**Subject Title : BASIC FOOD PROCESSING AND PRESERVATION**

**Subject Code : 16SACND4**

**UNIT-IV**

**Sugar concentrates** **– Gel formation**

**Sugar concentrates** are products where the preservation technique was used and lowering water activity (Aw). The **sugar concentrate** products are namely, jam, jelly, and marmalade.

A sugar concentration of about 60% in finished or processed fruit products generally insures their preservation. Preservation is not only determined by the osmotic pressure of sugar solutions but also by the water activity values in the liquid phase, which can be lowered by sugar addition; and by evaporation down to 0.848 aw; this value however does not protect products from mould and osmophile yeast attack.

Maximum saccharose concentration that can be achieved in the liquid phase of the product is 67.89%; however higher total sugar quantities (up to 70-72%) found in products are explained by an increased reducing sugar solubility resulting from saccharose inversion.

Fresh or pre-cooked fruit is boiled with a solution of cane or beet sugar until sufficient water has been evaporated to give a mixture which will set to a gel on cooling and which contains 32-34% water.

The mechanism of pectin gel formation is complex and depends on factors such as the type of pectin, the pH and temperature, and the soluble solids (Brix) and calcium content of the recipe. Gel formation is also dependent on the presence in the fruit of the carbohydrate pectin, which at a pH of 3.2 - 3.4 and in the presence of a high concentration of sugar, has the property of forming a viscous semi-solid.

**Chemical preservatives - Definition & Role**

**Chemical** food **preservatives** are substances which, under certain conditions, either delay the growth of microorganisms without necessarily destroying them or prevent deterioration of quality during manufacture and distribution.

Many chemicals will kill micro-organisms or stop their growth but most of these are not permitted in foods; chemicals that are permitted as food preservatives are listed in Table 5.3.1.

Chemical food preservatives are those substances which are added in very low quantities (up to 0.2%) and which do not alter the organoleptic and physico-chemical properties of the foods at or only very little.

Preservation of food products containing chemical food preservatives is usually based on the combined or synergistic activity of several additives, intrinsic product parameters (e.g. composition, acidity, water activity) and extrinsic factors (e.g. processing temperature, storage atmosphere and temperature).

This approach minimises undesirable changes in product properties and reduces concentration of additives and extent of processing treatments.

The concept of combinations of preservatives and treatments to preserve foods is frequently called the hurdle or barrier concept. Combinations of additives and preservatives systems provide unlimited preservation alternatives for applications in food products to meet consumer demands for healthy and safe foods.

Chemical food preservatives are applied to foods as direct additives during processing, or develop by themselves during processes such as fermentation. Certain preservatives have been used either accidentally or intentionally for centuries, and include sodium chloride (common salt), sugar, acids, alcohols and components of smoke. In addition to preservation, these compounds contribute to the quality and identity of the products, and are applied through processing procedures such as salting, curing, fermentation and smoking.

5.3.1 Traditional chemical food preservatives and their use in fruit and vegetable processing technologies could be summarised as follows:

5.3.1.1. common salt: brined vegetables;

5.3.1.2. sugars (sucrose, glucose, fructose and syrups):

5.3.1.2.1 foods preserved by high sugar concentrations: jellies, preserves, syrups, juice concentrates;

5.3.1.2.2 interaction of sugar with other ingredients or processes such as drying and heating;

5.3.1.2.3 indirect food preservation by sugar in products where fermentation is important (naturally acidified pickles and sauerkraut).

5.3.2 Acidulants and other preservatives formed in or added to fruit and vegetable products are as follows:

5.3.2.1 Lactic acid. This acid is the main product of many food fermentations; it is formed by microbial degradation of sugars in products such as sauerkraut and pickles. The acid produced in such fermentations decreases the pH to levels unfavourable for growth of spoilage organisms such as putrefactive anaerobes and butyric-acid-producing bacteria. Yeasts and moulds that can grow at such pH levels can be controlled by the inclusion of other preservatives such as sorbate and benzoate.

5.3.2.2 Acetic acid. Acetic acid is a general preservative inhibiting many species of bacteria, yeasts and to a lesser extent moulds. It is also a product of the lactic-acid fermentation, and its preservative action even at identical pH levels is greater than that of lactic acid. The main applications of vinegar (acetic acid) includes products such as pickles, sauces and ketchup.

