Food Processing and Preservation

Class : II MSc

Processing of Cereals and Pulses

The Rice Kernel Composition

Most rice varieties are composed of roughly 20% rice hull or husk, 11% bran layers, and 69% starchy endosperm, also referred to as the total milled rice.

In an ideal milling process this will result in the following fractions: 20% husk, 8−12% bran depending on the milling degree and 68−72% milled rice or white rice depending on the variety. Total milled rice contains whole grains or head rice, and brokens. The by-products in **rice milling** are rice hull, rice germ and bran layers, and fine brokens.

The modern rice milling process

1.**Pre-cleaning**:Paddy cleaner is the most essential equipment in a rice mill, as it separates all the impurities like dust, straw, sand, clay and heavy particles of even an uneven sizes from paddy. The advantages with the paddy cleaner are that increases the life of rubber rollers and the percentage of oil in bran.

2.De-stoning: Separating small stones from paddy.

3.**Husking:**This dehusker machine is used for dehusking of paddy and removing of husk. The machine is based on centrifugal principle.

4.Husk aspiration:separating the husk from the brown rice/unhusked paddy

5.Paddy separation:separating the unhusked paddy from the brown rice

6.De-stoning:separating small stones from the brown rice

7.Whitening**:**Removing all or part of the bran layer and germ from brown rice . The whitener is used for whitening (i.e. removal of bran) of brown rice to white rice. Through a smooth flow of rice and the efficient aspiration system inside the machine, the rice is whitened very gently.

8.**Polishing:**improving the appearance of milled rice by removing remaining ran particles and by polishing the exterior of the milled kernel Improving the appearance of milled rice by removing the remaining bran particles and by polishing the exterior of the milled kernel.

9.Length Grading : Separating small and large brokers from head rice.

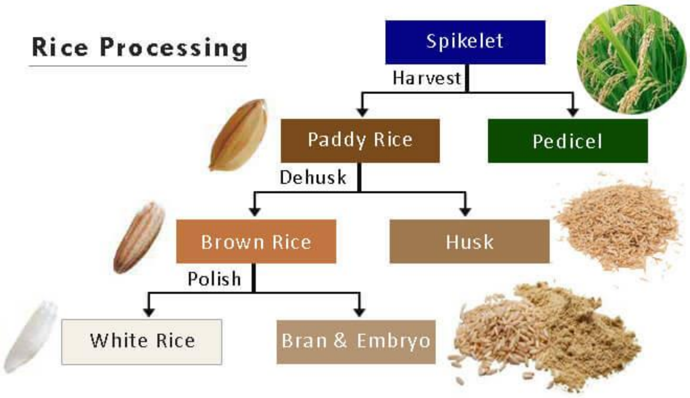
10.Blending: Mixing head rice with predetermined amount of brokers, as required by the customer.

11.Sifting:separating small impurities or chips from the milled rice

12.Length grading:separating small and large brokens from the head rice

13.**Blending:**mix head rice with predetermined amount of brokens, as required by the customer

14.Weighing and bagging：preparing milled rice for transport to the customer



Flow diagram of a modern rice mill

1-paddy is dumped in the intake pit feeding the pre-cleaner

A-straw, chaff and empty grains are removed

2-pre-cleaned paddy moves to the rubber roll husker:

B-husk removed by the aspirator

3-mixture of brown rice and unhusked paddy moves to the separator

4-unhusked paddy is separated and returned to the rubber roll husker

5-brown rice moves to the destoner

C-small stones, mudd balls etc. removed by de-stoner

6-de-stoned, brown rice moves to the 1st stage (abrasive) whitener

7-partially milled rice moves to the 2nd stage (friction) whitener

D-Coarse (from 1st whitener) and fine (from 2nd whitener) bran removed from the rice grainduring the whitening process

8-milled rice moves to the sifter

E-Small brokens/brewer's rice removed by the sifter

9a-(for simple rice mill) ungraded, milled rice moves to bagging station

9b-(for more sophisticated mill) milled rice moves to the polisher1

10-Polished rice, will move to length grader

11-Head rice moves to head rice bin

12-Brokens moves to brokens bin

13-Pre-selected amount of head rice and brokens move to blending station

14-Custom-made blend of head rice and brokens moves to bagging station

15-Bagged Rice moves to the market

Nutritional Values of Rice

The rice grain consists of rice husks, cortex, embryo and endosperm, the weight percentage of which is 18~21% of husk, about 6% of cortex, 66~70% of endosperm and 2~3% of embryo respectively. And the chemical composition of each part is different, rive husks contains about 40% of fiber which possess little nutritional value; the cortex rice in fat and protein as well as riches in the fiber; the embryo contains a lot of protein, fat and vitamins; the endosperm is with the least fiber content and carbohydrates compare these three elements.

2. Development of Rice Processing Technology

The aim of rice processing is to separate the endosperm from other parts with the smallest degree of fragmentation, thereby producing high quality of rice. The main rice processing steps can be divided into paddy cleaning, paddy husking and rice milling.

Paddy hulling process---The process of paddy husking is to remove rough rice shell to make it for brown rice.The husk is removed by friction as the paddy grains pass between two abrasive surfaces that move at different speeds. Machine that used for husking paddy is called Paddy Huller Machine, the most commonly used rice huller is rubber roller hulling machine. The main components of the roller hulling machine are a pair of parallel rubber rollers that rotated in opposite directions with the different. Peripheral. The shell of grains will be removed under the press and twist force of the two roller. Rice is not completely hulled after the first hulling, and about 20% of the paddy is not hulled, so the materials after the hulling (brown rice, paddy and rice gluten, etc.) should be separated from brown rice by using paddy separating equipment, and then, re-hull the rice back into the hulling machine to achieve the effect of efficient hulling purpose.

Paddy De-cleaning Process-- There are some impurities such as, sand, clay, coal, nails, rice straw and weed seeds and so on in rice. Efficient cleaning of these impurities in rice can not only provide high-quality cleaning rice for people but also improve the quality and market value of rice

Cleaning rice according to its volume--to choose the suitable screening sieve according to the different width and thickness of rice and impurities, which can effectively clean the impurities in rice.

Cleaning rice according to its length--to choose the screening sieve according to length of the rice and impurities. This kind of screen is engraved with hemispherical sieve hole with curved or round face,when the screening screen begins to rotate, the short grain will be embedded into the curved sieve hole and be throw out when reached a certain height; while the long grain can not be embedded in the curved sieve hole, and flow out from another side of machine.

Winnowing Cleaning: to use the screening sieve according to different gravity and suspended velocity of rice and impurities.So, impurities with the light quality (such as chaff, rice straw, etc,) will be separated from rice under the wind force in the rising or horizontal airflow.

Gravity Cleaning--to choose cleaning equipment according to the different proportions of rice and gravel. Grains and stones are separated into two layers in the oblique vibration of the screen surface under the force of airflow and linear reciprocating vibration of sieve,grains are graded automatically after they enter into the upper sieve, stones are stay on the sieve's surface due its gravity and being discharged from outlet, the rice will floating in the upper layer.

Rice Milling Process--After the process of hulling, the surface of the cortex contains more fiber that affects the quality and taste of rice. Milling of brown rice means to crush the cortex. The working principle of Rice Milling Machine is to crush the cortex by the rice mill friction and grind.The main parts of rice mill is whitening chamber with rotating roller and local pressurization device (rice knife, pressure screen section), the external rice screen which used to exclude from the rice on the milled rice bran.

In order to reduce the pressure of rice grain in the milling process, to reduce broken rice and make the brown rice to high-precision rice generally required by two to four rice milling process for gradually crushing the cortex. Grinding out of the finished rice to be finished, including the use of rice separating machine to separate the complete rice and broken rice.

What are the steps of wheat milling process?

The wheat milling process involves separating the wheat grain into its constituents that is the germ, bran, and endosperm. It follows the steps below. However, wheat milling is more complex than is conveyed by this simplified view. Preparing the wheat;The wheat is weighed, inspected then graded. The grain is separated by size, shape and weight.

Cleaning;Here, the wheat is cleaned to remove impurities such as sticks and stones and other course and fine materials. The whole pure wheat is then passed for further processing into the conditioning bins.

Tempering and conditioning;At this stage in the wheat milling process, soaking of the wheat in water takes place for easy removal of the bran. Conditioning is done before milling to ensure moisture content is uniform throughout the grain. Moisture helps to prevent the bran (outer layer) from breakage during milling.

Gristing; Gristing refer to the blending of conditioned and cleaned wheat. At this stage different wheat batches are mixed to create the required specific kind and quality of flour.

Separating;The grist goes through a series of rolls rotated at various speed levels. The rolls only split the wheat grain open to separate the inner white portion form the bran.

Milling;The wheat is ground by a machine that crush it into pieces. It is then put through sifters from which the meal obtained starts out course. With repeated grinding and sifting, the meal becomes fine flour, wheat germ and wheat bran. These can be sold separately, used to produce different flours or used together to produce whole meal flour.

Blending;Here, constituents are mixed together to produce different flours. For instance, a blend of wheat bran and white flour produce whole wheat flour.

Different types of flour

White flour is produced from early rolls. The flour gets less white on later rolls with the increased amount of bran particles.

Brown flour is produced as a mixture of the other streams and white flour.

Whole meal flour is produced when all the other streams are mixed back in their original quantities. The left over wheat feed and brans are sometimes used in animal feed and breakfast cereals.

Carbohydrates

Unrefined wheat contains an excellent source of complex carbohydrates (starch), and 25 percent of the total carbohydrates is dietary fiber. This source of carbohydrates is ideal for diabetics because it takes longer to digest and absorb sugar into the bloodstream.

Composition of Nutrition

Proteins

Gluten is the wheat protein, which constitutes about 20 to 25 percent of the caloric content. It is made up of proteins gliadin and glutenin, which are incomplete proteins. Therefore, you must eat other types of foods (rice, beans, lean meats) to complement in order to get all eight essential amino acids.

Fats

One hundred grams of unrefined wheat contains only 15 to 20 grams of unsaturated fat, which helps promote healthy cholesterol. Wheat products make an excellent substitution for higher-fat snacks and foods.

B-Vitamins

Wheat is rich in B-vitamins, such as thiamine, niacin, pantothenic acid, riboflavin and folate.B-Vitamins

Wheat is rich in B-vitamins, such as thiamine, niacin, pantothenic acid, riboflavin and folate. All of these vitamins are needed for cellular respiration, disease prevention (beriberi and pellagra) and proper neural function.

Minerals

Wheat is also an excellent source of iron, magnesium, zinc and phosphate, but the bioavailability to absorb these minerals (particularly iron) is less than what's found in animal sources because they are bound to the plant by protein bonds.

Pulses are highly consumed across the world for their wider health benefits. Pulses are also called as Dal, and it is consumed in the form of dehusked splits. The outer layer of the Pulses or grain is called as husk, and it is mainly attached with starch and protein bearing the cotyledons. Milling of the Pulses is the process in which the cereal grains will be grounded into the flour. In most of the traditional methods, it is followed by grinding the grain between stones or quern stone and hand stone.

In the modern-day, the dry milling of pulses is quite important for various reasons:

Improved Quality:

With the dry milling of pulses, it is an easier option for removing the presence of a layer of gums in between the husk as well as cotyledons. So, it would automatically increase the growth rate and enhance the quality to the maximum. With the advancement in technology, pulses and grains are milled much easier, and it is categorized in the easy-to-mill pulses. Outer husk layers are mainly separated from cotyledons and split into two halves so that they can be consumed.

Removal Of Dirt:

The de-husking process will be carried on for improving product appearance, palatability, product quality, and digestibility. With the substantial amount of the avoidable loss have been taking place in various stages of milling. However, all the dirt will be automatically removed.

Fast Production:

Pulse milling is considered as the 3rd largest processing industry compared to the flour and rice milling. Dry milling of pulses is a faster process giving more benefits in the production rate. It is estimated that about 75% of pulses have been produced has been processed for the dal in the mills. Most of the people mainly prefer to have dry pulses instead of the wet pulses. Top Grain Milling Solutions offers the dry milling of pulses with advanced techniques without losing the quality.

Tremendous Time Saving:

Dryers are used for ye process for easily drying the Grains, and it does not consume much more energy compared to the other process.

Wet treatment

In this method of treatment, soaking and drying are considered as effective technique to loosen the husk. This method has the advantage of facilitating dehusking and splitting the cotyledons, giving less breakage. This can be attributed to lower deshusking percentage of grains in water treatment process. However, it has the disadvantage of being weather dependent and labour intensive. Dal produced by this method cooks better but takes longer time to cook. Commonly adopted red earth treatment is considered as wet method. In this method, grains are thoroughly mixed with a paste of red earth after soaking in water for about 12 hours and heaping for about 16 hours. The grains are spread in thin layer in drying yards for 2–4 days. When dried, the red earth is removed by sieving and the grains are then milled on power operated stone or emery coated vertical chakki to yield dal.

Dry treatment

Dry milling treatment is reported to produce dal that cooks faster, however, losses due to broken and powdering are high. In dry method, oil/water application followed by drying are important steps in processing of pulses.

