding Kiln dried potato shreds.

(iii) Dehydrated potato slices by grinding in a hammer mill.

(iv) By grinding' dried boiled mashed potatoes.

(5) Canned Potatoes

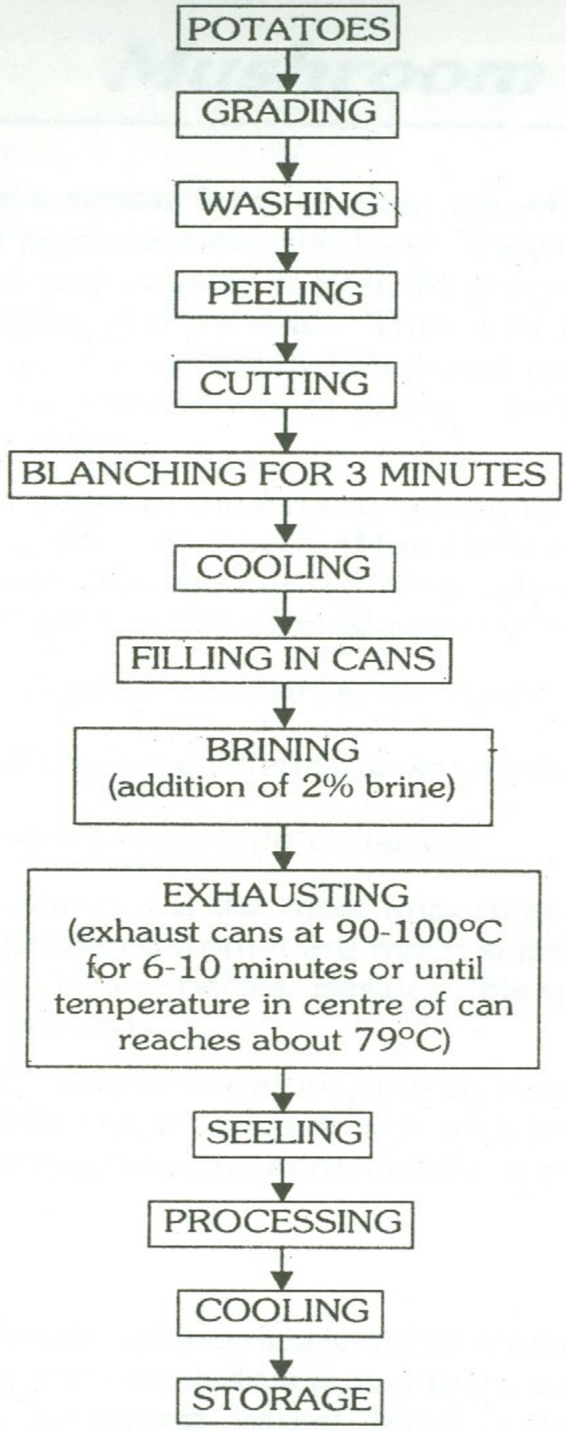
Canning of potatoes is not a preferred form of processing, because:

(i) The cost of cans add very substantially to the cost of raw material and the final product becomes prohibitively costly, and

(ii) The weight and the bulk of the canned potatoes is many times that of the raw potatoes, making it costly to transports

However, small quantities of potatoes are canned annually, primarily, to meet the requirements of the armed forces.

FLOW -SHEET FOR PROCESSING OF CANNED POTATOES



LECTURE-27

Vegetable Papads-Processing of Papads-preparation-equipment used for preparation- packing.

Vegetable Papads

Potato Papad ingredients

- Potato - 1 kgs. (medium sized)
- Salt - less than 1 tea spoon (according to the taste)
- Red Chilli Powder - less than a 1/2 tea spoon.
- Oil - 2 table spoon.

Method

Wash and boil the Potatoes in the cooker in 2 cups of water for upto 1 whistle. After the first whistle, boil the Potatoes for 3-4 minutes on a medium flame until they get soft or tender.Once the Potatoes are boiled and cools down, peel and grate them. Add salt, red chilli powder into the grated Potatoes and mash them. Now grease your hands and make small balls from the mixture. Make as much balls as you can from the mixture, but remember that all the balls should be of same size. Make all the balls and keep on placing them on a plate. You will be able to make 20-22 balls from the mixture of 1 k.g potatoes.To roll out the Potato Balls you need 1x2 ft. thick polythene sheet and a big flat polythene -sheet is required to dry them under the Sun. Spread the big polythene -sheet on top of a bedsheet on the terrace floor. Put any heavy substance like bricks on all the four corners of the sheet so it doesn't misplace. To roll out the Papad take any thick transparent polythene sheet. Place the sheet on a rolling board in a way that half of it should be fall outside the board and half should be covering the inside of the board. You can even take two equal parts of a polythene - sheet. Place the potato ball on one sheet and the cover it with the other sheet. Apply some oil on the first polythene - sheet and on both sides of the potato ball. Place the first sheet on the rolling board and keep the greased potato ball on it. Now cover the potato ball from other sheet and press it with hands o flatten it. Roll the potato ball into thin flat disc as we do while making chapatis. Moreover, you can also press the potato ball with your fingers to give it a round shape.

Drying

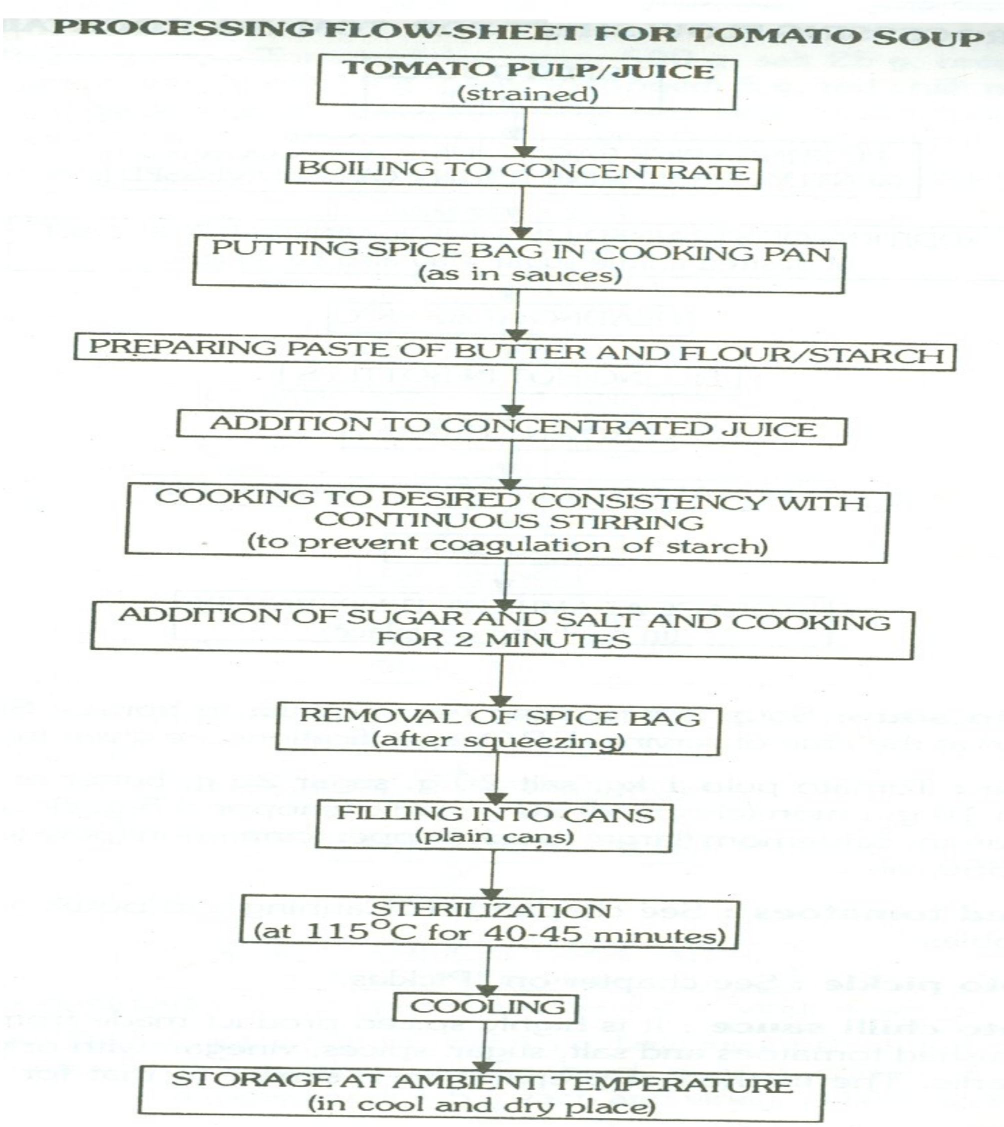
Strip out the one side of polythene - sheet from the rolled out papad and put it over the big polythene - sheet from the side of the papad. Now press the papad with hands to stick it on the big polythene - sheet and strip out the other part of the polythene - sheet also. Press the papad against the big polythene sheet to settle it down. Place all the other papad on the sheet in the same manner.Let the papad dry in the Sun. After 3-4 hours turn the sides of the papad, when they are little moist. If the papad will get completely dry from one side, then they might break on turning or get stick to the polythene - sheet. Usually it take a day for a papad to get completely dry, but if they are still little moise then collect them at the end of the first day and spread them again the next day to get completely dried.