5.3.2.3 Other acidulants

* Malic and tartaric (tartric) acids is used in some countries mainly to acidify and preserve fruit sugar preserves, jams, jellies, etc.
* Citric acid is the main acid found naturally in citrus fruits; it is widely used (in carbonated beverages) and as an acidifying agent of foods because of its unique flavour properties. It has an unlimited acceptable daily intake and is highly soluble in water. It is a less effective antimicrobial agent than other acids.
* Ascorbic acid or vitamin C, its isomer isoascorbic or erythorbic acid and their salts are highly soluble in water and safe to use in foods.

5.3.3 Commonly used lipophilic acid food preservatives

5.3.3.1 Benzoic acid in the form of its sodium salt, constitutes one of the most common chemical food preservative. Sodium benzoate is a common preservative in acid or acidified foods such as fruit juices, syrups, jams and jellies, sauerkraut, pickles, preserves, fruit cocktails, etc. Yeasts are inhibited by benzoate to a greater extent than are moulds and bacteria.

5.3.3.2 Sorbic acid is generally considered non toxic and is metabolised; among other common food preservatives the WHO has set the highest acceptable daily intake (25 mg/kg body weight) for sorbic acid.

Sorbic acid and its salts are practically tasteless and odourless in foods, when used at reasonable levels (< 0.3 %) and their antimicrobial activity is generally adequate.

Sorbates are used for mould and yeast inhibition in a variety of foods including fruits and vegetables, fruit juices, pickles, sauerkraut, syrups, jellies, jams, preserves, high moisture dehydrated fruits, etc.

Potassium sorbate, a white, fluffy powder, is very soluble in water (over 50%) and when added to acid foods it is hydrolysed to the acid form. Sodium and calcium sorbates also have preservative activities but their application is limited compared to that for the potassium salt, which is employed because of its stability, general ease of preparation and water solubility.

5.3.4 Gaseous chemical food preservatives

5.3.4.1 Sulphur dioxide and sulphites. Sulphur dioxide (SO2) has been used for many centuries as a fumigant and especially as a wine preservative. It is a colourless, suffocating, pungent-smelling, non-flammable gas and is very soluble in cold water (85 g in 100 ml at 25°C).

Sulphur dioxide and its various sulphites dissolve in water, and at low pH levels yield sulphurous acid, bisulphite and sulphite ions. The various sulphite salts contain 50-68% active sulphur dioxide. A pH dependent equilibrium is formed in water and the proportion of SO2 ions increases with decreasing pH values. At pH values less than 4.0 the antimicrobial activity reaches its maximum.

Sulphur dioxide is used as a gas or in the form of its sulphite, bisulphite and metabisulphite salts which are powders. The gaseous form is produced either by burning Sulphur or by its release from the compressed liquefied form.

Metabisulphite are more stable to oxidation than bisulphites, which in turn show greater stability than sulphites.

The antimicrobial action of sulphur dioxide against yeasts, moulds and bacteria is selective, with some species being more resistant than others.

Sulphur dioxide and sulphites are used in the preservation of a variety of food products. In addition to wines these include dehydrated/dried fruits and vegetables, fruit juices, acid pickles, syrups, semi-processed fruit products, etc. In addition to its antimicrobial effects, sulphur dioxide is added to foods for its antioxidant and reducing properties, and to prevent enzymatic and non-enzymatic browning reactions.

5.3.4.2 Carbon dioxide (CO2) is a colourless, odourless, non-combustible gas, acidic in odour and flavour. In commercial practice it is sold as a liquid under pressure (58 kg per cm³) or solidified as dry ice.

Carbon dioxide is used as a solid (dry ice) in many countries as a means of low-temperature storage and transportation of food products. Beside keeping the temperature low, as it sublimes, the gaseous CO2 inhibits growth of psychrotrophic micro-organisms and prevents spoilage of the food (fruits and vegetables, etc.).

Carbon dioxide is used as a direct additive in the storage of fruits and vegetables. In the controlled/ modified environment storage of fruit and vegetables, the correct combination of O2 and CO2 delays respiration and ripening as well as retarding mould and yeast growth.

The final result is an extended storage of the products for transportation and for consumption during the off-season. The amount of CO2 (5-10%) is determined by factors such as nature of product, variety, climate and extent of storage.

4.3.4.3 Chlorine. The various forms of chlorine constitute the most widely used chemical sanitiser in the food industry. These chlorine forms include chlorine (Cl2), sodium hypochlorite (NaOCl), calcium hypochlorite (Ca(OCl)2) and chlorine dioxide gas (ClO2).