Nuts and Oil seed

ntroduction

India is fourth oilseed producing country in the next only to USA, China and Brazil. Many varieties of oilseeds, the major oilseeds are soybean, cottonseed, groundnut, Sunflower, Rapeseed, Sesame seed, Copra, Castor seed and Palm Kernels. India occupies the place of pride as the world's largest producer of Groundnuts, Sesame seeds, Linseeds and Castor seeds. Ending on the period of cultivation, the oilseeds are classified as "Kharif crop" and "Rabi crop".

The oils and fats are composed of mixtures of glycerides of various fatty acids. The fats and oils are broadly classified in to edible and non edible. Groundnut, soybean, mustard are some of the sources of the edible oil. The edible oil is main source of fat taken in daily meals and is used for cooking purposes and salad dressings. Oils are also used in the soap industry, paint, varnishes and plasticizers industry. The mechanical expression and solvent extraction methods are employed for the manufacture of oil from the oil seeds.

7.1 Raw material preparation

Oilseed and nut should be properly dried before storage, and cleaned to remove sand, dust, leaves and other contaminants. All raw materials should be sorted to remove stones and moudly nuts. Some moulds, especially in the case of groundnuts, can cause aflatoxin poisoning. When storage is necessary, this should be in weather proof, ventilated rooms which are protected against birds, insects and rodents. Some raw materials (for example groundnuts, sunflower seeds) need dehusking (or decorticating). Decortication is important to give high yields of oil and reduce the bulk of material to processed. However, expellers normally require a proportion of fibrous material in order to work and, particularly with groundnuts; some husk is normally added to allow oil to escape more freely from the press. Coconut is dehusked and split manually by skilled operators. Most oilseeds (copra, palm kernels and groundnuts) need grinding in mills before oil extraction to increase the yields of oil. All oil-bearing materials need to have correct moisture content to maximize the oil yields.

7.2 Oil Extraction methods

a) Mechanical expression

During the process of mechanical expression, the oil seeds are compressed in various types of compression devices/equipment. Expression is the process of mechanically pressing liquid out of liquid containing solids. Screw press, roll presses, collapsible plate are some examples of wide range of equipment used for expression of liquid.

i) Hydraulic press: The hydraulic press is considered of a series of horizontal corrugated iron plates. These plates are separated by 4 – 14 premoulded oil seed cakes. Pressing is completed in two stages. In first stage, the oil seeds are pressed at about 5 MPa for 15-20 min and then pressure of 28 MPa is applied for 5-10 min to complete the expression process. The recovery of the oil varied depending upon the sizes and seed being pressed. But, the at commercial level, the hydraulic press is replaced by screw type presses.

ii) Screw press: A screw press has a horizontal main shaft. The screw assembly is formed integrally with this shaft. The screw rotates within a cage or barrel. The barrel is made of case hardened, tool steel bars or rings to allow drainage of the oil as the pressure on the feed material is increased. At the discharge end, a movable choke or cone controls the operating pressure. It is achieved by changing the width of annular space through which the oil cake passes. The choke is adjusted by a hand wheel on the opposite end of the screw. The configuration of screw is such that the volume displacement at the feed end of the press is considerably greater than at the discharge end. As a result of such configuration, as the material is conveyed from feed end to discharge end, it is subjected to increasing pressure. As pressure increases, the material is compressed and oil is expelled through the spacers between the cage lining bars.

iii) Ram press: A long pivoted lever moves a piston backwards and forewords inside a cylindrical cage constructed from a metal bars spaced to allow the passage of oil. At one end of the piston's stroke, it opens an entry port from the seed hopper so that seed enters the press cage. When the piston is moved forward, the entry post is closed and the oilseed is compressed in the cage. As a result, oil is expelled from the oilseed the emerges through the gaps in the cage. Compressed seed is pushed out through the gaps in the cage. Compressed seed is pushed out through circular gap at the end of the cage.

b) Oil Extraction

Extraction is a process of separating a liquid from a solid system with the use of a solvent. Extraction is also a process of diffusion with the help of low boiling point solvent. This process gives a higher recovery of oil and a drier cake than expression. Solvent extraction is capable of removing nearly all of the available oil from oilseed meal. This extraction process provides meal of better preservation qualities and with higher protein qualities.

In this process, the solvent is poured to the well prepared material. It is then followed by the diffusion of oil solvent mixture to the surface of solid for recovery of oil. The most common solvent used in India is *n-hexane* having boiling point of 65.5 ºC. The oil is separated from mixture of oil and hexane called miscella by distillation and stripping under vacuum. The extracted meal having hexane is de-solventized by heating with live steam in a de-solventizer. This meal is known as deoiled cake and it contains about less than 1 % residual oil. The solvent from the distillation and stripping columns as well as from the de-solventizer is condensed and recovered and stored in the solvent storage tank. The separated from the miscella goes to the storage tank after cooling.

Solvent extraction plant use hexane as a solvent to extract oil from oilseed cake. These plants are expensive and only suitable for large volumes which justify the capital cost of equipment. Where large amounts of oilseed cake are available, solvent extraction becomes a commercially- viable option to extract residual oil left in the cake and leave an almost oil-free powder known as oilseed meal. Both cake and meal are incorporated in animal feeds.

7.3 Process of Oil Refining

In many local markets further refining is not required as the complexes of unrefined oils are preferred. International markets tend to prefer lighter less intense oils for cooking which means further processing of the oil.

There is serious of refining processes that can be carried out after the oil has been filtered.

i) De-odorising

Volatile compounds that produce bad odours can eliminated through the process of sparging, i.e. bubbling steam through the oil, under a vacuum.

ii) Wintering

Allowing the oil to stand for a time at low temperatures so that glycerides, which naturally occur in the oil, with higher melting points solidify and can then be removed from the oil by filtering. Over time glycerides can degrade releasing fatty acids into the oil increasing the acidity levels and reducing the quality.

iii) Neutralisation

Fatty acids can be neutralized by adding a sodium hydroxide solution, also known as caustic soda, or by stripping, which is a similar process to de-odorising.

iv) Bleaching

Some oils have a very dark colour to them that is unpopular with consumers. The appearance of the oil can be lightened by bleaching.

v) De-gumming

De-gumming is a way of treating seed that have high phosphatide content. The phosphetide, which makes a gummy residue, is removed by mixing the oil with 2 to 3% water. This hydrated phosphatide can then be removed by settling, filtering or centrifuged.

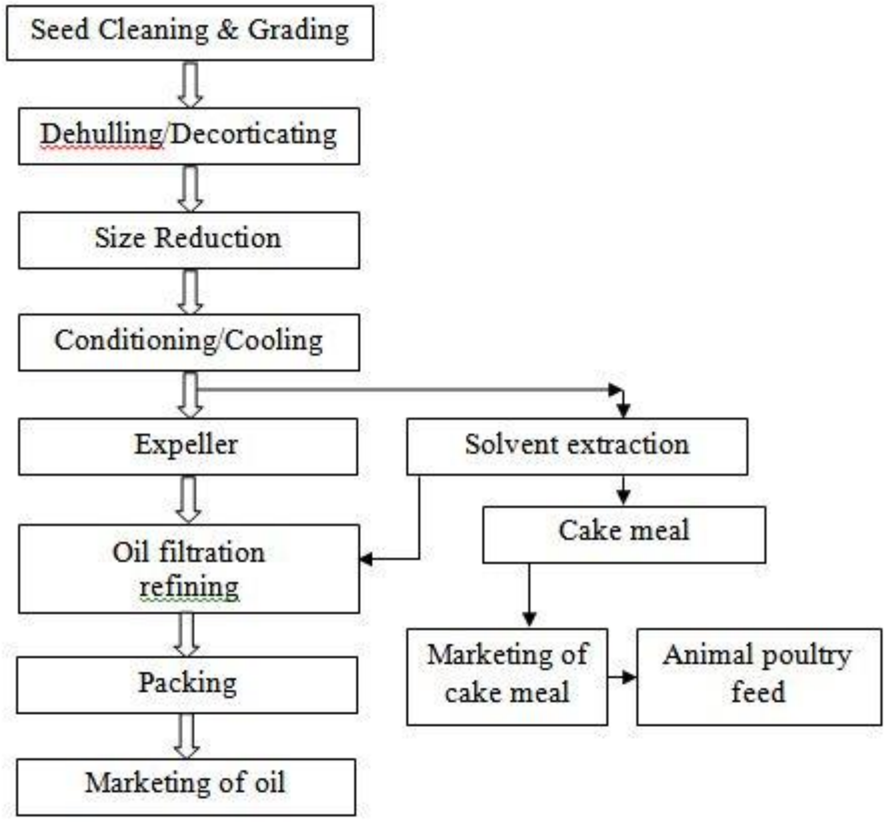


Fig. 7.1 Process flow chart of oil seeds processing

1. **Almonds:** Almonds are an incredibly dense package of nutrients. They are concentrated source of energy as they have 60 percent fat. Almonds have 20 percent protein like pulses. Like other nuts, carbohydrate content is low. They are fairly good source of B-vitamins and contributes to vitamin E content. Almonds are good

source of monounsaturated fatty acids which reduce the risk of heart disease by reducing LDL (bad) cholesterol.

2. **Gardencress seeds**: Gardencress seeds are excellent source of protein iron and B- vitamins. These seeds are traditionally consumed as a complementary food in the post-partum period by women in India. Processing improves bioavailability of iron and protein.

3. **Groundnut**: Ground nut is also known as peanuts, earthnuts and monkey nuts. They are rich in fat. The whole seed contains about 40 % fat, twice the amount in soyabeans. They are exceptionally rich in niacin. Groundnut protein lacks methionine. Groundnuts are rich in the antioxidant flavonol.

   Groundnuts are boiled or roasted and consumed. But the chief product is the oil, which can be used either as cooking oil or for making margarine. The secondary product is the residue or cake left after the expression of the oil. It is also purified and used in supplementary mix.

   1. **Edible groundnut flour**: The pre cleaned seeds, free from fungus and insects are roasted at 80- 900c for 10 minutes and subjected to abrasion to remove the red skin. The decuticled seeds are expeller-pressed for recovering oil and edible grade flour. The protein rich flour has been used for the preparation of nutritionally balanced food supplements such as the multipurpose food, Balahar, fortified wheat flour and mass-feeding programmes.

2. **Protein isolate**: The proteins of groundnut flour are solubilised in aqueous alkaline medium, the insoluble carbohydrates seperated by filtration or centrifugation and proteins are precipitated as the isoelectric point. The protein isolate is bland, cream- coloured and has more than 90 % protein with good nitrogen solubility index. Groundnut protein isolate is used in miltone, baby foods, biscuits, confectionary and as coffee/ tea whiteners.

On the basis of peroxide value and acidity, deep green bottles have been found to be better than colourless bottles for the storage of oil.

3. **Groundnut milk**:

Good quality peanut kernels are cleaned from impurities and roasted lightly and the red skin is removed.

4.

- The cleaned kernels are ground to a smooth paste. The paste is mixed with 7 times the weight of the weight of water in a blender. Calcium hydroxide solution is added till the PH of the milk is adjusted to 6.8.
- A mixture of disodium phospate and acid potassium phosphate having P H 7.0 is added to stabilise the milk.
- The milk is filtered through a fine cloth and fortified with vitamins A, D, B 2, folic acid, B12 and mineral, calcium and iron. Cane sugar is added at 7 per cent level.

The milk obtained from soyabean or peanut can be used as a supplement to the diets of pre-school and school children. Or it can be used as substitute for ordinary milk, in the case of allergies to milk.

5. **Peanut butter**: Good quality peanut kernel is cleaned it is roasted to a moderate degree till a pleasant aroma develops.

   Red skin is removed by passing the roasted kernel through a blanching machine.The kernels are ground in a grinding machine to medium grind. Hydrogenated fat containing vitamin A is added at 5 % level as this helps to prevent separation of oil. Sodium chloride is added at 2 %. The mixture is ground to a smooth paste and packed in bottles. Peanut butter can be consumed with chapati, puri or

The oxidation of food products involves the addition of an oxygen atom to or the removal of a hydrogen atom from the different chemical molecules found in food. Two principal types of oxidation that contribute to food deterioration are autoxidation of unsaturated fatty acids (i.e., those containing one or more double bonds between the carbon atoms of the hydrocarbon chain) and enzyme-catalyzed oxidation.

The autoxidation of unsaturated fatty acids involves a reaction between the carbon-carbon double bonds and molecular oxygen (O_2). The products of autoxidation, called free radicals, are highly reactive, producing compounds that cause the off-flavours and off-odours characteristic of oxidative rancidity. Antioxidants that react with the free radicals (called free radical scavengers) can slow the rate of autoxidation. These antioxidants include the naturally occurring tocopherols (vitamin E derivatives) and the synthetic compounds butylated hydroxyanisole

(BHA), butylated hydroxytoluene (BHT), and tertiary butylhydroquinone (TBHQ).