LECTURE-28

Processing of Soups- preparation of tomato soup-packing/canning preparation of soup powders-technology and equipment required.

Tomato soup: Soup is becoming very popular in homes. Stored soup is warmed at the time of serving.

Recipe: Tomato pulp 1 kg, salt 20 g, sugar 20 g, butter or cream 20 g, flour/starch 10 g, onion (chopped) 20 g, garlic (chopped) 5 g, clove (headless) 5 numbers,cumin, cardamom (large), black pepper, cinnamon (powdered) 1 g each and water 350 ml.



LECTURE-29

Fermented products from fruits and vegetables –Vinegar –types of vinegar-methods of vinegar production-Quick method-Orleans slow process-Generator process – problem in vinegar production.

Decomposition of carbohydrates by microorganisms or enzymes is called fermentation. Fermentation of food results in the production of organic acids, alcohol, etc., which not only help in preserving the food but may also produce distinctive new food products.

The term fermentation has come to have somewhat different meanings as its underlying causes have become better understood. The derivation of the word fermentation signifies a gentle bubbling condition. The term was first applied to the production of wine more than a thousand years ago. The bubbling action was due to the conversion of sugar to carbon dioxide gas. When the reaction was defined following the studies of Gay-Lussac, fermentation came to mean the breakdown of sugar into alcohol and carbon dioxide. Pasteur later demonstrated the relationship of yeast to this reaction, and the word fermentation became associated with microorganisms, and still later with enzymes. The early research on fermentation dealt mostly with carbohydrates and reactions that liberated carbon dioxide. It was soon recognized, however, that microorganisms or enzymes acting on sugars did not always evolve gas. Further, many of the microorganisms and enzymes studied also had the ability to break down non-carbohydrate materials such as proteins and fats, which yielded carbon dioxide, other gases, and a wide range of additional materials.

Currently, the term fermentation is used in various ways which require clarification. When chemical change is discussed at the molecular level, in the context of comparative physiology and biochemistry, the term fermentation is correctly employed to describe the breakdown of carbohydrate materials under *anaerobic* conditions. **In** a somewhat broader and less precise usage, where primary interest is in describing the end products rather than the mechanisms of biochemical reactions, the term fermentation refers to breakdown of carbohydrate and carbohydrate like materials under either *anaerobic* or *aerobic* conditions. Conversion of lactose to lactic acid by *Streptococcus lactis* bacteria is favoured by anaerobic conditions and is true fermentation; conversion of ethyl alcohol to acetic acid by *Acetobacter aceti* bacteria is favoured by aerobic conditions and is more correctly termed an oxidation rather than a fermentation. But the word fermentation also is used in a still broader and less precise manner. The term *fermented foods* is used to describe a special class of food products characterized by various kinds of carbohydrate breakdown; but seldom is carbohydrate the only constituent acted upon. Most fermented foods contain a complex mixture of carbohydrates, proteins, fats, and so on, undergoing modification simultaneously, or in some sequence, under the action of variety of micro- organisms and enzymes. This creates the need for additional terms to distinguish between major types of change. Those reactions involving carbohydrates and carbohydrate like materials (true fermentations) are referred to as "fermentative". Changes in proteinaceous materials are designated *proteolytic* or *putrefactive.* Breakdowns of fatty substances are described as *lipolytic.* When complex foods are "fermented" under natural conditions, they invariably undergo different degrees of each of these types of change. Whether fermentative, proteolytic, or lipolytic end products dominate will depend on the nature of the food, the types of microorganisms present, and environmental conditions affecting their growth and metabolic patterns. In specific food fermentations, control of the types of microorganisms and environmental conditions to produce desired product characteristics is necessary.

Fermentations occur when microorganisms consume susceptible organic substrates as part of their own metabolic processes. Such interactions are fundamental to the decomposition of natural materials, and to the ultimate return of chemical elements to the soil and air without which life could not be sustained. Natural fermentations have played a vital role in human development and are probably the oldest form of food preservation. Although the growth of microorganisms in many foods is undesirable and considered spoilage, some fermentations are highly desirable. Fruit and fruit juices left to the elements acquired an alcoholic flavour; milk on standing became mildly acidic and eventually became cheese; cabbage turned to sauerkraut. These changes tasted good and so early civilizations encouraged the conditions that permitted them to occur. Sometimes the desired results were obtained repeatedly, but this was not always so. It soon was also discovered that certain alcoholic fruit juices and sour milks would keep well, and so part of the food supply was converted into these terms as a means of preservation.

Today, other methods of food preservation are superior to fermentation as means of preserving many foods. **In** technically advanced societies the major importance of fermented foods has come to be the variety they add to diets. In many less developed areas of the world, however, fermentation and natural drying are still the major food preservation methods, and, as such, are vital to survival of much of the world's population, The various preservation methods are based on the applications of heat, cold, radiation, removal of water, and other principles, all have the common objective of decreasing the numbers of living organisms in foods, or at least holding them in check against further multiplication. In contrast, fermentation, whether for preservation purposes or not, encourages the multiplication of microorganisms and their metabolic activities in foods. But only selected organisms are encouraged, and their metabolic activities and end products are highly desirable. The increasing application of biotechnology and genetic engineering techniques to food production is bringing added importance to food fermentations.

Acetic, lactic and alcoholic are the three important kinds of fermentation involved in fruit and vegetable preservation. The keeping quality of vinegar, fermented pickles and alcoholic beverages depends upon the presence of acetic acid, lactic acid and alcohol, respectively. Care should be taken to exclude air from the fermented products to avoid further unwanted or secondary fermentation. Wines, cider, vinegar, fermented pickles and other fermented beverage, etc., are prepared by these processes.