These compounds are used as water adjuncts in processes such as product washing, transport, and cooling of heat-sterilised cans; in sanitising solutions for equipment surfaces, etc.

Important applications of chlorine and its compounds include disinfection of drinking water and sanitation of food processing equipment.

5.3.5 General rules for chemical preservation

5.3.5.1 Chemical food preservatives have to be used only at a dosage level which is needed for a normal preservation and not more.

5.3.5.2 "Reconditioning" of chemical preserved food, e.g. a new addition of preservative in order to stop a microbiological deterioration already occurred is not recommended.

5.3.5.3 The use of chemical preservatives MUST be strictly limited to those substances which are recognised as being without harmful effects on human beings' health and are accepted by national and international standards and legislation.

5.3.6 Factors which determine/ influence the action of chemical food preservatives

5.3.6.1 Factors related to the chemical preservatives:

1. chemical composition;
2. concentration.

5.3.6.2 Factors related to micro-organisms:

a) micro-organism species; as a general rule it is possible to take the following facts as a basis:

* sulphur dioxide and its derivatives can be considered as an "universal" preservative; they have an antiseptic action on bacteria as well as on yeasts and moulds;
* benzoic acid and its derivatives have a preservative action which is stronger against bacteria than on yeasts and moulds;
* sorbic acid acts on moulds and certain yeast species; in higher dosage levels it acts also on bacteria, except lactic and acetic ones;
* formic acid is more active against yeasts and moulds and less on bacteria.

b) the initial number of micro-organisms in the treated product determines the efficiency of the chemical preservative.

The efficiency is less if the product has been contaminated because of preliminary careless hygienic treatment or an incipient alteration. Therefore, with a low initial number of micro-organisms in the product, the preservative dosage level could be reduced.

5.3.6.3 Specific factors related to the product to be preserved:

1. product chemical composition;
2. influence of the pH value of the product: the efficiency of the majority of chemical preservatives is higher at lower pH values, i.e. when the medium is more acidic.
3. physical presentation and size which the product is sliced to: the chemical preservative's dispersion in food has an impact on its absorption and diffusion through cell membranes on micro-organisms and this determines the preservation effect.

Therefore, the smaller the slicing of the product, the higher the preservative action. Preservative dispersion is slowed down by viscous foods (concentrated fruit juices, etc.)

5.3.6.4 Miscellaneous factors

1. Temperature: chemical preservative dosage level will be established as a function of product temperature and characteristics of the micro-flora;
2. Time: at preservative dosage levels in employed in industrial practice, the time period needed in order to obtain a "chemical sterilisation" is a few weeks for benzoic acid and shorter for sulphurous acid.

Usual accepted chemical food preservatives are detailed in Table 5.3.1.

TABLE 5.3.1 Chemical Food Preservatives

|  |  |  |
| --- | --- | --- |
| Agent | Acceptable Daily intake (mg/Kg body weight) | Commonly used levels (%) |
| Lactic acid | No limit | No limit |
| Citric acid | No limit | No limit |
| Acetic acid | No limit | No limit |
| Sodium Diacetate | 15 | 0.3-0.5 |
| Sodium benzoate | 5 | 0.03-0.2 |
| Sodium propionate | 10 | 0.1-0.3 |
| Potassium sorbate | 25 | 0.05-0.2 |
| Methyl paraben | 10 | 0.05-0.1 |
| Sodium nitrite | 0.2 | 0.01-0.02 |
| Sulphur dioxide | 0.7 | 0.005-0.2 |

Source: FDA, 1991

For the purpose of this document, some food products in common usage are summarised as follows:

Citric acid: fruit juices; jams; other sugar preserves;

Acetic acid: vegetable pickles; other vegetable products;

Sodium benzoate: vegetable pickles; preserves; jams; jellies; semi-processed products;

Sodium propionate: fruits; vegetables;

Potassium sorbate: fruits; vegetables; pickled products; jams, jellies;

Methyl paraben: fruit products; pickles; preserves;

Sulphur dioxide: fruit juices; dried / dehydrated fruits and vegetables; semi-processed products.