Specific enzymes may also carry out the oxidation of many food molecules. The products of these oxidation reactions may lead to quality changes in the food. For example, enzymes called phenolases catalyze the oxidation of certain molecules (e.g., the amino acid tyrosine) when fruits and vegetables, such as apples, bananas, and potatoes, are cut or bruised. The product of these oxidation reactions, collectively known as enzymatic browning, is a dark pigment called melanin. Antioxidants that inhibit enzyme-catalyzed oxidation include agents that bind free oxygen (i.e., reducing agents), such as ascorbic acid (vitamin C), and agents that inactivate the enzymes, such as citric acid and sulfites.

Colorants

Colour is an extremely important sensory characteristic of foods; it directly influences the perception of both the flavour and quality of a product. The processing of food can cause degradation or loss of natural pigments in the raw materials. In addition, some formulated products, such as soft drinks, confections, ice cream, and snack foods, require the addition of colouring agents. Colorants are often necessary to produce a uniform product from raw materials that vary in colour intensity. Colorants used as food additives are classified as natural or synthetic. Natural colorants are derived from plant, animal, and mineral sources, while synthetic colorants arePrimarily petroleum-based chemical compounds.

Most natural colorants are extracts derived from plant tissues. The use of these extracts in the food industry has certain problems associated with it, including the lack of consistent colour intensities, instability upon exposure to light and heat, variability of supply, reactivity with other food components, and addition of secondary flavours and odours. In addition, many are insoluble in water and therefore must be added with an emulsifier in order to achieve an even distribution throughout the food product.

Synthetic colour

colorants are water-soluble and are available commercially as powders, pastes, granules, or solutions. Special preparations called lakes are formulated by treating the colorants with aluminum hydroxide. They contain approximately 10 to 40 percent of the synthetic dye and are insoluble in water and organic solvents. Lakes are ideal for use in dry and oil-based products. The stability of synthetic colorants is affected by light, heat, pH, and reducing agents. A number of dyes have been chemically synthesized and approved for usage in various countries. These colorants are designated according to special numbering systems specific to individual countries.

The flavour of food results from the stimulation of the chemical senses of taste and smell by specific food molecules. Taste reception is carried out in specialized cells located in the taste buds. The five basic taste sensations—sweet, salty, bitter, sour, and umami—are detected in regions of the tongue, mouth, and throat. Taste cells are specific for certain flavour molecules (e.g., sweeteners).

In addition to the basic tastes, the flavouring molecules in food stimulate specific olfactory (smell) cells in the nasal cavity. These cells can detect more than 10,000 different stimuli, thus fine-tuning the flavour sensation of a food.

A flavour additive is a single chemical or blend of chemicals of natural or synthetic origin that provides all or part of the flavour impact of a particular food. These chemicals are added in order to replace flavour lost in processing and to develop new products. Flavourings are the largest group of food additives, with more than 1,200 compounds available for commercial use. Natural flavourings are derived or extracted from plants, spices, herbs, animals, or microbial fermentations. Artificial flavourings are mixtures of synthetic compounds that may be chemically identical to natural flavourings. Artificial flavourings are often used in food products because of the high cost, lack of availability, or insufficient potency of natural flavourings.

Flavour enhancers are compounds that are added to a food in order to supplement or enhance its own natural flavour. The concept of flavour enhancement originated in Asia, where cooks added seaweed to soup stocks in order to provide a richer flavour to certain foods. The flavour-enhancing component of seaweed was identified as the amino acid L-glutamate, and monosodium glutamate (MSG) became the first flavour enhancer to be used commercially. The rich flavour associated with L-glutamate was called umami.

Other compounds that are used as flavour enhancers include the 5′-ribonucleotides, inosine monophosphate (IMP), guanosine monophosphate (GMP), yeast extract, and hydrolyzed vegetable protein.

Flavour enhancers may be used in soups, broths, sauces, gravies, flavouring and spice blends, canned and frozen vegetables, and meats.

Unmodified starches, with and without pregelatinization, do not have maximum limits of usage. However, the Code of Federal Regulations specifies the maximum use level of gums by various product categories (e.g., bakery, snack foods, salad dressings, confections, etc.). The gum is usually mixed in with the flour in dry mixes. In beverages, sauces and dressings, the gum is allowed to hydrate at the required conditions of temperature, pH, ionic requirements and other cofactors, based on supplier recommendations. The sequence of incorporation, synergy, particle size and chemical nature of the polysaccharide also affect the hydration rate.

When some specific gums are used in combination, it significantly enhances or modifies the functional properties due to synergistic action. For example, a combination of xanthan gum and locust bean gum forms a heat-reversible flexible gel, whereas the individual gums are not gel-forming. The reaction of locust bean gum with kappa carrageenan to yield heat-reversible rigid gels works as a gelling agent in baked goods, desserts and confections. Gums and starches are typically combined in a formulation, since the gums generally help reduce retrogradation problems involved with high-amylose starches.

Processing of Fruits and Vegetables

Combined preservation procedures

In practice preservation procedures aim at avoiding microbiological and biochemical deterioration which are the principal forms of deterioration. Even with all recent progress achieved in this field, no single one of these technological procedures applied alone can be considered wholly satisfactory from a microbiological, physico-chemical and organoleptic point of view, even if to a great extent the food value is assured.

Thus, heat sterilisation cannot be applied in order to destroy all micro-organisms present in foods without inducing non desirable modifications. Preservation by dehydration/drying assures microbiological stability but has the drawback of undesirable modifications that appear during storage: vitamin losses, oxidation phenomena, etc.

Starting with these considerations, the actual tendency in food preservation is to study the application of combined preservation procedures, aiming at the realisation of maximum efficiency from a microbiological and biological point of view, with reduction to a minimum of organoleptical degradation and decrease in food value.

The principles of combined preservation procedures are:

- avoid or reduce secondary (undesirable) effects in efficient procedures for microbiological preservation;
- avoid qualitative degradation appearing during storage of products preserved by efficient procedures from a microbiological point of view;
- increase microbiological efficiency of preservation procedures by supplementary means;

- combine preservation procedures in order to obtain maximum efficiency from a microbiological point of view, by specific action on various types of micro-organisms present;
- establish combined factors that act simultaneously on bacterial cells.

Research and applications in this direction were followed by microbiological and biochemical way, obtaining a serial of combination of preservation procedures with the possibility of application in industrial practice. [unclear]

Fresh fruit and vegetable storage can be combined with:

- storage in controlled atmosphere where carbon dioxide and oxygen levels are monitored, increasing concentration of CO2 and lowering that of oxygen according to fruit species. Excellent results were obtained for pomace fruit; in particular the storage period for apples has been extended. Application of this combined procedure requires airtight storage rooms.
- storage in an environment containing ethylene oxide; this accelerates ripening in some fruit: tomatoes, bananas, mangoes, etc.

Cold storage can be combined with storage in an environment with added of carbon dioxide, sulphur dioxide, etc. according to the nature of product to be preserved.

Preservation by drying/dehydration can be combined with:

- freezing: fresh fruit and vegetables are dehydrated up to the point where their weight is reduced by 50% and then they are preserved by freezing.

This procedure (freeze-drying) combines the advantages of drying (reduction of volume and weight) with those of freezing (maintaining vitamins and to a large extent organoleptic properties).

A significant advantage of this process is the short drying time in so far as it is not necessary to go beyond the inflexion point of the drying curve. The finished products after defreezing and rehydration/reconstitution are of a better quality compared with products obtained by dehydration alone.

- cold storage of dried/dehydrated vegetables in order to maintain vitamin C; storage temperature can be varied with storage time and can be at -8° C for a storage time of more than one year, with a relative humidity of 70-75 %.
- packaging under vacuum or in inert gases in order to avoid action of atmospheric oxygen;, mainly for products containing beta-carotene.
- chemical preservation: a process used intensively for prunes and which has commercial applications is to rehydrate the dried product up to 35 % using a bath containing hot 2 % potassium sorbate solution. Another possible application of this combined procedure is the initial dehydration up to 35% moisture followed by immersion in same bath as explained above; this has the advantage of reducing drying time and producing minimum qualitative degradation. Both applications suppress the dehydrated products reconstitution (rehydration) step before consumption.
- packaging in the presence of desiccants (calcium oxide, anhydrous calcium chloride, etc.) in order to reduce water vapour content in the package, especially for powdered products.

Preservation by concentration, carried out by evaporation, is combined with cold storage during warm season for tomato paste (when water content cannot be reduced under the limit needed to inhibit moulds and yeasts, e.g. $a_w = 0.70...0.75$).

Chemical preservation is combined with:

- acidification of food medium (lowering pH);
- using combined chemical preservatives.

Preservation by lactic fermentation (natural acidification) can be combined with cold storage for pickles in order to prolong storage time or shelf-life.

4.3.7 Preservation with sugar is combined with pasteurization for some preserves having a sugar content below 65%

Climacteric fruits: These are harvested at full maturity, can be ripened off the parent plant. These produce much larger quantities of ethylene in association with their ripening, and exposure to ethylene treatment will result in faster and more uniform ripening. The respiration rate is minimum at maturity and remains rather constant, even after the harvest. The rate will rise up abruptly to the climacteric peak only when ripening is about to take place, and then it will slowly decline. Fruit softening, colour changes, development of taste and flavour and a number of other parameters of ripening process are associated with the climacteric cycle.

Non-climacteric fruits: These are not capable of continuing their ripening process, once they are detached from the parent plant. Also, these fruits produce a very small quantity of endogenous ethylene, and do not respond to external ethylene treatment. Non-climacteric fruits show comparatively low profile and a gradual decline in their respiration pattern and ethylene production, throughout the ripening process

CHANGES DURING RIPENING

Fruit ripening involves many complex biochemical changes, including seed maturation, change in colour, abscission from the parent plant, texture softening, production of flavour volatiles, wax development on skin, tissue permeability and change in carbohydrate composition, organic acids and proteins. During ripening the composition of fruit is altered either due to formation of new compounds or degradation of others. Out of various biochemical and physical changes occurring, changes in flavour, colour and texture are of utmost importance, for the acceptability of the fruit. 7.3.1Colour Changes Pigments are essential for the attractiveness of fruits and accumulate most often in the skin during the ripening process. Color is often the major criteria used by consumers to determine whether the fruit is ripe or unripe. As fruit matures and ripen, green colour decline and develops yellow, red or other colours due to the presence of accessory pigments, which are characteristic of the various cultivars.

Preservation of Meat

Meat preservation helps to control spoilage by inhibiting the growth of microorganisms, slowing enzymatic activity, and preventing the oxidation of fatty acids that promote rancidity. There are many factors affecting the length of time meat products can be stored while maintaining product safety and quality. The physical state of meat plays a role in the number of microorganisms that can grow on meat. For example, grinding meat increases the surface area, releases moisture and nutrients from the muscle fibres, and distributes surface microorganisms throughout the meat. Chemical properties of meat, such as pH and moisture content, affect the ability of microorganisms to grow on meat. Natural protective tissues (fat or skin) can prevent microbial contamination, dehydration, or other detrimental changes. Covering meats with paper or protective plastic films prevents excessive moisture loss and microbial contamination.

Cold Storage

Temperance is the most important factor influencing bacterial growth. Pathogenic bacteria do not grow well in temperatures under 3 °C (38 °F). Therefore, meat should be stored at temperatures that are as cold as possible. Refrigerated storage is the most common method of meat preservation. The typical refrigerated storage life for fresh meats is 5 to 7 days.

Freezer storage is an excellent method of meat preservation. It is important to wrap frozen meats closely in packaging that limits air contact with the meat in order to prevent moisture loss during storage. The length of time meats are held at frozen storage also determines product quality. Under typical freezer storage of −18 °C (0 °F) beef can be stored for 6 to 12 months, lamb for 6 to 9 months, pork for 6 months, and sausage products for 2 months.

freezing

The rate of freezing is very important in maintaining meat quality. Rapid freezing is superior; if meats are frozen slowly, large ice crystals form in the meat and rupture cell membranes. When this meat is thawed, much of the original moisture found in the meat is lost as purge (juices that flow from the meat). For this reason cryogenic freezing (the use of supercold substances such as liquid nitrogen) or other rapid methods of freezing meats are used at the commercial level to maintain maximal product quality. It is important to note, however, that freezing does not kill most microorganisms; they simply become dormant. When the meat is thawed, the spoilage continues where it left off.

Thawing meats often can cause more detrimental quality changes than freezing. In contrast to freezing, thawing should be a slow process. Meats are best thawed in the refrigerator with packaging left intact, so that moisture loss is minimized. Placing frozen meats out on a warm countertop or under warm water subjects the meat's outer layers to room temperatures for long periods of time before the meat is ready for cooking (completely thawed). This rapid method provides a conducive environment for the growth of food-borne microorganisms and increases the risk of food poisoning.

Vacuum packaging

Oxygen is required for many bacteria to grow. For this reason most meats are vacuum-packaged, which extends the storage life under refrigerated conditions to approximately 100 days. In addition, vacuum packaging minimizes the oxidation of unsaturated fatty acids and slows the development of rancid meat.

Canning

The second most common method of meat preservation is canning. Canning involves sealing meat in a container and then heating it to destroy all microorganisms capable of food spoilage. Under normal conditions canned products can safely be stored at room temperature indefinitely. However, certain quality concerns can compel processors or vendors to recommend an optimal “sell by” date.