Some industrial fermentations in fruit and vegetable industries

(A) *Acetic acid* fermentation (Acetic acid bacteria)

Wine, cider, malt honey, or any alcoholic and sugary or starchy products may be converted to vinegar

(B) *Lactic acid* fermentation (Lactic acid bacteria)

Cucumbers → dill pickles, sour pickles, salt stock
Tomato → pickles
Lemon → pickles
Mango → pickles
Cauliflower → pickles
Olives → green olives, ripe olives
Cabbage → sauerkraut
Turnips → sauerruben
Lettuce → lettuce kraut
Mixed vegetables, turnips, radish, cabbage→Paw Tsay
Mixed vegetables in Chinese cabbage →Kimchi
Vegetables and milk → Tarhana
Vegetables and rice → Sajur asin
Coffee cherries → coffee beans
Vanilla beans → vanilla

Lactic acid bacteria with other microorganisms

With yeasts—Nukamiso pickles
With mould—tempeh, soy sauce

(C) Alcoholic fermentation (yeasts)

Fruit—wine, vermouth
Malt—beer, ale, porter, stout, bock, Pilsner
Wines—brandy
Grain mash—whiskey

Yeasts with lactic acid bacteria

Ginger plant—ginger beer
Beans — vermicelli

Yeasts with acetic acid bacteria

Cacao beans
Citron

Vinegar

Vinegar is perhaps the oldest known product or fermentation. The word is *derived* from French 'vinaigre' meaning sour wine *(vin* = wine, aigre= sour). Vinegar is a liquid obtained by alcoholic and acetic fermentation of suitable materials containing sugar and starch (at least 10 per cent fermentable sugar). It contains about 5 per cent acetic acid and has germicidal and antiseptic properties. In the trade, vinegar is labelled according to the material used in its manufacture, e.g., malt vinegar (from malt) and cider *vinegar* (from apple juice). The amount of acid in vinegar is expressed as 'grain strength' which is ten times the percentage of the acetic acid present in it, e.g., *vinegar having* 5 per cent acetic acid is termed as vinegar of '50 grain strength'.

Types of vinegar

Vinegars are of two types-
(A) Brewed *vinegars,* and (B) Artificial *vinegars*

(A) Brewed vinegars : Brewed *vinegars* are made from *various* fruits, starchy materials (potato) and sugar containing substances (molasses, honey) by alcoholic and subsequent acetic fermentation.

(1) Fruit vinegar: Generally apple, grape, orange, jamun, peach, pear, pineapple, apricot and banana are used. Vinegar made from apple juice is known as cider or apple cider vinegar, while that from grapes as wine or grape *vinegar.*

(2) Potato vinegar: In this case starch is extracted from potato and hydrolyzed by the enzyme diastase before fermentation.

(3) Malt vinegar: Malt *vinegar* is *derived* wholly from malted barley, with or without the addition of the cereal grain, malted or otherwise, the starch of which is saccharified by the diastase of the malt before fermentation. Distilled malt *vinegar* is prepared by distilling the malt *vinegar.* The product merely contains the volatile constituents of the vinegar from which it is de*rived.* It is colourless and is generally used in the manufacture of pickled onions.

(4) Molasses vinegar: In this case molasses is diluted to 16 per cent total soluble solids, neutralized with citric acid and then fermented.

(5) Honey vinegar: It is prepared from low grade honey.

(6) Spirit vinegar: Spirit vinegar is the product prepared by acetous fermentation of a distilled alcoholic fluid which in turn is produced by fermentation. It is usually made by alcoholic fermentation of molasses and then distilled prior to acetic fermentation. It is also called as grain vinegar. distilled vinegar, white vinegar or alcohol vinegar.

(7) Spiced vinegar: Spiced vinegars are prepared by steeping the leaves or spices in an ordinary vinegar.

(8) Artificial vinegars: Artificial vinegars are prepared by diluting synthetic acetic acid or glacial acetic acid to a legal standard of 4 per cent and are coloured with caramel. Artificial vinegars are also called as synthetic vinegar or non-brewed vinegar.

Steps involved in vinegar production

Two distinct steps are involved in its preparation.

(i) Conversion of the sugar in fruits, etc., into alcohol by yeast (alcoholic fermentation) : The most efficient yeasts for fermentation of sugary substances and fruit juices into alcohol are *Saccharomyces ellipsoideus,* S. *malei* and S. *cerevisiae.* For starchy substances. S. *cerevisiae* is the best. In order to obtain quality vinegar, it is essential to first destroy wild (naturally occurring) yeasts and other microorganisms by pasteurization, and then to inoculate pure yeast. The nutrients for the growth of yeast such as phosphates, ammonium and potassium salts and suq. .rs are naturally present in fruit juices and in honey and molasses. The most favourable temperature for the growth of yeast is 25-27°C. Fermentation becomes abnormal at 38°C and ceases altogether at 41°C and below 7.^{0}C.

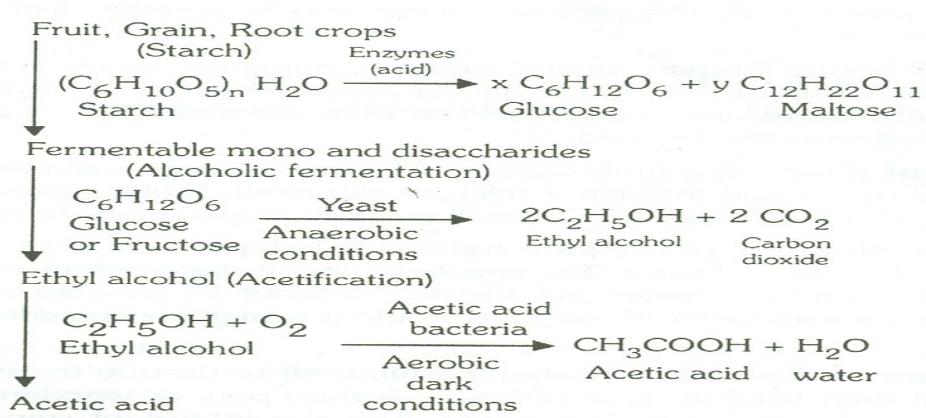
The chemical reaction involved in alcoholic fermentation is as under:

$$\underset{\substack{\text{Glucose or Fructose}\\\text{(Fermentable sugar)}}}{C_6H_{12}O_6} \xrightarrow[\text{Anaerobic condition}]{\text{Yeast}} \underset{\substack{\text{Ethyl}\\\text{alcohol}}}{2C_2H_5OH} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{2CO_2}$$

(ii) Conversion of alcohol into vinegar by acetic acid bacteria (acetification) Acetic acid fermentation is brought about by acetic acid bacteria *(Acetobacter* spp.) which are strongly aerobic but whose activity is greatly reduced by light. Acetic acid fermentation should, therefore, be carried out in the dark. The nutrients required for bacterial growth are generally present in the alcoholic liquor itself, but in the case or distilled alcohol, malt sprouts phosphoric acid, potassium carbonate, trisodium phosphate and ammonium hydroxide are added as nutrients. For acetic acid fermentation, the alcohol content of the fermented mash is adjusted to 7-8 per cent by dilution with water, because acetic acid bacteria do not grow well at higher concentration! of alcohol. After this adjustment, mother vinegar containing acetic acid bacteria is added at the rate of one part to ten parts of fermented mash in order to check the growth of undesirable microorganisms and to hasten the fermentation process. The chemical reaction involved is as under:

$$\underset{\substack{\text{Ethyl}\\\text{alcohol}}}{C_2H_5OH} + \underset{\text{Oxygen}}{O_2} \xrightarrow[\substack{\text{Aerobic}\\\text{dark}\\\text{conditions}}]{\substack{\text{Acetic acid}\\\text{bacteria}}} \underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Water}}{H_2O}$$

Outline scheme of vinegar production



Preparation of vinegar

Vinegar is prepared by the following methods:

(A) Slow process

(B) Orleans slow process

(C) Quick process (Generator or German process)

(A) Slow process

This process is generally used in India. The fruit juice or sugar solution, filled in earthen pots or wooden barrels, is kept for at least 5-6 months in a warm, damp room to undergo spontaneous alcoholic and acetic fermentations. No special care is taken, but the mouth of the container is covered with cloth to keep out insects, dirt, etc. The main defects of this method are:

(i) Incomplete alcoholic fermentation;

(ii) Slow acetic fermentation;

(iii) Low yield; and

(iv) Inferior quality of vinegar.