**Permitted preservatives-FPO Specification**

The FPO passed in 1946, under the defence of Indian rules, was revised under the essential commodities act, 1955. The FPO standards are mainly concerned with the standards required for maintaining the quality of fruits & vegetables & products manufactured from them. The FPO also specifies the conditions of hygiene & sanitation required to be maintained by the manufacturer of F & V products. The specification for the labelling & packaging of these products has been laid down. Under the FPO it is necessary for manufacturers to get a licence is only issued if the conditions of manufacture & the quality of the products conform to the standards laid down by the order.

Food may be contaminated or adulterated and may injurious to health due to various reasons. It is essential to set the minimum limits of the desirable characteristics required and the maximum limits of the undesirable components.

 Food Laws are for the following reasons:

* To maintain the quality of the food produced in the country.
* To prevent exploitation of the consumers by the sellers.
* To safeguard the health of the consumers.
* To establish criteria for quality of the food products

**Most common standards are :**

**Legal Standards**: These are established by federal, central, state or municipal agencies and are generally mandatory. These are set up by the law or through regulation. They generally concerned with freedom from adulteration.

**Company or Voluntary Standards**: These are established by various segments of the food industry. These standards generally represent consumer image and become symbol of product quality. These are used by private firms or supermarkets.

**Industry Standards**: These standards are established by an organizational group to maintain the quality of the given commodity. These standards become effective by pressure where other legal standards are not involved.

**Consumer or Grade Standards**: These standards represent consumer's requirements of the product and generally based on the experience of the industry for consumers.

**FRUIT PRODUCTS ORDER (FPO) 1955**

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Constituted under Essential Commodities Act it is mandatory for all manufacturers of Fruit and Vegetable Products to obtain a licence under FPO. The act is implemented by the Food Safety and Standards Authority of India through Directorate of Fruit & Veg. Processing at its Regional Offices.

The Fruit Product Order (FPO) lays down statutory minimum standards in respect of the quality of various fruits and vegetable products and processing facilities at manufacture, storage and sale. The Agricultural marketing Advisor is authorized by law to issue a license for manufacturing fruits and vegetable products, after due inspection of the factory for hygiene, sanitation and quality of formulation.   Periodic inspection by Government inspectors in  establishments is carried out to ensure conformity of standards by processors.   Licenser is empowered to put the FPO specification mark on the product. The products covered in FPO include, fruit juice, pulp concentrate, squashes, cordials, crush, fruit syrups, nectar, aerated water containing fruit juice or pulp and ready to serve beverages etc., Depending on their quality the products are grade in four categories as ordinary, fair, good and special. The FPO specifications cover list of constituents, a method of presentation permissible colors in the preparation and also minimum quality requirement of the product. An expert committee known as the Central Food Product Advisory Committee deals with all matters relating to the FPO.

FPO  also lays down specific requirements in regard to the following:

* Containers and labeling requirement
* Limits of poisonous metals in fruit products
* List of permissible harmless food colors
* Limits for permitted preservatives in fruit products
* Other permitted additives

**Limits for permitted preservatives in fruit juice and beverages as per Fruit Products Order.**

|  |  |  |
| --- | --- | --- |
| **Fruit juice/beverages** | **Preservative** | **Part per million (ppm)** |
| 1.Fruit pulp or juice for conversions into jams and other products  a. Cherries  b. Strawberries & Raspberries  c. Other fruits  2. Fruit juice concentrate  3. Squashes, crushes, fruit syrup, sharbats, cordials,   fruit juice and barley water.  4. Sweetened ready to serve Beverages | SO2  SO2  SO2  SO2  SO2  Or  Benzoic acid  SO2  or  Benzoic acid | 3,000  2,000  1,000  1,500  350  600  70  120 |

**Fruit product is well defined under the Fruit Products Order Act ,1955 it includes the followings:**

1. Synthetic beverages, Syrups and sharbat
2. Vinegar whether brewed or Synthetic
3. Pickles
4. Dehydrated fruits and vegetables
5. Squashes, crushes, cordials, barley water, barrelled juice and all other beverages containing fruit juice or fruit pulp, fruit nectar
6. Jam, jellies and marmalades
7. Tomato products, ketchup and sauces
8. Preserved, candied and crystallized fruits and peels
9. Chutneys
10. Canned and bottled fruits, juices, pulps and vegetables
11. Frozen Fruit and vegetables
12. Sweetened aerated water with or without fruit juices and pulp
13. Fruit cereal Flakes
14. Any other item of Fruit and vegetables not specified

**Types of fermentation- Common fermented foods, Wine making**

**Definition:** Fermentation is an enzyme catalysed metabolic process whereby organisms convert starch or sugar to alcohol or an acid anaerobically releasing energy. The science of fermentation is called “zymology”.