Drying

Drying is another common method of meat preservation. Drying removes moisture from meat products so that microorganisms cannot grow. Dry sausages, freeze-dried meats, and jerky products are all examples of dried meats capable of being stored at room temperature without rapid spoilage.

Fermentation

One ancient form of food preservation used in the meat industry is fermentation. Fermentation involves the addition of certain harmless bacteria to meat. These fermenting bacteria produce acid as they grow, lowering the pH of the meat and inhibiting the growth of many pathogenic microorganisms.

Irradiation

Irradiation, or radurization, is a pasteurization method accomplished by exposing meat to doses of radiation. Radurization is as effective as heat pasteurization in killing food-spoilage microorganisms. Irradiation of meat is accomplished by exposing meat to high-energy ionizing radiation produced either by electron accelerators or by exposure to gamma-radiation-emitting substances such as cobalt-60 or cesium-137. Irradiated products are virtually identical in character to nonirradiated products, but they have significantly lower microbial contamination. Irradiated fresh meat products still require refrigeration and packaging to prevent spoilage, but the refrigerated storage life of these products is greatly extended.

Curing and Smoking

Meat curing and smoking are two of the oldest methods of meat preservation. They not only improve the safety and shelf life of meat products but also enhance the colour and flavour. Smoking of meat decreases the available moisture on the surface of meat products, preventing microbial growth and spoilage. Meat curing, as commonly performed in products such as ham or sausage, involves the addition of mixtures containing salt, nitrite, and other preservatives.

Salt decreases the moisture in meats available to spoilage microorganisms. Nitrite prevents microorganisms from growing and retards rancidity in meats. Nitrite also produces the pink colour associated with cured products by binding (as nitric oxide) to myoglobin. However, the use of nitrite in meat products is controversial owing to its potential cancer-causing activity.

Sodium erythorbate or ascorbate is another common curing additive. It not only decreases the risks associated with the use of nitrite but also improves cured meat colour development. Other common additives include alkaline phosphates, which improve the juiciness of meat products by increasing their water-holding ability.

Processing on Poultry

Raw poultry products

Whole or individual parts of birds may be packaged raw for direct sale. Poultry packaged in the United States must include instructions about safe handling, including the need to wash all equipment that has come in contact with raw poultry and the need to wash one’s hands before preparing other foods. Most raw turkey is sold frozen, while most chicken is sold fresh.

Fresh poultry

The birds are generally cut into a number of pieces, which are placed on plastic foam trays and covered with a plastic film. A “diaper” (absorbent paper with a plastic backing) is often used to catch any liquid that may be released from the meat. Fresh poultry should be used within 14 to 21 days after slaughter and generally should not be kept in the home refrigerator for more than three days. In the United States, poultry that has been frozen to a temperature of −5 to −4 °C (22 to 24 °F) and then allowed to thaw can legally be sold as “fresh.”

Frozen poultry

Most frozen poultry is vacuum-packed in plastic bags and then frozen in high-velocity freezers. The birds are kept in cold storage until needed. Before freezing, poultry may be injected with various salts, flavourings, and oils in order to increase the juiciness of the meat. Injections are usually done with a multi-needle automatic injector, and information about the added ingredients is indicated on the package label.

Frozen storage time (including poultry bought fresh and frozen in a home freezer) depends on the temperature of the freezer, the quality of the packaging, and the cycling of the freezer. For best results poultry should be used within three months. Frozen poultry products can be used directly in the frozen state or thawed first. Thawing should be done in the refrigerator or under running cold water to minimize the potential for microbial contamination.

Processed poultry products

Poultry may be further processed into other products. The number of processed poultry products has increased dramatically since the 1970s because of the low cost of poultry and its versatile, bland flavour.

Tumbling and massaging

In the manufacturing of many poultry products, the meat is mixed with a variety of nonmeat ingredients, including flavourings, spices, and salt. Tumbling and massaging are gentle methods that produce a uniform meat mixture. A tumbler is a slowly rotating drum that works the meat into a smooth mixture. A massager is a large mixing chamber that contains a number of internal paddles. Cured turkey products (i.e., treated with sodium nitrite), such as turkey ham and turkey pastrami, are often tumbled or massaged during processing.

Smoking

Poultry may be smoked. Prior to smoking, the birds must be brined (soaked in a salt solution containing certain flavourings) and then allowed to dry. Smoking can be done using real wood shavings or a smoke flavouring. In the last case this must be labeled in the United States as “natural smoke flavor added.”

Deboning and grinding

Further processed poultry products leave the backs, necks, and bones available for their own processing. These materials are run through a machine called a mechanical deboner or a meat-bone separator. In general, the crushed meat and bones are continuously pressed against a screen and the edible, soft materials pushed through the screen. The resulting minced product is similar in texture to ground beef and has been used for many poultry products such as frankfurters (hot dogs) and bologna. Poultry frankfurters and bologna are made using a process similar to that for beef and pork. The meat is combined with water or ice, salt, and seasonings and chopped to emulsify the materials. The mixture is stuffed into plastic casings and cooked in a smokehouse. The meat is then quickly chilled, peeled, and vacuum-packaged. Bologna is stuffed into a larger casing and is not necessarily peeled.

Processing of Fish

The word *fish* is commonly used to describe all forms of edible finfish, mollusks (e.g., clams and oysters), and crustaceans (e.g., crabs and lobsters) that inhabit an aquatic environment. Fish from the marine and freshwater bodies of the world have been a major source of food for humankind since before recorded history. Harvesting wild fish from fresh and marine waters and raising cultured fish in ponds were practices of ancient Egyptians, Greeks, and other Mediterranean peoples. Rudimentary processing techniques such as sun-drying, salting, and smoking were used by these ancient groups to stabilize the fish supply. Modern methods of processing and preservation have encouraged the consumption of many species of fish that are popular throughout the world.

Nutrient composition

The composition of fish may vary considerably—especially in their fat content—during certain growth periods and annual spawning or migration periods. In addition, the composition of fish bred in captivity (i.e., aquaculture fish) may vary according to their artificial diet. The table shows the nutrient composition of several types of fish.

Protein

Fish are an excellent source of high-quality protein. Mollusks are generally lower in protein compared with finfish and crustaceans because of their high water content. The proteins found in fish are essentially the same as those found in the meat derived from other animals—that is, the sarcoplasmic proteins (e.g., enzymes and myoglobin), the contractile or myofibrillar proteins (e.g., actin and myosin), and the connective tissue proteins (i.e., collagen).

Fat

The fat in fish is mostly liquid (i.e., fish oil), because it contains a relatively low percentage of saturated fatty acids. Fish belong in a special nutritional class because they contain the omega-3 polyunsaturated fatty acids—eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)—which have been shown to protect against several diseases, including heart disease. Unlike land plants, the marine and freshwater plants on which fish feed are rich in EPA and DHA.

Vitamins and Minerals

Fish provide a number of important vitamins and minerals to the diet. They are a good source of the fat-soluble vitamins A, D, E, and K and the B vitamins riboflavin, niacin, and thiamine. The mineral content includes calcium, magnesium, phosphorus, and iron.

Microbiology

Because of their soft tissues and aquatic environment, fish are extremely susceptible to microbial contamination. At the time of harvest, fish carry a high microbial load on the surface of their skin, in their intestinal tract, and in their gills

The type and number of microorganisms that live in fish vary according to the season, the species, and the natural habitat. Additional contamination may occur during the harvesting, handling, or processing of the fish. Common spoilage microorganisms of fish include species of *Pseudomonas*, *Moraxella*, and *Acinetobacter*, found mainly in marine fish, and *Bacillus* and *Micrococcus*, found in freshwater fish. Fish may also contain pathogenic (disease-causing) microorganisms such as *Salmonella* and *Escherichia coli*. Pathogenic contamination is of special concern with mollusks because they are often eaten raw and as whole animals.

Handling Of Harvested Fish

The retention of nutritional properties and product quality of fish is dependent on proper handling of the catch after it has been harvested from its aquatic environment.

.Harvested fish must be immediately stored in a low-temperature environment such as ice or refrigerated seawater. This chilling process slows the growth of microorganisms that live in fish and inhibits the activity of enzymes. Because fish have a lower body temperature, softer texture, and less connective tissue than land animals, they are much more susceptible to microbial contamination and structural degradation. If immediate chilling is not possible, then the fish must generally be sold and eaten on the day of the harvest.

Ice cooling and holding normally requires a one-to-one or one-to-two weight ratio of ice to fish, depending on the specific geographic location and the time it takes to transport the fish to the processing plant. Refrigerated seawater cooling and holding causes less bruising and other structural damage to the fish carcasses than ice cooling. However, fish cooled in refrigerated seawater absorbs salt from the water. For this reason fish that is destined for sale on the fresh or frozen market may be held in refrigerated seawater for only a limited amount of time. The addition of salt during canning or smoking processes is adjusted in order to compensate for any absorbed salt.

Preprocessing

Preprocessing of fish prepares the raw material for final processing. It is often performed on shipboard or in a shore-based plant and includes such operations as inspection, washing, sorting, grading, and butchering of the harvested fish.

The butchering of fish involves the removal of nonedible portions such as the viscera, head, tail, and fins. Depending on the butchering process, as much as 30 to 70 percent of the fish may be discarded as waste or reduced to cheap animal feed. The lower figure applies when the fish is canned or sold as “whole.” The higher figure applies when the fish is filleted or made into other pure meat products; in these cases the skeleton is discarded with as much as 50 percent of the edible flesh attached. Efforts to utilize this discarded fraction for the production of alternative food products have begun in the fish industry. (*See below* Total utilization of raw materials.)

Processing of Fish

The four basic procedures used in the final processing of fish products are heating, freezing, controlling water activity (by drying or adding chemicals), and irradiating. All these procedures increase the shelf life of the fish by inhibiting the mechanisms that promote spoilage and degradation. Each of these procedures also has an effect on the nutritional properties of the final product.

Heating

Heat treatment can significantly alter the quality and nutritional value of fish. Fish is exposed to heat during both the cooking process and the canning process.

Cooking

Fish is cooked in order to produce changes in the texture and flavour of the product and to kill pathogenic microorganisms. Heating fish to an internal temperature above 66 °C or 150 °F (i.e., pasteurization conditions) is sufficient to kill the most resistant microorganisms. The cooking time must be closely regulated in order to prevent excessive loss of nutrients by heat degradation, oxidation, or leaching (the loss of water-soluble nutrients into the cooking liquid).

Canning

The canning process is a sterilization technique that kills microorganisms already present on the fish, prevents further microbial contamination, and inactivates degradative enzymes. In this process fish are hermetically sealed in containers and then heated to high temperatures for a given amount of time. Canned fish can be stored for several years. However, sterilization does not kill all microorganisms, and bacterial growth and gas production may occur if the products are stored at very high temperatures.

Because the severe thermal conditions of canning cause the disintegration and discoloration of the flesh of many species of fish, only a few types of fish are available as canned products. The most common types are tuna, salmon, herring, sardines, and shrimp. The thermal processing does not have a detrimental effect on the high-quality protein of the fish. In addition, these species are often canned with their bones left intact. The bones become soft and edible, significantly increasing the level of calcium present in the fish product. Tuna is an exception; because of special handling considerations, the bones of tuna are removed prior to canning. Tuna is normally caught far offshore and must be frozen and held for some period of time prior to canning. During this freezing and holding period unsaturated fatty acids are oxidized, causing the tuna to become rancid. The rancidity is removed by precooking, and the bones are removed at this time in order to facilitate the cutting and preparation of the meat for canning.

Freezing

Of the many processing methods used to preserve fish, only freezing can maintain the flavour and quality of fresh fish. Freezing greatly reduces or halts the biochemical reactions in fish flesh. For instance, in the absence of free water, enzymes cannot react to soften and degrade the flesh. The three steps for freezing fish include immediate cooling and holding, rapid freezing, and cold storage. If fish is frozen improperly, structural integrity may be compromised because of enzymatic degradation, texture changes, and dehydration.

Immediate cooling

The rapid cooling and holding of fish at temperatures between 2 and −2 °C (36 and 28 °F) takes place immediately after the fish have been harvested. (See above Handling of harvested fish: Chilling.)

Rapid freezing

The key to freezing is rapid reduction of the temperature to between −2 and −7 °C (28 and 20 °F). This temperature range represents the zone of maximum ice crystal formation in the cells of the flesh. If water in the cells freezes quickly, then the ice crystals will remain small and cause minimal damage to the cells. However, slow freezing results in the formation of large ice crystals and the rupturing of the cell membranes. When slow-frozen flesh is thawed, the ruptured cells release water (called drip) and many compounds that provide certain flavour characteristics of fish, resulting in a dry, tasteless product. Fish that passes through the zone of maximum ice crystal formation in less than one hour will generally have minimum drip loss upon thawing.