(B) Orleans slow process

The vinegar prepared by this process is clear and of superior quality. The steps of the process are:

1. **Selection of fruit:** Grapes, apples, oranges, mangoes, dates, jamun, or any other sweet fruit of third grade having about 10 per cent sugar in the juice are taken. Cores and peels of certain fruits discarded during canning and jam making can also be used.

2 **Extraction of juice** : The fruits or vegetables are cut into small pieces and then crushed or pressed through a thick muslin cloth. Fruits which do not yield juice readily are heated with a small quantity of water before pressing.

3. **Adjustment of sugar:** Only juice containing low percentage of sugar is suitable for the growth of yeast. The concentration of sugar is determined by means of a hand refractometer and adjusted to about 10 per cent either by diluting the juice with water (if the sugar content is high) or by adding additional sugar.

4. **Fermentation:** The juice is heated (pasteurized) to destroy the microorganisms and then filled in glass carboys, earthen pots or wooden barrels (Fig.A) to three-fourths of their capacity. The two important steps in the preparation of vinegar are:

   a. Alcoholic fermentation

   b. Vinegar fermentation.

   a. *Alcoholic fermentation:* Pure wine yeast, obtained from a winery or a chemist's shop, is well powdered and dissolved in a little warm juice and then added at the rate of 1.5 g per litre to the whole lot of juice with frequent stirring. The mouth of the carboy or barrel is loosely plugged with cotton wool to allow carbon dioxide gas to escape. The gas should be completely removed otherwise it hinders the yeast fermentation. Initially there is continuous frothing which indicates the progress of fermentation, but it ceases after 3 weeks when the fermentation is complete. All the sugar is converted into alcohol as can be seen by testing with a hand refractometer which indicates 0-1 per cent total soluble solids.

During the fermentation the temperature is maintained at 22 to 27°C as fermentation ceases above 41°C and below 7°C. The fermented juice is stored for 1 to 2 weeks for sedimentation and then strained through a cloth, or the clear supernatant is syphoned off into a clean container which is filled up to three-fourths its capacity :Fig. B). Vinegar fermentation should be taken up only after ascertaining that the alcoholic fermentation is complete, otherwise yeast will retard the fermentation. For vinegar fermentation the alcohol content of the fermented liquid is adjusted to 7-8 per cent by dilution with water, because acetic acid bacteria do not grow at a higher concentration of alcohol.

b.Vinegar (acetic) fermentation: This is brought about by acetic acid bacteria. Unpasteurized vinegar or "mother" vinegar is added to the product of alcoholic fermentation in the ratio of 1: 10, and mixed well. Thereafter the liquid should not be disturbed otherwise the firm of vinegar bacteria will break and sink to the bottom and consume the nutrients in the liquid without producing vinegar. The mouth of the container is closed with a cork having two holes for proper aeration. The temperature of this liquid is maintained at 21 to *2rC* and the fermentation is completed in 10 to 15 weeks when the acetic acid content reaches a maximum.

Then the vinegar is syphoned off or strained through a thick cloth leaving at the bottom of the container a turbid liquid, which is used as "mother" vinegar for fresh fermentation.

5. **Aging:** Vinegar prepared by the above method is turbid and does not possess a good taste. It is stored in containers for 4 to 8 months during which the vinegar develops a good aroma and flavour and becomes mellow.
6. **Clarification:** The dear aged liquid should be syphoned out and filtered.
7. **Colouring:** Caramel colour is added for colouring.
8. **Pasteurization:** The vinegar is poured into previously sterilized bottles, corked airtight and the bottles heated (pasteurized) in hot water at 71 to 77°C for 15 to 20 minutes, so that further growth of bacteria is stopped and the strength of vinegar maintained during storage.

Note: An *ideal vinegar should contain only about 0.3 per cent sugar.* A *higher percentage denotes incomplete fermentation* due, *to* excess *of* acetic acid *during yeast fermentation.*

(C) Quick process (Generator or German process)

In this process additional oxygen is supplied for the growth of bacteria and the surface of the bacterial culture is also increased resulting in rapid fermentation. The equipment, used known as "Upright Generator", is a cylinder of height 3.66 to 4.2 m and diameter 1.2 to 1.5 m which is divided into three compartments:

(i) Distributing (ii) Central, and (iii) Receiving.

(i) Distributing compartment: This is the upper compartment and is about 30 cm above the central one. It is separated from the central compartment by a partition having small perforations. In the distributing compartment then! is fitted a W-shaped tilting trough or revolving sprinkler which distributes the liquid by trickling slowly over the material filled in the central compartment.

(il) Central compartment: This is filled with pumice stone, straw, corn cobs, rattan or beech wood shavings to increase the surface area. Beech wood shavings are preferred as they remain tightly coiled even when wet with vinegar. This compartment is fitted with an adjustable opening near the bottom for admission of air.

(iii) Receiving compartment: This is the lowest compartment of the generator and is separated from the central one by a perforated partition placed about 1.5 m above the bottom of the generator. Here the vinegar is collected.

Method of Preparation: The material in the central compartment is sprinkled and wetted with unpasteurized vinegar containing acetic bacteria. Then a mixture of the alcoholic fermentation product and vinegar (2: 1) is slowly trickled through the generator to promote the growth of vinegar bacteria. Within a few days the bacterial growth is enough for efficient functioning of the generator. The alcoholic fermentation liquid is now mixed with mother vinegar in the ratio of 1: 2 to increase its acidity from 3 to 3.5 per cent and passed through the generator

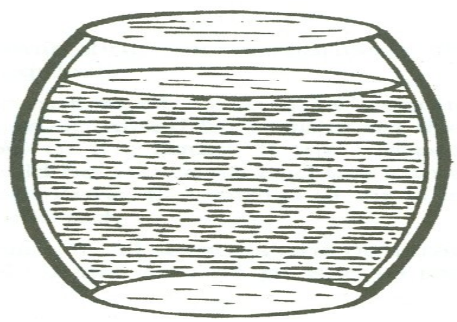


Fig. A.
Wooden Barrel placed vertically
for Alcoholic Fermentation

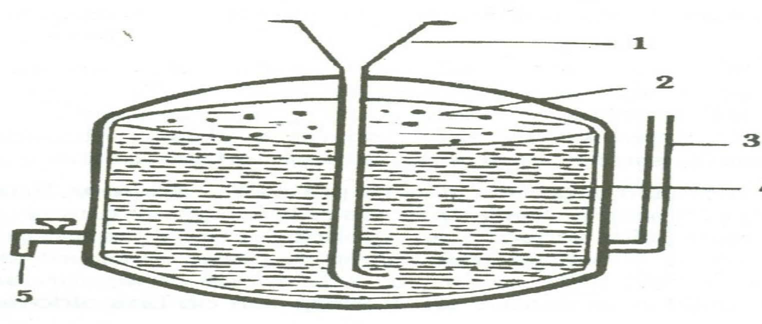


Fig. B.
By Vinegar Bacteria

1. Funnel, 2. Disc with hole,
3. Level indicator, 4. Liquid
5. Outlet

LECTURE-30 & 31

Fermented fruit beverages – Wine- types of wines-equipment required preparation-problems.

&

Sparkling clear wines-Champagne and Cider; Fortified wines-Sherry, vermouths; orange wine , Perry ,Tokay, Port.