Types of Fermentation

* **Homo fermentation:** When only one type of product is formed
* **Hetero fermentation:** When more than one products are formed

**Lactic Acid Fermentation**

* Lactic acid is formed from pyruvate produced in glycolysis. Lactobacillus bacteria prepare curd from milk by this type of fermentation.

**Alcohol Fermentation**

* This is used in the industrial production of wine, beer, biofuel, etc. Yeast and some bacteria carry out this type of fermentation. Enzyme pyruvic acid decarboxylase and alcohol dehydrogenase catalyse these reactions.

**Acetic acid Fermentation**

* Vinegar is produced by this process. This is a two-step process.
* The first step is the formation of ethyl alcohol from sugar anaerobically using yeast.
* In the second step, ethyl alcohol is further oxidised to form acetic acid using acetobacter bacteria. Microbial oxidation of alcohol to acid is an aerobic process.

**Butyric acid Fermentation**

* This type of fermentation is characteristic of obligate anaerobic bacteria of genus clostridium. This occurs in retting of jute fibre, **rancid butter**, tobacco processing and tanning of leather. Butyric acid is produced in the human colon as a product of dietary fibre fermentation. It is an important source of energy for colorectal epithelium. This type of fermentation leads to a relatively higher yield of energy.

**Some common fermented products**

* Wine
* Beer
* Biofuels
* Yogurt
* Pickles
* Bread
* Tofu
* cultured milk and yoghurt.
* Cider
* tempeh.
* miso.
* **kimchi**.
* **sauerkraut**.
* Sour foods containing lactic acid
* Certain antibiotics and vitamins

Fermentation can make food nutritious, digestible and flavoured. There are many benefits of consuming fermented food.

* It improves digestion and helps to maintain intestinal bacteria
* It has an anti-cancer effect.
* Improves immune system
* Reduces lactose intolerance

Other than the food industry there are many other areas where the fermentation process is used. Methane is produced by fermentation in the sewage treatment plants and freshwater sediments.

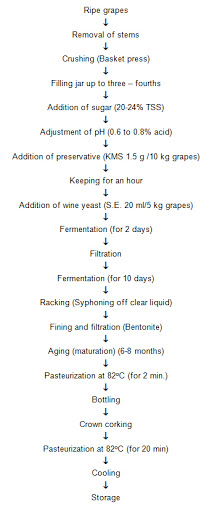
## What Are the Different Stages of the Fermentation Process?

* **Primary fermentation**. In this brief phase, microbes begin rapidly working on raw ingredients such as fruit, vegetables, or dairy. The microbes present or in the surrounding liquid (such as brine for fermented vegetables) prevent putrefying bacteria from colonizing the food instead. Yeasts or other microbes convert carbohydrates (sugars) into other substances such as alcohols and acids.
* **Secondary fermentation**. In this longer stage of fermentation, which lasts several days or even weeks, alcohol levels rise and yeasts and microbes die off and their available food source (the carbohydrates) becomes scarcer. Winemakers and brewers use secondary fermentation to create their alcoholic beverages. The pH of the ferment can differ significantly from when it started out, which affects the chemical reactions taking place between the microbes and their environment. Once alcohol is between 12–15% and it kills the yeast, preventing further fermentation, distillation is needed to remove water, condensing alcohol content to create a higher percentage of alcohol (proof).

## What Are the Advantages of Fermentation?

Fermented foods are rich in probiotics, beneficial microorganisms that help maintain a healthy gut so it can extract nutrients from food.

* Probiotics aid the immune system because the gut produces antibiotic, anti-tumor, anti-viral, and antifungal substances, and pathogens don’t do well in the acidic environment fermented foods create.
* Fermentation also helps neutralize anti-nutrients like phytic acid, which occurs in grains, nuts, seeds, and legumes and can cause mineral deficiencies. Phytates also make starches, proteins, and fats less digestible, so neutralizing them is extremely beneficial.
* Fermentation can increase the vitamins and minerals in food and make them more available for absorption. Fermentation increases B and C vitamins and enhances folic acid, riboflavin, niacin, thiamin, and biotin. The probiotics, enzymes, and lactic acid in fermented foods facilitate the absorption of these vitamins and minerals into the body.

WINE MAKING PROCESS