Cold storage

Once fish is frozen, it must be stored at a constant temperature of −23 °C (−10 °F) or below in order to maintain a long shelf life and ensure quality. A large portion of fresh fish is water (e.g., oysters are more than 80 percent water). Because the water in fish contains many dissolved substances, it does not uniformly freeze at the freezing point of pure water. Instead, the free water in fish freezes over a wide range, beginning at approximately −2 °C (28 °F). The amount of remaining free water decreases until the product reaches a temperature of approximately

−40 °C (−40 °F). Fish held below that temperature and packaged so as not to allow water loss through sublimation can be stored for an indefinite period. Unfortunately, there are relatively few commercial freezers capable of storing fish at -40° because of the tremendous variation in energy costs. Fish are therefore normally stored at −18 to −29 °C (0 to −20 °F), resulting in a variable shelf life ranging from a few weeks to almost one year.

Controlling water activity

Reducing the water activity of fish inhibits the growth of microorganisms and slows the chemical reactions that may be detrimental to the quality of the fish product. The control of water activity in fish is accomplished by drying, adding chemicals, or a combination of both methods.

Drying

The principal methods of drying, or dehydrating, fish are by forced-air drying, vacuum drying, or vacuum freeze-drying. Each of these methods involves adding heat to aid in the removal of water from the fish product. During the initial stages of drying, known as the constant-rate period, water is evaporated from the surface of the product and the temperature of the product remains constant. In the final stages of drying, known as the falling-rate period, the temperature of the product increases, causing water to move from the interior to the surface for evaporation.

Curing

Curing reduces water activity through the addition of chemicals, such as salt, sugars, or acids. There are two main types of salt-curing used in the fish industry: dry salting and pickle-curing. In dry salting the butchered fish is split along the backbone and buried in salt (called a wet stack). Brine is drained off until the water content of the flesh is reduced to approximately 50 percent (the typical water content of fresh fish is 75 to 80 percent) and the salt content approaches 25 percent. In heavy or hard-cure salting, an additional step is taken in which warm air is forced over the surface of the fish until the water content is reduced to about 20 percent and the salt content is increased to approximately 30 percent. Most dry-salted fish products are consumed in warm, humid countries or in areas that have few means of holding products in refrigeration or cold storage.

In pickle-curing, fish are preserved in airtight barrels in a strong pickle solution formed by the dissolving of salt in the body fluids. This curing method is used for fatty fish such as herring.

Smoking

Traditionally, smoking was a combination of drying and adding chemicals from the smoke to the fish, thus preserving and adding flavour to the final product. However, much of the fish smoked today is exposed to smoke just long enough to provide the desired flavour with little, if any, drying. These products, called kippered fish, have short shelf lives, even under refrigeration, since the water activity remains high enough for spoilage organisms to grow.

The smoking process consists of soaking butchered fish in a 70 to 80 percent brine solution for a few hours to overnight, resulting in a 2 to 3 percent salt content in the fish. The fish are then partially dried on racks. As the brine on the surface dries, dissolved proteins produce a glossy appearance, which is one of the commercial criteria for quality. Smoking is carried out in kilns or forced-air smokehouses that expose the fish to smoke from smoldering wood or sawdust. In cold-smoking the temperature does not exceed 29 °C (85 °F), and the fish is not cooked during the process. Hot-smoking is more common and is designed to cook the fish as well as to smoke it.

Irradiating

Irradiation offers a means of pasteurizing or sterilizing a variety of food products. However, the use of this process has not been universally accepted throughout the food industry.

Food irradiators utilize radioisotopes, such as cobalt-60 (^{60}Co) or cesium-137 (^{137}Cs), or electron beam generators to provide a source of ionizing radiation. The irradiation of seafood has been extensively studied since the 1950s. The pasteurization of fresh fish using low-level dosages of ionizing radiation may extend the shelf life of the product up to several weeks. The sensory and nutritional characteristics of the fish are unaffected at these low levels of radiation.

Processing of Eggs

Methods of egg preservation

There are different methods for preserving the surplus eggs. Following are commercial methods of preservation.

Cold storage (5 to 8 months)

The temperature of an egg-storage room should be maintained at +0.50C to –0.50C (310 to 330F) being the temperature usually preferred. A relative humidity of 75 to 85 per cent is necessary. Too much humidity favours the formation of moulds.

Frozen eggs

The freezing of the internal contents of eggs is now a common method of preservation specially in developed countries. The eggs are first candled and when they are broken out, the smell and appearance of the contents are noted for any possible defects. The yolk and the white may be frozen separately with addition of 5% glycerine. The egg contents are then freezed in 30-40 lb., tin at a low temperature range of 100F to 300F below zero. The contents are then kept at a low temperature until required for use. In case the storage temperature is zero or below, the frozen eggs may be stored with little or no loss of flavour for 12 months or longer.

Dried eggs

Egg drying is now largely practised in place of freezing. Although the process is more expensive but there is a considerable saving in transport and less need for cold storage. The egg contents are dried at a temperature of 1600F and stored less than 500F to convert white, yolk or the whole egg into a fine powder. The whole egg is of use for bakery products, the yolk for flours and the albumen for confectionaries.

Refrigeration □ Eggs must be cooled to a core temperature of 45 ˚F. □ Eggs held prior to processing must also be cooled. □ All eggs being transported must be hauled in a refrigerated trailer so that the core temperature is held constant at 45 ˚F.

Care and Handling □ Mechanical Handling □ Eggs are moved using conveyor systems between the production facility and the processing plant. □ The processing machinery is fully mechanical and most of the equipment on commercial farms works to wash, dry, sort by weight and quality, and package the eggs into specified packaging. □ Once eggs are consolidated to pallets, fork lifts are used to handle the product.

Processing of TEA

The history of tea processing corresponds intimately with the role that tea played in Chinese society and the preferred methods of its consumption in ancient Chinese society. Although tea had been cultivated in Chinese society for a long time it was never found in a wild state. It is assumed that Chinese travelers took back tea seeds from Assam (India) as wild tea trees were reportedly found in 1823 in the mountainous regions of Assam and it is agreed by many that the variety *Thea assamica* Mast. is the forefather of the cultivated ones. Variations of these processing techniques are still used in modern tea processing albeit being far more mechanized.

Green

The ancient Chinese society first encountered the tea plant in what is now south-eastern China and processed it as an additional medicinal herb for use in Chinese herbology. The processing technique used to process fresh tea leaves was to immediately steam the fresh tea leaves and dry them for preservation, which is the most ancient Chinese form of tea leaf processing known to date. This processing method was perfected near the end of the Han Dynasty (206 BCE – 220 CE) and produced a dried tea that would be classified today as *green tea* and quite similar to modern Japanese sencha. For consumption, dried tea leaves were either decocted with water and other herbs, or ground into a powder to be taken straight, or suspended in a liquid in the manner of matcha.

With the increase of tea's use in Chinese herbology, production methods changed, where the processed green tea leaves were not immediately dried after steaming. Rather the steamed tea leaves were first pulverized into a paste form, with the paste then formed in molds and slowly dried into brick tea, a technique well described by Lu Yu in his work *The Classic of Tea*. Tender leaves and leaf buds were generally not used, as older mature tea leaves were preferred for tea production. Some tea bricks were also produced from mature whole leaves, which typically required the use of a cooked rice slurry to bind the tea brick together. The preference of producing tea in brick form possibly stems from the fact that it can be more easily transported and stored.

Yellow and fermented

The use of steam in fixation of tea leaf enzymes is an important step in processing tea, with the leaves quickly cooled down and then undergoing further processing. The less tightly controlled methods of it in the past resulted in the creation of *yellow tea* when the tea leaves were over-steamed for fixation or were not quickly spread out, doused with water and cooled. Although green tea was the most popular in Lu Yu's time, he personally considered yellow tea to be superior to green.

Even when the leaves were quickly cooled, if they are left in piles for too long before processing, the leaves will begin to undergo microbial fermentation to produce *post-fermented tea*.This technique is somewhat similar to composting, albeit tightly controlled, and still used in the production of Liu'an tea and was more recently introduced for the production of the *ripe* type Pu-erh tea. The production of tea in brick forms and their storage also resulted in another type of post-fermented tea, which was produced by aging. The long transport and storage times of the day unwittingly allowed the tea bricks to undergo prolonged exposure to the elements and to various microflora, which resulted in the aging, oxidation, and fermentation of green brick teas. A brick of green tea that had been stored and aged into post-fermented tea was charred over charcoal to rid it of the layer of detritus, dust, and shiny multicoloured growths before being broken down into a powder, cooked, and then consumed. By the end of the Tang Dynasty (618–907 CE) green, yellow, and post-fermented tea was commonly used in China and moved from purely being used in herbology to becoming a beverage drunk for pleasure.

Oolong and white[

The Tang Dynasty was also the period when oolong tea was first developed in the Fujian province. It was originally produced in thin brick form, known then under the name *Beiyuan* tea . The importance of the withering process for producing oolong tea was described by poet Huang Furen in his poem "", which indicated that the processing of tea leaves is not a simple task, requiring the scaling of steep cliffs to pick the choicest leaves and the withering of the leaves under the sun and warm winds

White tea was also developed in the Fujian province with its first mentions in the Song Dynasty document *Treatise on Tea*, where the delicate buds used for producing white tea, the difficulty in producing it, its taste, and its rarity were lauded.[3] The production method of white tea was described by Ming Dynasty author Tian Yiheng in "Zhuquan Xiaopin" (produced in the 33rd year of the Jiajing Emperor) regarding Fuding white tea . In this work, he stated that tea buds that have undergone fixation by panning over flames (as with green tea) are second to white tea that was simply allowed to dry under the sun, since it's more natural in taste and lacks flavours imparted by the smoke and flames.

Black

The technique for producing black tea was first developed during the late Ming Dynasty in Wuyishan, Fujian, either resulting from the over-oxidation of tea-leaves during the manufacture of oolong tea or indirectly from the methods of manufacturing green and white teas. In the early 1600s, tea producers in the Wuyi Mountains began kneading the sun-withered tea leaves to macerate them, then allowed them to dry under the sun, thus reaching full oxidation and producing *Gongfu* black tea When there was insufficient sun and temperatures were low, the withered leaves would be processed indoors in warmed rooms and allowed to fully oxidize, then smoked dry over pine fires thus producing lapsang souchong. According to oral traditions of the region, the discovery of Lapsang Souchong processing was due to military troops passing through a Wuyishan tea factory during the last years of the Ming Dynasty, causing delays to tea leaf processing thus resulting in a completely oxidized leaf that the producer salvaged by drying over a fire built from pine branches. By the Qing Dynasty, both Lapsang Souchong and Gongfu black tea were well recognized in China and noted in "Records on Yiwu mountain" by the scholar Dong Tiangong

Although each type of tea has a different taste, smell, and visual appearance, tea processing for all tea types consists of a very similar set of methods with only minor variations. Without careful moisture and temperature control during its manufacture and life thereafter, fungi will grow on tea. This form of fungus causes real fermentation that will contaminate the tea and may render the tea unfit for consumption.

1. **Plucking**: Tea leaves and flushes, which includes a terminal bud and two young leaves, are picked from *Camellia sinensis* bushes typically twice a year during early spring and early summer or late spring. Autumn or winter pickings of tea flushes are much less common, though they occur when climate permits. Picking is done by hand when a higher quality tea is needed, or where labour costs are not prohibitive. Depending on the skill of the picker, hand-picking is performed by pulling the flush with a snap of the forearm, arm, or even the shoulders, with the picker grasping the tea shoot using the thumb and forefinger, with the middle finger sometimes used in combination. Tea flushes and leaves can also be picked by machine, though there will be more broken leaves and partial flushes reducing the quality of the tea. However, it has also been shown that machine plucking in correctly timed harvesting periods can produce good leaves for the production of high quality teas.
2. **Withering / wilting**: The tea leaves will begin to wilt soon after picking, with a gradual onset of *enzymatic oxidation*. Withering is used to remove excess water from the leaves and allows a very slight amount of oxidation. The leaves can be either put under the sun or left in a cool breezy room to pull moisture out from the leaves. The appropriate conditions for withering, such as temperature and relative humidity, are not readily defined in literature as it can vary depending on climate, producing region and type of process used. However, variations in the rate of withering, such as a hard or soft wither, has been shown to influence flavor compounds. The leaves sometimes lose more than a quarter of their weight in water during withering. The process is also important in promoting the breakdown of leaf proteins into free amino

acids and increases the availability of freed caffeine, both of which change the taste of the tea.