Fermented fruit beverage

These have been known to mankind from time immemorial. But the development of biochemical principles of fermentation was originated by Lavoisier in France in 1789 by way of analyzing the chemical composition of sugar and its fermentation products such as ethanol, carbon dioxide and a trace of acetic acid. Much later in 1860, the fellow countryman Louis Pasteur carefully analyzed the fermentation products and showed that in addition to ethanol and carbon dioxide, other compounds such as glycerol and succinic acids are also produced. Fermentation process in beverage preparation is mediated through yeast and in the process it produces a range of products such as organic acids, alcohols, esters and sulphurous compounds. Grape wine is the oldest example of a fermented beverage.

(1) Wine

Wine is defined differently in the laws of different countries, e.g., in China wine is considered to be an alcoholic beverage and the Chinese word for it may be translated as *appetite* wine. In California, it is defined as the fermented juice of various fruits. But wine generally denotes the product produced by fermentation of grape juice. The most satisfactory definition seems to be "wine is a beverage resulting from the fermentation by yeasts of the grape juice with proper processing and addition."

In other words, wine strictly signifies the fermented alcoholic beverage produced from grape juice without distillation. Grapes have been historically associated with wine-making because of following advantages:

(i) Juice Is extremely rich in natural sugar.

(ii) Natural association of fermentative yeasts with berries.

(iii) High content of nitrogenous matters in promoting growth of yeast-and hence fermentation.

(iv) High acidity of juice favouring yeasts and protecting against other bacterial fermentation.

(v) High alcohol and acid content in the fermented wine keep it stable and safe for prolonged storage.

The varieties of wines are endless and they differ in so many attributes that it is difficult to classify them. According to colour, there are two types, *red* and *white.* In making *red* wines, the grapes are crushed and stemmed but the skin and seeds are left in the must. *White* wines are made from white or greenish grapes or from the juice of grapes from which the skin have been removed.

Grape wines are of two kinds, *dry* and *sweet. Dry wines* are those which contain very little or no sugar that can be detected by testing. In *sweet wines,* the sugar content is high enough to be detected by taste. The alcohol content of these two kinds of wines ranges from 7 to 20 per cent. Wines with 7 to 9 per cent alcohol are known as *"light",* those with 9 to **16** per cent "medium", and those with **16 to 21** per cent *"strong".*
Sparkling wine contains Co_2. They are made effervescent by secondary fermentation in closed containers, generally in the bottle itself. *Still wines* are those which do not contain carbon dioxide. *Fortified wines* contain added alcohol in the form of brandy. Generally wines with more than 12 per cent alcohol are fortified with fruit brandy (alcohol) prepared by distilling grape wine.

Equipments used for wine making

(i) For crushing and pressing: Roller crusher or basket press.

(ii) Primary fermentation vessel : Open-ended cylindrical vessels of suitable size made of plastic or wood.

(iii) **Secondary fermentation vessel** : Narrow mouthed containers of wood, plastic or glass.

Thermometer, hydrometer, hand refractometer. measuring cylinder. Siphon tube, filter, bottles. Crown corks and corking machine. etc., are also required.

(i) Selection of fruit: The grape berries should be ripe and fresh. White wine is produced from varieties having greenish or yellowish skin. Red wines derive their colour from red pigment present in the skin or flesh of coloured varieties. The different species and varieties of grapes suitable for wine making are given in the following table.

S.No	Botanical name	English name	Variety
1	*Vitis uinifera*	European grape	-Beauty Seedless.
2	V. *labrusca*	American grape	Concord, Catawea.
3	V. *rotundifolia*	Muscadine grape	Jems, Scupper

(ii) Crushing: It is done with the help of a basket press. Before crushing the grapes their stems and stalks are removed. Crushed material (must) is put in jars which should not be filled more than three-fourths.

(iii) Addition of sugar : Cane sugar is added to maintain at least 20 per cent total soluble.solids but not more than 24 per cent. If the grapes are sour, 70 g of sugar are added for each kg of grapes. at the rate of 1.5 g for every 10 kg of grapes, mixed and allow to stand for 2 to 4 hours. KMS inhibits growth of wild yeasts and spoilage organisms.

(vi) Addition of wine yeast: Wine yeast. e.g., *Saccharomyces ellipsoideus* inoculum is added at the rate of 20 ml for every 5 kg of grapes, about an hour after the addition of preservative. If the yeast is not available then potassium metabisulphite is not added. The yeast present in the skin of grapes can also ferment and produce wine but it is not of good quality.

(vii) Fermentation : Grapes are allowed to ferment for two days in a cool place, i.e., at 22 to 28°C. The mouth of the jar is covered with cloth during fermentation.

(viii) Filtration: The contents are filtered through a thin muslin cloth or a filter aid on the third day and the filtrate again allowed to ferment in a cool place for another ten days without any disturbance. During this period yeast cells and other solids settle at the bottom.

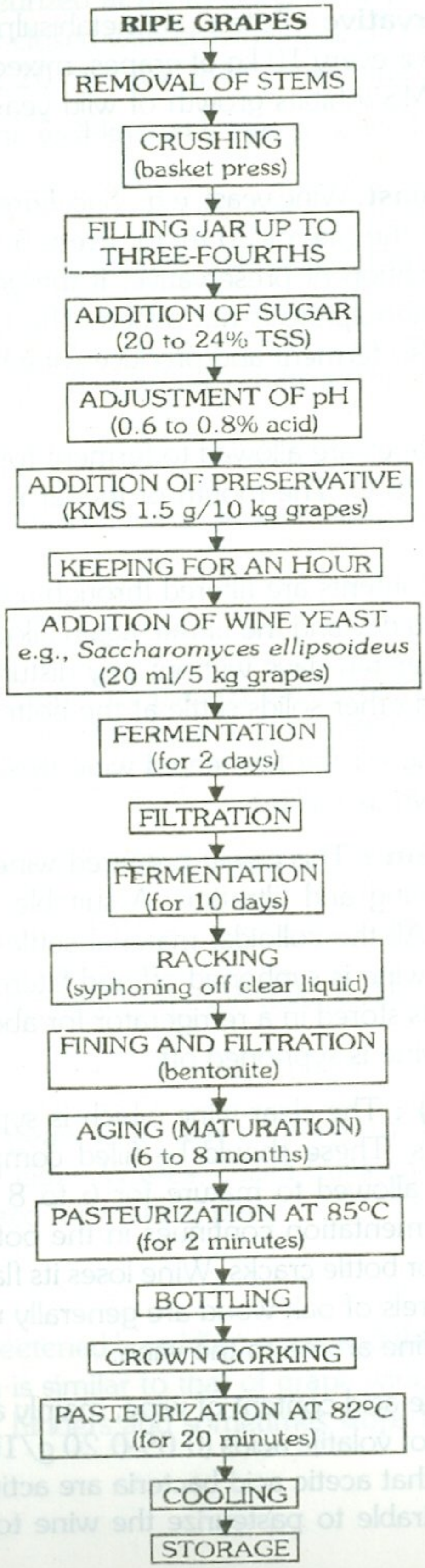
(ix) Racking: Syphoning off the fermented wine to separate it from the solid deposits is Known as racking.

(x) Fining and Filtration: The newly prepared wine is sometimes not clear and requires fining and filtration. A suitable fining agent, e.g., bentonite, is added. All the colloidal material settles down along with bentonite. The clear wine is syphoned off and filtered if necessary. Alternatively, the wine is stored in a refrigerator for about two weeks and thereafter the clear wine is syphoned off.

(xi) Aging (Maturation) : The clear wine which is syphoned off is filled into bottles or barrels. These should be filled completely and sealed airtight. The wine is allowed to mature for 6 to 8 months in a cool place. Sometimes fermentation continues in the bottle with the result that the cork flies off or bottle cracks. Wine loses its flavour during aging because of which barrels of oak wood are generally used for storing it. The wood imparts a fine aroma to the wine.

(xii) Packing: The volatile acid content of wine, mainly acetic acid, should be low. High content of volatile acids (0.09-0.20 g/100 ml in terms of acetic acid) indicates that acetic acid bacteria are active during fermentation. It is often desirable to pasteurize the wine to destroy spoilage organisms and coagulate the colloids that cause cloudiness. Generally wines are pasteurized at 82 to 88°C for 1-2 minutes and then bottled. The bottles are closed with crown corks of good quality, pasteurized at 65°C for about 20 minutes, then cooled and stored.

TECHNOLOGICAL FLOW-SHEET FOR PROCESSING OF GRAPE WINE



The following' are the well-known wines produced in various countries:

(2) Champaigne

It is a sparkling wine, made chiefly in France, from certain varieties of grapes such as Chardonay and Pinot Noir. It is made in other countries as well. The fermentation is allowed to proceed to completion in bottles which are specially made to withstand high pressure of gas produced during fermentation.

(3) Port

It is a fortified, sweet red wine made originally in Portugal, but now in other countries also.

(4) Sherry

A Spanish wine, matured by placing the barrels for 3 to 4 months in sunlight, where the temperature is as high as 54 to 60°C.

(5) Tokay

This is a very famous fortified wine made in Hungary.

(**6) Muscat**

It is prepared from Muscat grapes in Italy, California. Spain and Australia.

(7) Perry

Wine made from pears is known as *perry.* Its method of preparation is similar to that of apple cider. Wastes, culled fruits and trimmings left over from canning may also be used for making perry.

(8) Orange wine

Orange juice is sweetened by adding sugar and then allowed to ferment. The method of preparation is similar to that of grape wine. Orange oil should not be added to the juice as it hinders and sometimes stops fermentation.

(9) Berry wine

Wines prepared from berries like strawberry, blackberry are known as 'Berry wines'. These products are generally popular in other countries but are not common in India.

(10) Nira

It is prepared from the juice of the palm tree.

(11) Feni

This is a fermented wine made from cashew apple in Goa.

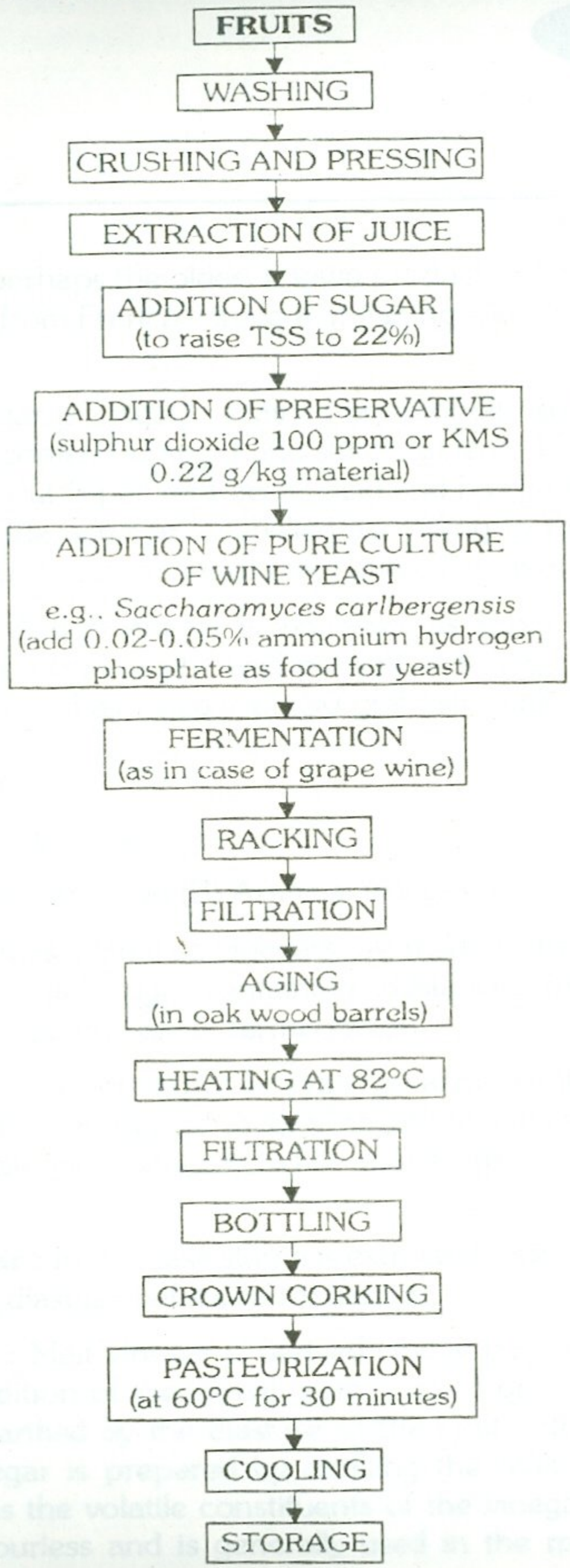
(12) Cider

It is mostly prepared by fermentation of special grade of apples which have a high tannin content of 0.1-0.3 per cent. However, a great deal of confusion exists as far as the apple cider is concerned. In the U.S.A., apple cider means non-clarified apple juice, whereas apple juice is the clarified and treated sparkling juice. On the contrary in the Europe and in India. apple cider partially fermented apple juice. In the U.K., special varieties of apples known as cider apples are used. For cider preparation apples may be graded on the basis of tannin and organic acid contents as 'bitter-sweet', 'bitter-sharp', 'sweet' and 'sharp'. Nearly 60 per cent of full-flavoured cider is prepared using bitter-sweet and bitter sharp apple. Cider apples are so chosen that their juice contain higher percentage of sugar (i.e., 12.5 per cent) than normal apple juice (10.5 per cent) with higher proportion of sugar in the form of fructose. In India, cider apples are not available in sufficient quantity, hence dessert varieties which are easily available, are used. There are two types of apple cider, dry and sweet.

Fruits such as bael, jamun, phalsa and aonla can also be used for preparation of cider. The technique of preparation which is more or less similar to that of grape wine is summarized on the next page.

To attract wider clientele for the cider consumers, most cider preparations are carbonated nowadays. This is done by refermentation of cider by repeating the process of sugar and yeast additions in a pressure tank or sometimes by chilling cider prior to subjecting carbon dioxide injection under controlled pressure. Cider thus carbonated, is protected from microbial attack by sulphitation and pasteurization.

TECHNOLOGICAL FLOW-SHEET FOR PROCESSING OF CIDER



LECTURE-32

Cashew wine/ Brandy (Feni), Neera, Toddy, Arrack and different distilled spirits –their source and alcohol percentages.

Cashew wine

Location of Production

Cashew wine is made in many countries in Asia and Latin America**.**

Product description

Cashew wine is a light yellow alcoholic drink prepared from the fruit of the cashew tree (*Ancardium occidentale*). It contains an alcohol content of between 6 and 12% alcohol.

Preparation of raw materials

In gathering the fruits and transporting them to the workshop, the prime purpose should be to have the fruit arrive in the very best condition possible. Cashew apples are sorted and only mature undamaged cashew apples should be selected. These should be washed in clean water.

Processing

The cashew apples are cut into slices to ensure a rapid rate of juice extraction when crushed in a juice press. The fruit juice is sterilised in stainless steel pans at a temperature of 85^{o}C in order to eliminate wild yeast. The juice is filtered and treated either sodium or potassium metabisulphite to destroy or inhibit the growth of any undesirable types of micro-organisms - acetic acid bacteria, wild yeasts and moulds. Wine yeast (*Saccharomyees cerevisiae - var ellipsoideus*) are added. Once the yeast is added, the contents are stirred well and allowed to ferment for about two weeks.