3. **Disruption**: Known in the Western tea industry as *disruption* or *leaf maceration*, the teas are bruised or torn in order to promote and quicken oxidation. The leaves may be lightly bruised on their edges by shaking and tossing in a bamboo tray or tumbling in baskets. More extensive leaf disruption can be done by kneading, rolling, tearing, and crushing, usually by machinery.The bruising breaks down the structures inside and outside of the leaf cells and allows from the co-mingling of oxidative enzymes with various substrates, which allows for the beginning of oxidation. This also releases some of the leaf juices, which may aid in oxidation and change the taste profile of the tea.
4. **Oxidation**: For teas that require oxidation, the leaves are left on their own in a climate-controlled room where they turn progressively darker. This is accompanied by agitation in some cases. In this process the chlorophyll in the leaves is enzymatically broken down, and its tannins are released or transformed. The tea producer may choose when the oxidation should be stopped, which depends on the desired qualities in the final tea as well as the weather conditions (heat and humidity). For light oolong teas this may be anywhere from 5–40% oxidation, in darker oolong teas 60–70%, and in black teas 100% oxidation. Oxidation is highly important in the formation of many taste and aroma compounds, which give tea its liquor colour, strength, and briskness. Depending on the type of tea desired, under or over-oxidation can result in grassy flavours, or overly thick winey flavours. This process is sometimes referred to erroneously as *fermentation* in the tea industry.
5. **Fixation / kill-green**: Kill-green or *shāqīng* is done to stop the tea leaf oxidation at a desired level. This process is accomplished by

moderately heating tea leaves, thus deactivating their oxidative enzymes and removing unwanted scents in the leaves, without damaging the flavour of the tea. Traditionally, the tea leaves are panned in a wok or steamed, but with advancements in technology, kill-green is sometimes done by baking or *panning* in a rolling drum. In some white teas and some black teas such as CTC blacks, kill-green is done simultaneously with drying.

6. **Sweltering / yellowing**: Unique to yellow teas, warm and damp tea leaves from after kill-green are allowed to be lightly heated in a closed container, which causes the previously green leaves to turn yellow. The resulting leaves produce a beverage that has a distinctive yellowish-green hue due to transformations of the leaf chlorophyll. Through being sweltered for 6–8 hours at close to human body temperatures, the amino acids and polyphenols in the processed tea leaves undergo chemical changes to give this tea its distinct briskness and mellow taste.

7. **Rolling / shaping**: The damp tea leaves are then rolled to be formed into wrinkled strips, by hand or using a rolling machine which causes the tea to wrap around itself. This rolling action also causes some of the sap, essential oils, and juices inside the leaves to ooze out, which further enhances the taste of the tea. The strips of tea can then be formed into other shapes, such as being rolled into spirals, kneaded and rolled into pellets, or tied into balls, cones and other elaborate shapes. In many types of oolong, the rolled strips of tea leaf are then rolled into spheres or half spheres and this is typically done by placing the damp leaves in large cloth bags, which are then kneaded by hand or machine in a specific manner. The tea can also be pressed into bricks through the use of heavy stones or presses.

8. **Drying**: Drying is done to finish the tea for sale. This can be done in a myriad of ways including panning, sunning, air drying, or baking. Baking is usually the most common. Great care must be taken to not over-cook the leaves. The drying of the produced tea is responsible for many new flavour compounds particularly important in green teas.
9. **Aging / curing**: While not always required, some teas require additional aging, fermentation, or baking to reach their drinking potential. For instance, a green tea puerh, prior to curing into a post-fermented tea, is often bitter and harsh in taste, but becomes sweet and mellow through fermentation by age or dampness. Additionally, oolong can benefit from aging if fired over charcoal. Flavoured teas are manufactured in this stage by spraying the tea with aromas and flavours or by storing them with their flavorants.
10. **Sorting**: Tea sorting can help remove physical impurities, such as stems and seeds. Using sorting equipment to improve tea production efficiency is very common in tea processing plants, especially in black tea processing. A Color sorter may also be used to classify final product grades according to color and shape.

Processing of Coffee

1. Picking the Ripe red coffee cherries
2. The cherries are washed. This removes any undesirable excess material, such as dirt and stones
3. The pulping stage extracts the two coffee beans inside a coffee cherry and removes red skin and fruit pulp. Removed pulp is placed back in the plantation as fertiliser.
4. The coffee beans are allowed to ferment in a fermentation box, which increases their roasted flavour via a sequence of chemical reactions.The coffee is

washed once again to remove any leftover excess materials from the pulping stage. This washing stage brings the coffee's moisture level to 57%.

5. A final drying stage is used to lower the moisture down to less than 12.5%

DRYING METHODS

The coffee may be dried be mechanical means by a manmade dryer, by the sun, or by both.

When sun-drying is used, the beans are laid out on brick or concrete patios. Sometimes these aren't available and the beans are instead laid out on netting made of fine mesh wire which is preferable . Frequent turning occurs so that the drying is even all over the bean, and takes anywhere from 8 to 10 days to complete. This is of course dependent upon humidity and temperature, both of which can help or hinder this method.

Hot-air drying machines make this process much faster, especially for large coffee farms where many coffee beans require processing at once and there may not be enough patio space to sun-dry all the beans. However, it can be easy to accidentally damage the coffee beans and ruin their cup quality, so monitoring the machines and beans inside them carefully is a necessity.

DRY METHOD:

Jam-like fruit flavours accompany coffees processed using this method, with a heavy body and a strong cup. The method is also known as "neutral", and as one of the most dated methods around, does not necessitate the use of much machinary.

In the dry method, the entire hand-picked coffee cherry is dried. This process has a number of differences depending on which group of people is carrying out the task, what facilities can be used, and the entire plantation's size.

1. Sorting must first take place in order to eradicate any damaged, unripe, or otherwise defective cherries. Since the cherries are not washed in the same way as they are in the wet method, excess waste like soil and twigs is usually removed by

hand using a seive. If a washing channel is available, however, the cherries can be floated in it and the excess can be removed in this way.

2. As with the wet method, he coffee is then dried – however, the fruit is still covering the beans in the dry method. Even drying may only be assured by turning the coffee regularly. Because the beans are still covered by their protective layer of cherry it can take much longer for the coffee to reach the goal of a moisture level of less than 12.5% – up to four weeks, depending on the weather. Larger farms and plantations may consider machine-drying after the coffee has rested in the sun for a few days, in order to make the process overall less time-consuming.
3. After the cherries have properly dried, they are then held by large coffee silos and sent to a mill. The mill will hull, sort and grade the coffee, and the hulling process will remove the fruit.

Coffee Fermentation

The coffee beans covered in the slippery mucilage can be sent to the patios to dry as pulped natural coffees or can be sent to coffee fermentation tanks. The coffee fermentation tanks are used to remove the mucilage before drying. The pulped coffee beans are put into cement tanks with water and are allowed to ferment for 16-36 hours. On the way to the fermentation tanks, another density separation can occur. The highest quality coffees are the densest and should be separated and fermented in a different tank.

PUPLED NATURAL / HONEY PROCESS:

This processing method produces balanced and sweet coffees, taking the best from both worlds; they are uniform and far cleaner than natural drying, but are less thin and have a lower acidity than what the wet processed provides.

After going through the pulping machinery, the coffee is dried on parchment, like with the wet method.

You can produce a particular type of coffee called Honey Coffee by washing the beans less, thus keeping the protective mucilage on the bean. For this method you also need to leave out the fermentation stage, so that silverskin is not removed. As the mucilage has a lot of sugar this produces very sweet coffee with beautiful honey qualities. The beans can literally ooze this substance during the drying process.

Brazil is particularly famous for this method, as it was one of the first countries to produce honey coffee, and is renowned the world over as having some of the best natural pulped coffees. However, this process may only be used in countries with low humidity, as the coffee must be quickly dried for optimum results.

WET HULLED/SEMI WASHED:

Many prized coffees are produced through this method. It results in an earthy, rustic cup, often also coming with an aroma of sweet chocolate and a pleasant earthiness.

Nutrition information

Black coffee contains no significant amounts of the macronutrients, fat, carbohydrate and protein and therefore contains only 1-2 kcal per 100ml[34].

However, the final nutritional profile of a cup of coffee will be affected by several factors:

- The addition of milk, cream, sugar or other sweeteners to taste will affect the final nutritional value and may increase the calorie content.
- The variation in cup sizes used across Europe may alter the nutritional value.

Black coffee contains a number of micronutrients, notably potassium, magnesium and niacin. The sodium level is very low.

Processing of Cocoa

Cleaning cocoa beans

Raw cocoa beans usually contain some impurities, such as dirt, sand, leaves and so on. For the safety of food production and the processing quality of cocoa powder and cocoa butter, the first step of the treatment is carried out with a cocoa cleaning and stone removing machine.

2. Roasting cocoa

Roast raw cocoa beans to reduce moisture, while the temperature and time of roasting will determine the aroma and flavor of the chocolate.

3. Peeling and crushing cocoa beans

The roasted cocoa beans become cocoa nibs after being peeled and crushed. Cocoa nibs are the raw materials for making chocolate. This cocoa nib is not suitable for direct consumption and is bitter.

4. Grinding - produce cocoa mass

After the cocoa nibs are heated and grinded by cocoa grinding machine, they become a flowing paste and become a "cocoa mass". After cooling, they form a hard block and become a "cocoa liquor". The cocoa liquor adds various secondary materials to form chocolate of various flavors.

Pressing

Cocoa liquor contains about 55% fat. If you press the cocoa liquor by cocoa butter press machine, you can extract the "cocoa oil" (the same as soybean extract soybean oil).

2. Filtration

Filter and remove some residues contained in cocoa oil to ensure its purity.

3. Cooling

Cocoa oil cools to become a cocoa butter solid, which is rich in natural hot oils and is a must-have for chocolate artisans to make a variety of glamorous chocolates.

After cocoa liquor squeezes out the cocoa butter, the remaining chunk is called cocoa cake. Because of its large volume, it is first coarsely pulverized into a powder.

Fine crushing

The second time, fine pulverization is carried out to produce more fine cocoa powder and improve the quality.

Processing of Spices

Spices play an important role in enhancing the flavor and taste of the processed foods. In addition, medicine industry is a major consumer of spices. Spice shall mean or to be applied to any dried, fragrant, aromatic or pungent, edible vegetable or plant substance, in the whole, broken or ground form, which contributes flavor; whose primary function in food is seasoning rather than nutrition, and which may contribute relish or piquancy to foods or beverages that is true to name, and from which no portion of any volatile oil or other flavoring principle has been purposely removed, or which no additive or spent spice has been added. Spices may be either the bark, buds, bulbs, flowers, fruit, leaves, rhizome, roots, seeds, stigmas and styles or the entire plant tops.

Condiments:

A condiment is a spice, sauce, or spice mixture that is mainly added to different food dishes to contribute a specific flavor, to improve its flavor, or in some nations, to supplement the dish. It is mainly added to food immediately before consumption. Food items such as pickles, sauces, mustards, etc. are considered to be condiments.

Condiments and spices are substances which are used as adjuncts to food, and which in themselves supply but little nourishment, their effect being mainly of a stimulating character either to the nerves of taste or secretion. They add flavor to otherwise insipid food, and relieve monotony in diet.

Spices have been an integral part of the Indian diet, and the demand for spices has been growing year after year. India has certain natural comparative advantages with respect to production and utilization of spices; these include diverse agro-climatic production environments, availability of innumerable varieties and cultivars of each spice suitable for different climatic conditions, cheap labor, large domestic market and a strong tradition of using spices and their products in food, medicine and cosmetics. India is the largest producer, consumer, and exporter of spices in the world. India, known as the home of spices, boasts a long history of trading with the ancient civilizations of Rome and China. Today, Indian spices are the most sought-after globally, given their exquisite aroma, texture, taste and medicinal value. India has the largest domestic market for spices in the world. Traditionally, spices in India have been grown in small land holdings, with organic farming gaining prominence in recent times

The increasing sale of Condiments is driven by its diverse application across the food industries. The rich flavor imparted by the condiments to the food preparations is considered a major driver for the product. Technology developments in developed regions has led to the innovation in flavors along with increasing the shelf-life of the Condiments which has supported its sale globally. High focus on research and development sector of the food industries has influenced the positive growth rate of the market.

Cold Storage

They are based on the freezing of foods, slowing the growth of bacteria, subjecting them to low temperatures.

Freezing food is the art of preparing, packaging and freezing food at its peak of freshness. You can freeze most fresh vegetables and fruits, meats and fish, breads and pastries, clear soups and casseroles.

1- Refrigeration

In refrigeration it does not imply placing food below 0 degrees centigrade, but these are subject to a delay in those catalysts in their composition that prevent the bacteria from being born or reproduced.

2- Freezing

Unlike refrigeration, foods are subjected to temperatures below zero, which causes all the liquid present in them to solidify, forming ice.

This method allows the preservation of meat, poultry and fish for a very long time, even though its quality deteriorates after the expiration date.

3- Ultra-freezing

Taken to extremes, deep freezing is the method by which food is processed by immersion in liquids at very low temperature. It is not a domestic method.

Heat conservation

Heat treatment is one of the most important conservation techniques of long duration. Its purpose is to destroy and totally or partially inhibit enzymes and microorganisms that could alter the food or render it improper for human consumption.

In general terms, the higher the temperature and the longer the term, the greater the effect.

However, we must also take into account the thermal resistance of microorganisms and enzymes, whose strength may vary according to the time of year and where they are.

4- Sterilization

Sterilization involves exposing the food to a temperature generally above 100 ° C for a period sufficient to inhibit enzymes and all forms of microorganisms, including bacterial spores or residues.

Sterilization is not sufficient in itself, as subsequent contamination by the environment of microorganisms can occur, so it is necessary to resort to the subsequent sterilization of containers and containers.

5- Pasteurization

Pasteurization is a heat treatment sufficient to moderate and destroy the microorganisms with their pathogens, counting among them a number of altering microorganisms and fungi.

The temperature of the treatment usually goes below 100 ° C, having a duration time of from a few seconds to several minutes, depending on the case.

6- Scalding

It is a heat treatment of a few minutes that oscillates between the 70 ° C and 100 ° C to destroy the enzymes that affect the vegetables or fruits before their later processing (freezing, drying, etc.).

This treatment kills part of the microorganisms, fixes the natural color and eliminates the air inside the product by expansion, which being otherwise could end in decomposition.

Chemical Methods

The use of chemical substances for the conservation of foodstuffs began when man learned to protect each crop until the next, and to preserve meat and fish by salting or smoking them.

Egyptians, for example, used dyes and scents to increase the appeal of certain foodstuffs, and the Romans have used nitrate (or nitrate for proper preservation).

7- Salting

Salar, as it is commonly called, is a technique that lives and is still carried out using the same methods and processes. Salt is able to preserve most of the food products for months or even years.

At the same time, this method of conservation confers flavor to foods whose refinement derives from its high degree of salinity.

8- Acidification

This process is carried out with the aim of reducing and eliminating almost all the PH of the food in question to avoid the birth of germs that would cause serious diseases to the human organism. One quite common example is soaking the lettuce in vinegar. This process prevents the spread of amebiasis by means of this vegetable.

9- Additives

Most of the food preservation methods used today employ some kind of chemical additive to reduce spoilage.

All are designed to kill or slow the growth of pathogens, or to prevent and slow chemical reactions that lead to oxidation of food.

A special class of oxidation-reducing additives are known as sequestrants. The sequestrants are compounds that capture metal ions, such as copper, iron and nickel; And remove them from contact with food.

The removal of these ions helps to preserve food because in their free state they increase the speed of oxidation of food.

Gums and starches are highly functional ingredients in snack foods, beverages, cereal products and other food systems mainly due to viscosity, water-binding and gelling properties. Viscosity ranges of hydrocolloids can vary significantly (from 10 cps to 4,000 cps at 1% gum level) due to their chemical nature, degree of branching and polymerization.

Hydrocolloid gums, when combined with unmodi- fied starches, can help increase moisture retention, reduce ice crystal growth, act as suspending and adhesive agents, inhibit weeping (syneresis), stabilize foam and emulsions, and improve freeze/thaw stability. Some seaweed extracts, such as agar, carrageenan, pectins and alginates, work as gelling agents in pie fillings, icings and glazes. As a source of fiber, gums such as gum acacia, pectin and guar gum can be used at levels compatible with the end product.

Individual achievements

While all the natural gums share general functionalities in stabilizing foods and beverages, the specifics vary widely. The product designer needs to consider the strengthsand weaknessesof each when choosing the appropriate gum or blend.

Agar, derived from red seaweeds, consists of two repeating units of polysaccharides: alpha-D-galactopyranosyl and 3,6-anhydro-alpha-L-galactopyranosyl alternating segments. The gelling component is known as agarose. Traditional agar can bind about 100 times its weight of water and, when boiled to 212°F and cooled, forms a strong gel. It is one of the most-potent gel-forming gums known and is unique among gums in that the gelation temperature is far below the gel-melting temperature. A solution of agar (1.5%) congeals in the range of 32° to 39°C (89.6° to 102.2°F) but does not melt below 85°C (185°F). This temperature difference between gelation and liquefaction is important for many food applications. For example, the high melting point of agar is important in icing formulations for bakery products and gelled confections stored and/or transported at high temperatures.

A more-recent type of agar does not require boiling, unlike traditional agar. The seaweed sources (Gelidium, Gelidiella or Gracilaria species) are subjected to a series of manufacturing procedures that yield a natural product that can be hydrated at 170° to 180°F, instead of 212°F. This is a desirable feature, considering the expense of boiler operations. A gum system with nonboiling agar and other hydrocolloids has been developed to replace gelatin as the gelling agent in yogurt and other dairy products.

Carrageenan, a water-soluble gum, is isolated from red seaweeds like Eucheuma, Gigartina and Chondrus, among others. Consisting of sulfated linear polysaccharides of D-galactose and 3,6-anhydro-D-galactose, carrageenans act as anionic polyelectrolytes. Due to the presence of the half-ester sulfate groups, a reaction occurs with charged amino-acid chains of proteins to form stable gels or to act as thickeners. The three common types of carrageenanskappa, iota and lambdadiffer in degree and location of sulfated ester groups and the linkage of the repeating units.

An important property of kappa carra geen an is its ability to form gels in the presence of potassium ions, and also to form rigid gels with locust bean gum. This gel-forming ability is beneficial in preparing piping gels, bakery jellies and similar products. Meat injection with brine mixed with semi-refined, natural carra geen an plus starch can reduce cooking losses in poultry and meat. Lambda carra geen an, a non gelling type, binds or retains moisture, and helps suspend cocoa solids in beverages. Iota carra geen an, which requires calcium ions to form a pliable gel, finds use in many fruit applications.

Alginates contain alginic acid, a high-molecular weight linear polysaccharide, that consists of homo- and heteropolymers with polymannuronic and polyguluronic acid units. The guluronic and mannuronic acid content of the seaweed affects the nature of the gel formed. Sodium alginate, in the presence of calcium ions, yields gels that are not thermally reversible. The method of addition and type of calcium salt added will affect the properties of the final gel. A calcium sequestrant can weaken the gel or delay its gelling time.

Sodium alginates, in combination with xanthan, help increase batter viscosity and increase cake volume. They also act as a cold-water gel base for instant bakery jellies and instant lemon-pie fillings. Freeze/thaw stability of the fillings has been reported to improve in samples treated with alginates. In icings, alginates reduce stickiness and cracking.

Gum acacia, also known as gum arabic, is a heteropolysaccharide consisting of an arabinogalactan complex (about 88.0%), an arabinogalactan-protein complex (10.4%) and a glycoprotein fraction (about 1.2%). It also consists of rhamnose and glucuronic acid, in addition to arabinose and galactose. It has excellent emulsifying properties and is unique among other polysaccharides due to its unusually low viscosity (15 cps at 10% solution). The highly branched, compact structure may account for its low viscosity, which can allow a higher percentage of soluble dietary fiber in beverages. Gum acacia is widely used in the food industry for its emulsifying properties, low viscosity, high fiber content, water-binding capacity, and adhesive and film-forming properties.

Unweighted beverage emulsions (e.g., cola drinks) make use of gum acacia as an emulsifying agent. It is also used as a flavor carrier in spray-dried flavors. Due to its low viscosity, 30% to 40% solutions can be prepared, and flavor oils can be encapsulated to form stable dry powders. Gum acacia is a main component in glazing agents, due to its adhesive properties; it also yields a pliable and stable icing base. As a surfactant and foam stabilizer, it can be used in whipped cream or toppings. Since gum acacia is high in dietary fiber, it can also be used as a texturizer and bulking agent in powdered bakery mixes. It is widely used by the confection industry, as it forms coacervates with gelatin.

Guar gums structural building blocks are the sugars mannose and galactose at a ratio of 2:1. The protein content ranges from 3% to 6%. It swells in cold water and is one of the most highly efficient water-thickening agents in the food industry. It also has a high percentage soluble dietary fiber (80% to 85%). It is a low-cost thickening and stabilizing agent in dressings and sauces. When added to cake mixes, it helps improve moisture retention in the finished product. It is a thickening agent and stabilizer for baked goods. Guar also helps to increase volume in yellow cake, probably by aiding in air entrapment. In combination with other hydrocolloids, guar can increase soluble-dietary-fiber content in bread without negatively impacting grain, mouthfeel, crumb body and taste aroma.

Locust bean gum, a natural polysaccharide, is isolated from the pods of a tree, Ceratonia species, of the legume family. It consists of mannose and galactose sugar units at a ratio of 4:1. Unlike guar, which hydrates rapidly in cold water, locust bean gum has to be heated to 80°C (176°F) for full hydration. Food-grade locust bean gum should have a protein content not exceeding 8%, as specified in the Code of Federal Regulations. FDA classi- fies locust bean gum as a direct food additive.

Solutions of locust bean gum are non-Newtonian and have zero yield value; thus, they flow as soon as slight shear is applied. When combined with xanthan, locust bean gum yields pliable gels. It also acts synergistically with kappa carrageenan to form strong, rigid gels. It is shown to have water-binding properties when used in bread doughs. When used at 0.1% to 0.2% in fruitpie fillings, it prevents the water from boiling out. In gel desserts, locust bean gum retards syneresis, or weeping.

Pectins occur in nature mainly in citrus fruits and apple and can form gels at varying suitable conditions. The main component of pectin is D-galacturonic acid partly esterified with methoxyl groups. Pectins can be classified into high methoxy (HM), low methoxy (LM) and amidated pectins. HM pectins require more than 60% solids and low pH to gel, while LM pectins require calcium and may gel at 25% to 35% solids given the proper gelling conditions. Amidated pectins are usually not considered natural. Heat-reversible bakery jellies may be prepared with HM pectins at 55% to 65% solids. Pectins, in combination with other gums, also inhibit syneresis of pie fillings and glazes. In protein beverages, combining pectin with thickeners like guar gum and xanthan gum can help provide suspension and stability.

Xanthan gum, a highly branched polysaccharide, is a biosynthetic product of a bacteria, Xanthomonas campestris. Hence, it is considered natural by the food industry, and has been allowed for food use by many countries, including the United States and Canada. It consists of repeating units of D-glucose, D-mannose and D-glucuronic acid. Food-grade xanthan is an acid-resistant thickener and stabilizer and has an ash content that does not exceed 9.0%. Xanthan gum solutions are extremely pseudoplastic and exceed most common gums in this aspect. Viscosity is reduced with increasing shear; viscosity is regained after shear is released. This property is an advantage when pumping gum-treated liquids.

Xanthan gum is an excellent emulsion stabilizer in salad dressings and sauces. In bakery fillings, the gum prevents water migration from the filling to the pastry due to its water-binding property. It appears to inhibit starch retrogradation and improves shelf life of the finished product.

Radiations Use of Food Processing

Although scientists have only known about radiation since the 1890s, they have developed a wide variety of uses for this natural force. Today, to benefit humankind, radiation is used in medicine, academics, and industry, as well as for generating electricity.

Medical Uses

Academic and Scientific Applications

Industrial Uses

Nuclear Power Plants

Medical

Hospitals, doctors, and dentists use a variety of nuclear materials and procedures to diagnose, monitor, and treat a wide assortment of metabolic processes and medical conditions in humans. In fact, diagnostic x-rays or radiation therapy have been administered to about 7 out of every 10 Americans. As a result, medical procedures using radiation have saved thousands of lives through the detection and treatment of conditions ranging from hyperthyroidism to bone cancer.

The most common of these medical procedures involve the use of x-rays — a type of radiation that can pass through our skin. When x-rayed, our bones and other structures cast shadows because they are denser than our skin, and those shadows can be detected on photographic film. The effect is similar to placing a pencil behind a piece of paper and holding the pencil and paper in front of a light. The shadow of the pencil is revealed because most light has enough energy to pass through the paper, but the denser pencil stops all the light. The difference is that x-rays are invisible, so we need photographic film to "see" them for us. This allows doctors and dentists to spot broken bones and dental problems.

X-rays and other forms of radiation also have a variety of therapeutic uses. When used in this way, they are most often intended to kill cancerous tissue, reduce the size of a tumor, or reduce pain. For example, radioactive iodine (specifically iodine-131) is frequently used to treat thyroid cancer, a disease that strikes about 11,000 Americans every year.

X-ray machines have also been connected to computers in machines called computerized axial tomography (CAT) or computed tomography (CT) scanners. These instruments provide doctors with color images that show the shapes and details of internal organs. This helps physicians locate and identify tumors, size anomalies, or other physiological or functional organ problems.

Academic and Scientific Applications

In addition, hospitals and radiology centers perform approximately 10 million nuclear medicine procedures in the United States each year. In such procedures, doctors administer slightly radioactive substances to patients, which are attracted to certain internal organs such as the pancreas, kidney, thyroid, liver, or brain, to diagnose clinical conditions.

Universities, colleges, high schools, and other academic and scientific institutions use nuclear materials in course work, laboratory demonstrations, experimental research, and a variety of health physics applications. For example, just as doctors can label substances inside people's bodies, scientists can label substances that pass through plants, animals, or our world. This allows researchers to study such things as the paths that different types of air and water pollution take through the environment. Similarly, radiation has helped us learn more about the types of soil that different plants need to grow, the sizes of newly discovered oil fields, and the tracks of ocean currents. In addition, researchers use low-energy radioactive sources in gas chromatography to identify the components of petroleum products, smog and cigarette smoke, and even complex proteins and enzymes used in medical research.