The wine is separated from the sediment. It is clarified by using fining agents such as gelatin, pectin or casein which are mixed with the wine. Filtration is carried out with filter-aids such as fullers earth. The filtered wine is transferred to wooden vats.The wine is then pasteurised at 50^{o} - 60^{o}C. Temperature should be controlled, so as not to heat it to about 70^{o}C, since its alcohol content would vaporise at a temperature of 75^{o}-78^{o}C. It is then stored in wooden vats and subjected to ageing. At least six months should be allowed for ageing. If necessary, wine is again clarified prior to bottling. During ageing, and subsequent maturing in bottles many reactions, including oxidation, occur with the formation of traces of esters and aldehydes., which together with the tannin and acids already present enhance the taste, aroma and preservative properties of the wine (Wimalsiri, Sinnatamby, Samaranayake and Samarsinghe, 1971).

Flow diagram

Selection ↓	Mature, sound cashew apples
Slicing ↓	To increase extraction of juice
Crushing ↓	
Sterilisation ↓	At 85° C
Filtered ↓	
Inoculation ↓	With *S. cerevisiae*
Fermentation ↓	Two weeks
Filtered ↓	
Pasteurisation ↓	50-60° C
Ageing ↓	In wooden vats for 6 months

Packaging and storage

The product is packaged in glass bottles with corks. The bottles should be kept out of direct sunlight.

Brandy

Brandy (from **brandywine**, derived from Dutch **brandewijn**—"burnt wine") is a spirit produced bydistilling wine. Brandy generally contains 35%–60% alcohol by volume and is typically taken as anafter-dinner drink. Some brandies are aged in wooden casks, while some are simply coloured with caramel colouring to imitate the effect of such aging (and some brandies are produced using a combination of both aging and colouring).Brandy is also produced from fermented fruits other than grapes, but these products are typically named eaux-de-vie.In some countries, fruit flavouring or some other flavouring may be added to a spirit that is called "brandy".

Types

There are three main types of brandy. The term "brandy" denotes *grape brandy* if the type is not otherwise specified.

1. Grape brandy

Grape brandy is produced by the distillation of fermented grapes.

- Albanian grape brandy (Raki e Rushi) is the most popular and traditional alcoholic beverage in Albania and the Albanian regions of Eastern Montenegro.
- American grape brandy is almost always from California. Popular brands include Christian Brothers and Korbel.
- Armenian brandy has been produced since the 1880s and comes from the Ararat plain in the southern part of Armenia. It was Winston Churchill's favorite brandy. Bottles on the market are aged anywhere from 3 to 20 years. During the International Exhibition in Paris in 1900, the brandy received the Grand-Prix and the legal right to be called 'cognac', not 'brandy', following a blind degustation.

2. Fruit brandy

Fruit brandies are distilled from fruits other than grapes. Apples, peaches, apricots, plums, cherries, elderberries, raspberries, and blackberries, are the most commonly used fruits. Fruit brandy usually contains 40% to 45% ABV. It is usually colourless and is customarily drunk chilled or over ice.

- Applejack is an American apple brandy, made from the distillation of hard cider. It was once made by fractional freezing, which would disqualify it as a proper brandy.
- Buchu brandy is South African and flavoured with extractsfrom *Agathosma* species.
- Calvados is an apple brandy from the French region of Lower Normandy. It is double distilled from fermented apples.

3. Pomace brandy

Pomace brandy (also called *marc* in both English and French) is produced by fermentation and distillation of the grape skins, seeds, and stems that remain after grapes have been pressed to extract their juice (which is then used to make wine). Most pomace brandies are neither aged nor coloured.

Examples of pomace brandy are:

- Albanian Raki e Rushi
- Bulgarian/Macedonian grozdova
- Cretan tsikoudia

History of distillation

The first clear evidence of distillation comes from Greek alchemists working in Alexandria in the 1st century AD. Distilled water was described in the 2nd century AD by Alexander of Aphrodisias, The Alexandrians were using a distillation alembic or still device in the 3rd century AD. The medieval Arabs learned the distillation process from the Alexandrians and used it extensively, but there is no evidence that they distilled alcohol.

Modern distillation

Except for the invention of the continuous still in the 19th century, the basic process of distillation has not changed since the 8th century. There have been many changes in the methods used to prepare organic material for the still, and the ways the distilled beverage is finished and marketed. Knowledge of the principles of sanitation and access to standardized yeast strains have improved the quality of the base ingredient; larger, more efficient stills produce more product per square foot and reduce waste; ingredients such as corn, rice, and potatoes have been used as inexpensive replacements for traditional grains and fruit. For tequila, the blue agave plant is used. Chemists have discovered the scientific principles behind aging, and have devised ways to accelerate aging without introducing harsh flavors. Modern filters have allowed distillers to remove unwanted residue and produce smoother finished products. Most of all, marketing has developed a worldwide market for distilled beverages among populations that previously did not drink spirits.

Micro_distilling is a trend that began to develop in the United States following the emergence and immense popularity of micro brewing and craft beer in the last decades of the 20th century. It is different from mega distilling in the quantity and quality of output. In some jurisdictions in the United States it is legal for unlicensed individuals to make their own beer and wine, but it is illegal to distill beverage alcohol without an appropriate license anywhere in the US. In some jurisdictions, it is also illegal to sell a still without an appropriate license. It is legal to distill beverage alcohol as a hobby for personal use in some countries including, but not limited to, Italy, Canada, and New Zealand and to a limited degree the UK. In those jurisdictions where it is illegal to distill beverage alcohol some people circumvent those laws by pretending to distill fuel but consuming the product, It is important not to confuse ethanol, which is a type of alcohol used for both beverages and fuel, with methanol, which is a different alcohol fuel that is poisonous. Methanol is also produced as a byproduct of beverage distillation, but only in small amounts which are ordinarily separated out during the beverage production process. Methanol will cause blindness or death if consumed in large amounts.

Spirits

Unsweetened, distilled, alcoholic beverages that have an alcohol content of at least 20%ABV are called *spirits*. Spirits are produced by the distillation of a fermented base product. Distilling concentrates the alcohol and eliminates some of the congeners. For the most common distilled beverages, such as whiskey and vodka, the alcohol content is around 40%.Spirits can be added to wines to create *fortified wines*, such as port and sherry.

Nomenclature of spirits

The term *spirit* refers to a distilled beverage that contains no added sugar and has at least 20%alcohol by volume (ABV). Popular spirits include brandy, fruit brandy (also known as eau-de-vie orschnapps), gin, rum, tequila, vodka, and whisky.

Distilled beverages that are bottled with added sugar and added flavorings, such as Grand Marnier,Frangelico, and American schnapps, are liqueurs. In common usage, the distinction between spirits and liqueurs is widely unknown or ignored; consequently all alcoholic beverages other than beer and wine are generally referred to as *spirits.*

Beer and wine, which are not distilled beverages, are limited to a maximum alcohol content of about 20% ABV, as most yeasts cannot reproduce when the concentration of alcohol is above this level; consequently, fermentation ceases at that point.

Arrack

Arrack, also spelled **arak**, is a distilled alcoholic drink typically produced in South Asia and Southeast Asia, made from either the fermented sap of coconut flowers, sugarcane, grain (e.g. red rice) or fruit, depending upon the country of origin. The clear distillate may be blended, aged in wooden barrels, or repeatedly distilled and filtered depending upon the taste and color objectives of the manufacturer. Arrack is not to be confused with *arak*, an anise-flavored alcoholic beverage traditionally consumed in Eastern Mediterranean and North African countries

Sri Lanka

Sri Lanka is the world's largest producer of coconut arrack.

Other than water, the entire manufacturing process revolves around the fermentation and distillation of a single ingredient, the sap of unopened flowers from a coconut palm (*Cocos nucifera*). Each morning at dawn, men known as toddy tappers move among the tops of coconut trees using connecting ropes not unlike tightropes. A single tree may contribute up to two liters per day.

Due to its concentrated sugar and yeast content, the captured liquid naturally and immediately ferments into a mildly alcoholic drink called "toddy", *tuak*, or occasionally "palm wine". Within a few hours after collection, the toddy is poured into large wooden vats, called "wash backs", made from the wood of teak or halmilla trees. The natural fermentation process is allowed to continue in the wash backs until the alcohol content reaches 5-7% and deemed ready for distillation.

Distillation is generally a two-step process involving either pot stills, continuous stills, or a combination of both. The entire distillation process is completed within 24 hours. The first step results in "low wine", a liquid with an alcohol content between 20 and 40%. The second step results in the final distillate with an alcohol content of 60 to 90%. Various blends of coconut arrack diverge in processing, yet the extracted spirit may also be sold raw, repeatedly distilled or filtered, or transferred back into halmilla vats for maturing up to 15 years, depending on flavor, color and fragrance requirements.

Premium blends of arrack add no other ingredients, while the inexpensive and common blends are mixed with neutral spirits before bottling. Most people describe the taste as resembling "…a blend between whiskey and rum", similar, but distinctively different at the same time.

Production types

According to the Alcohol and Drug Information Centre's 2008 report on alcohol in Sri Lanka, the types of arrack are:

Special arrack is produced in the highest volume, nearly doubling in production between 2002 and 2007. Molasses arrack is the least-produced kind and considered the common kind. Nevertheless, as a whole, arrack is the most popular local alcoholic beverage consumed in Sri Lanka and produced as a wide variety of brands that fit into the following three categories:

- Premium aged, after distillation, is aged in halmilla vats for up to 15 years to mature and mellow the raw spirit before blending. Premium brands include VSOA, VX, Old Reserve and Extra Special.
- Premium clear is generally not aged, but often distilled and/or filtered multiple times to soften its taste. Premium clear brands include Double Distilled and Blue Label.
- Common is blended with other alcohols produced from molasses or mixed with neutral spirits as filler.

Producers

Sri Lanka's largest manufacturers, listed in order based on their 2007 annual production of arrack, are:

- DCSL (Distilleries Company of Sri Lanka), 37.25 million litres
- IDL (International Distilleries Ltd), 3.97 million litres
- Rockland, 2.18 million litres
- Mendis, 0.86 million litres

Sri Lankan arrack was recently launched in the UK,[8] and will be imported to the US for an American launch.

Indonesia

Batavia arrack is distilled in Indonesia. It is the "rum" of Indonesia, because like rum, it is distilled from sugarcane. It is a pot still distillation, a type of still which was influenced by the Chinese, who brought the process to Indonesia. To start the fermentation, local fermented red rice is combined with local yeast to give a unique flavor and smell of the distillate. It is distilled to approx. 70% ABV. Like rum, Batavia arrack is often a blend of different original parcels. It is used as a component in liqueurs and *punsch*, and also in the confectioneryand flavor industries. It is said to enhance the flavor when used as a component in other products, as in the herbal and bitter liqueurs. Arrack is often created as a form of moonshine in Indonesia.

Some arracks reported to be methanol-tainted arrack have resulted in deaths in Indonesia.

Philippines

The Filipino term for wine (and by extension alcoholic beverages in general) is *alak*, derived from the word "arak".

Lambanóg is commonly described as coconut wine or coconut vodka. Distilled from the sap of the unopened coconut flower, it is particularly potent, having a typical alcohol content of 80 to 90 proof after a single distillation; this may go as high as 166 proof after the second distillation. As with coconut arrack, the process begins with the sap from the coconut flower. The sap is harvested into bamboo receptacles similar to rubber tapping, then cooked or fermented to produce a coconut toddy called *tubà*. The *tubà*, which by itself is also a popular beverage, is further distilled to produce lambanóg. Until recently, lambanóg was considered a local analogue to moonshine and other home-brewed alcoholic drinks due to the process's long history as a cottage industry. Though usually served pure, it is traditionally flavoured with raisins, but lambanóg has recently been marketed in several flavours such as mango, blueberry, bubblegum and cinnamon in an effort to appeal to all age groups.[13]

Finland

Cloetta Polly 'Original' and 'Milkchoco' chocolates contain "a taste of arrack". The famous Runeberg tart has spoonfuls of arrack in it.

Sweden

A popular beverage in Sweden based on arrack is *punsch*, often consumed during the winter month or drizzled on top of ice cream.

Types of Alcohols and Spirits

Early settlers in United States made whiskey from Rye. The whiskey had to be aged to take the harsh bite out during prohibition; all the distilleries were shut down. After the prohibition was lifted, there was no 'aged' whiskey and the consumers turned to Vodka and Gin. All spirits are 'aged' except for Gin and Vodka. At present, Vodka is number one spirit sold in United States.

American Whiskey

American whiskeys are distilled from fermented mash of Rye, Corn, Wheat and malted Barley to 95% alcohol level still retaining the flavor of original mash. The whiskeys are aged in Oak barrels (except Corn Whiskey), and bottled at 40%alcohol. An aged whiskey for more than 2 years is designated as "Straight".Rye whiskey must contain at least 51% Rye in the grain mash.Bourbon whiskey must contain at least 51% corn in the grain mash.Legally, Bourbon cannot be produced by any other country than Unites States.Corn Whiskey must contain at least 80% Corn in the grain mash.

Canadian Whisky

In Canada there are no standards that dictate the type of grains, or percentages thereof in the mash. Primary grain is Rye, always blended with other grains resulting in smoother taste.

Scotch whisky

Primary grain in Scotch whiskey is malt barley that is dried over peat fire giving it the Smokey flavor. Other grains are blended like corn and rye. "Single Malt" scotch comes from s single distillery. "Blended Scotch" is a blend of scotches from different distilleries as well as Neutral Grain Spirits (NGS) to achieve the brand's unique flavor. "Pure Malt" is a blended Scotch without any non-Scotch spirits. Scotch whiskey can only be made in Scotland.

Irish whiskey

Irish whiskeys are made exactly like Scotch and adhere to same definition of categorization. The only difference between Scotch and Irish whiskey is that malt barley is not dried over peat fire. Irish whiskey can only be made in Ireland.

Vodka

Vodka can be made from any types of grains and even potatoes. Distillation process consists of multiple distillation and charcoal filtering till it is reduced to Neutral Grain Spirit ("without distinctive character, aroma, taste, or color." according to US law). The NGS is diluted by water to get the needed alcohol level. Vodka is not aged. Vodka is normally associated with Russia and Poland.

Gin

Gin can be made from any types of grains just like Vodka. After original distillation, it is re-distilled with Juniper berries and other herbs such as Cardamom, Cassia, Fennel etc. The primary flavor is derived from Juniper berries. During British Raj, the herbs reminded British of herbs used in Indian Cooking. So Bombay Gin was born as a marketing ploy. Gin in not aged.Gin is an British slang name from Genever, the Dutch word for juniper.

Rum

Rum is made by distilling fermented sugar canes to 95% alcohol. In United States, most of the Rum comes from Caribbean Islands. Rum is bottled at 80 proofs. India produces the best rum in the world. India lacks the marketing and production capability to compete worldwide. In India Rum is bottled at 85.6 proof.

Tequila

Tequila is made from fermented Agave Tequilana Weber (``blue'' variety) mash and legally must be produced in Jalisco (Mexico). Tequila produced outside of Jalisco is known as "Mezcal". Tequila and Mezcal are bottled at 80 proof.