Archaeologists also use radioactive substances to determine the ages of fossils and other objects through a process called carbon dating. For example, in the upper levels of our atmosphere, cosmic rays strike nitrogen atoms and form a naturally radioactive isotope called carbon-14. Carbon is found in all living things, and a small percentage of this is carbon-14. When a plant or animal dies, it no longer takes in new carbon and the carbon-14 that it accumulated throughout its life begins the process of radioactive decay. As a result, after a few years, an old object has a lower percent of radioactivity than a newer object. By measuring this difference, archaeologists are able to determine the object'

Industry

We could talk all day about the many and varied uses of radiation in industry and not complete the list, but a few examples illustrate the point. In irradiation, for instance, foods, medical equipment, and other substances are exposed to certain types of radiation (such as x-rays) to kill germs without harming the substance that is being disinfected — and without making it radioactive. When treated in this manner, foods take much longer to spoil, and medical equipment (such as bandages, hypodermic syringes, and surgical instruments) are sterilized without being exposed to toxic chemicals or extreme heat. As a result, where we now use chlorine — a chemical that is toxic and difficult-to-handle — we may someday use radiation to disinfect our drinking water and kill the germs in our sewage. In fact, ultraviolet light (a form of radiation) is already used to disinfect drinking water in some homes.

Similarly, radiation is used to help remove toxic pollutants, such as exhaust gases from coal-fired power stations and industry. For example, electron beam radiation can remove dangerous sulphur dioxides and nitrogen oxides from our environment. Closer to home, many of the fabrics used to make our clothing have been irradiated (treated with radiation) before being exposed to a soil-releasing or wrinkle-resistant chemical. This treatment makes the chemicals bind to the fabric, to keep our clothing fresh and wrinkle-free all day, yet our clothing does not become radioactive. Similarly, nonstick cookware is treated with gamma rays to keep food from sticking to the metal surface.

The agricultural industry makes use of radiation to improve food production and packaging. Plant seeds, for example, have been exposed to radiation to bring about new and better types of plants. Besides making plants stronger, radiation can be used to control insect populations, thereby decreasing the use of dangerous pesticides. Radioactive material is also used in gauges that measure the thickness of eggshells to screen out thin, breakable eggs before they are packaged in egg cartons. In addition, many of our foods are packaged in polyethylene shrinkwrap that has been irradiated so that it can be heated above its usual melting point and wrapped around the foods to provide an airtight protective covering.

All around us, we see reflective signs that have been treated with radioactive tritium and phosphorescent paint. Ionizing smoke detectors, using a tiny bit of americium-241, keep watch while we sleep. Gauges containing radioisotopes measure the amount of air whipped into our ice cream, while others prevent spillover as our soda bottles are carefully filled at the factory.

Engineers also use gauges containing radioactive substances to measure the thickness of paper products, fluid levels in oil and chemical tanks, and the moisture and density of soils and material at construction sites. They also use an x-ray process, called radiography, to find otherwise imperceptible defects in metallic castings and welds. Radiography is also used to check the flow of oil in sealed engines and the rate and way that various materials wear out. Well-logging devices use a radioactive source and detection equipment to identify and record formations deep within a bore hole (or well) for oil, gas, mineral, groundwater, or geological exploration. Radioactive materials also power our dreams of outer space, as they fuel our spacecraft and supply electricity to satellites that are sent on missions to the outermost regions of our solar system.

Irradiation has both direct and indirect effects on biological materials. The direct effects are due to the collision of radiation with atoms, resulting in an ejection of electrons from the atoms. The indirect effects are due to the formation of free radicals (unstable molecules carrying an extra electron) during the radiolysis (radiation-induced splitting) of water molecules. The radiolysis of water molecules produces hydroxyl radicals, highly reactive species that interact with the organic molecules present in foods. The products of these interactions cause many of the characteristics associated with the spoilage of food, such as off-flavours and off-odours.

Safety concerns

Based on the beneficial effects of irradiation on certain foods, several countries have permitted its use for specific purposes, such as the inhibition of sprouting of potatoes, onions, and garlic; the extension of shelf life of strawberries, mangoes, pears, grapes, cherries, red currants, and cod and haddock fillets; and the insect disinfestation of pulses, peanuts, dried fruits, papayas, wheat, and ground-wheat products.

The processing room used for irradiation of foods is lined with lead or thick concrete walls to prevent radiation from escaping. The energy source, such as a radioactive element or a machine source of electrons, is located inside the room. (Radioactive elements such as ^{60}Co are contained in stainless steel tubes. Because an isotope cannot be switched on or off, when not in use it is lowered into a large reservoir of water.) Prior to the irradiation treatment, personnel vacate the room. The food to be irradiated is then conveyed by remote means into the room and exposed to the radiation source for a predetermined time. The time of exposure and the distance between the radiation source and the food material determine the irradiation treatment. After treatment, the irradiated food is conveyed out of the room, and the radioactive element is again lowered into the water reservoir.

Large-scale studies conducted around the world have concluded that irradiation does not cause harmful reactions in foods. In 1980 a joint committee of the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), and the World Health Organization (WHO) declared that an overall average dose of radiation of 10 kilograys was safe for food products. The maximum energy emitted by ^{60}Co and ^{137}Cs is too low to induce radioactivity in food. The energy output of electron-beam generators is carefully regulated, and the recommended energy outputs are too low to cause radioactivity in foods.

Food irradiation is the process of exposing food and food packaging to ionizing radiation. Ionizing radiation, such as from gamma rays, x-rays, or electron beams, is energy that can be transmitted without direct contact to the source of the energy (radiation) capable of freeing electrons from their atomic bonds (ionization) in the targeted food. The radiation can be emitted by a radioactive substance or generated electrically. This treatment is used to improve food safety by extending product shelf-life (preservation), reducing the risk of foodborne illness, delaying or eliminating sprouting or ripening, by sterilization of foods, and as a means of controlling insects and invasive pests. Food irradiation primarily extends the shelf-life of irradiated foods by effectively destroying organisms responsible for spoilage and foodborne illness and inhibiting sprouting.

Consumer perception of foods treated with irradiation is more negative than those processed by other means. The food is never in contact with the ionizing source, but still kills the living bacteria in the food. All independent research, the U.S. Food and Drug Administration (FDA), the World Health Organization (WHO), the Centers for Disease Control and Prevention (CDC), and U.S. Department of Agriculture (USDA) have performed studies that confirm irradiation to be safe. In order for a food to be irradiated in the US, the FDA will still require that the specific food be thoroughly tested for irradiation safety.

Food irradiation is permitted by over 60 countries, with about 500,000 metric tons of food annually processed worldwide. The regulations that dictate how food is to be irradiated, as well as the food allowed to be irradiated, vary greatly from country to country. In Austria, Germany, and many other countries of the European Union only dried herbs, spices, and seasonings can be processed with irradiation and only at a specific dose, while in Brazil all foods are allowed at any dose

Irradiation is used to reduce or eliminate the risk of food-borne illnesses, prevent or slow down spoilage, arrest maturation or sprouting and as a treatment against pests. Depending on the dose, some or all of the pathogenic organisms, microorganisms, bacteria, and viruses present are destroyed, slowed down, or rendered incapable of reproduction. Irradiation cannot return spoiled or over-ripe food to a fresh state. If this food was processed by irradiation, further spoilage would cease and ripening would slow down, yet the irradiation would not destroy the toxins or repair the texture, color, or taste of the food. When targeting bacteria, most foods are irradiated to significantly reduce the number of active microbes, not to sterilize all microbes in the product. In this respect it is similar to pasteurization.

Irradiation is used to create safe foods for people at high risk of infection, or for conditions where food must be stored for long periods of time and proper storage conditions are not available. Foods that can tolerate irradiation at sufficient doses are treated to ensure that the product is completely sterilized. This is most commonly done with rations for astronauts, and special diets for hospital patients.

Irradiation is used to create shelf-stable products. Since irradiation reduces the populations of spoilage microorganisms, and because pre-packed food can be irradiated, the packaging prevents recontamination of the final product.

Irradiation is used to reduce post-harvest losses. It reduces populations of spoilage micro-organisms in the food and can slow down the speed at which enzymes change the food, and therefore slows spoilage and ripening, and inhibits sprouting (e.g., of potato, onion, and garlic).

Food is also irradiated to prevent the spread of invasive pest species through trade in fresh vegetables and fruits, either within countries, or trade across international boundaries. Pests such as insects could be transported to new habitats through trade in fresh produce which could significantly affect agricultural production and the environment were they to establish themselves. This "phytosanitary irradiation" aims to render any hitch-hiking pest incapable of breeding. The pests are sterilized when the food is treated by low doses of irradiation. In general, the higher doses required to destroy pests such as insects, mealybugs, mites, moths, and butterflies either affect the look or taste, or cannot be tolerated by fresh produce.Low dosage treatments (less than 1000 gray) enables trade across quarantine boundaries and may also help reduce spoilage.

Food quality

Ionizing radiation can change food quality but in general very high levels of radiation treatment (many thousands of gray) are necessary to adversely change nutritional content, as well as the sensory qualities (taste, appearance, and texture). Irradiation to the doses used commercially to treat food have very little negative impact on the sensory qualities and nutrient content in foods. When irradiation is used to maintain food quality for a longer period of time (improve the shelf stability of some sensory qualities and nutrients) the improvement means that more consumers have access to the original taste, texture, appearance, and nutrients. The changes in quality and nutrition depend on the degree of treatment and may vary greatly from food to food.

There has been low level gamma irradiation that has been attempted on arugula,] spinach, cauliflower, ash gourd, bamboo shoots, coriander, parsley, and watercress. There has been limited information, however, regarding the physical, chemical and/or bioactive properties and the shelf life on these minimally processed vegetables.

There is some degradation of vitamins caused by irradiation, but is similar to or even less than the loss caused by other processes that achieve the same result. Other processes like chilling, freezing, drying, and heating also result in some vitamin loss.

The changes in the flavor of fatty foods like meats, nuts and oils are sometimes noticeable, while the changes in lean products like fruits and vegetables are less so. Some studies by the irradiation industry show that for some properly treated fruits and vegetables irradiation is seen by consumers to improve the sensory qualities of the product compared to untreated fruits and vegetables.

Quality Impact on Minimally Processed Vegetables[edit]

Watercress (*Nasturtium Officinale*) is a rapidly growing aquatic or semi aquatic perennial plant. Because chemical agents do not provide efficient microbial reductions, watercress has been tested with gamma irradiation treatment in order to improve both safety and the shelf life of the product. It is traditionally used on horticultural products to prevent sprouting and post-packaging contamination, delay post-harvest ripening, maturation and senescence.

In a Food Chemistry food journal, scientists studied the suitability of gamma irradiation of 1, 2, and 5 kGy for preserving quality parameters of the fresh cut watercress at around 4 degrees Celsius for 7 days. They determined that a 2 kGy dose of irradiation was the dose that contained most similar qualities to non-stored control samples, which is one of the goals of irradiation. 2 kGy preserved high levels of reducing sugars and favoured polyunsaturated fatty acids (PUFA); while samples of the 5 kGy dose revealed high contents of sucrose and monounsaturated fat (MUFA). Both cases the watercress samples obtained healthier fatty acids profiles. However, a 5kGy dose better preserved the antioxidant activity and total flavonoids.

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CHEMICAL PRESERVATION OF FOOD

Introduction

Preservative for food may be defined as any chemical compound and/or process, when applied to food, retard alterations caused by the growth of microorganisms or enable the physical properties, chemical composition and nutritive value to remain unaffected by microbial growth. Some chemicals have been used traditionally since several decades as direct or indirect inhibitors of microbial growth and are still widely used despite their limitations

The majority of food preservation operations used today also employ some kind of chemical additive to reduce spoilage. Of the many dozens of chemical additives available, all are designed either to kill or retard the growth of pathogens or to prevent or retard chemical reactions that result in the oxidation of foods.

Some familiar examples of the former class of food additives are sodium benzoate and benzoic acid; calcium, sodium propionate, and propionic acid; calcium, potassium, sodium sorbate, and sorbic acid; and sodium and potassium sulfite. Examples of the latter class of additives include calcium, sodium ascorbate, and ascorbic acid (vitamin C); butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT); lecithin; and sodium and potassium sulfite and sulphur dioxide.

Classification of Preservatives

According to FSSA rules → class I and class II preservatives

Class I preservatives

a. Common salt
b. Sugar
c. Dextrose
d. Glucose
e. Spices
f. Vinegar or acetic acid
g. Honey
h. Edible vegetable oil

Addition of class I preservatives in any food is not restricted, unless otherwise provide in the rule.

Class II preservatives

a. Benzoic acid including salts their of
b. Sulphurous acid including salts theirof
c. [Nitrates of] nitrites of sodium or potassium
d. Sorbic acid including its sodium, potassium and calcium salts
e. Nicin
f. Propionic acid including salts theirof
g. Methyl or propyl para-hydroxy benzoate
h. Sodium diacetate
i. Sodium, potassium and calcium salts of lactic acid

Use of class II preservatives is restricted. They shall be added to only specified product and at a concentration not exceeding the proportion specified for the product

Use of more than one class II preservative is prohibited. No person shall use in or upon a food more than one class II preservative

Benzoic acid and its salt

Widely use as an antimicrobial agent. Benzoate is more effective against yeasts and bacteria than molds. Antimicrobial activity is achieved by inhibition in enzymatic system of microbial cells, affecting acetic acid metabolism, citric acid cycle and oxidative phosphorylation.

Antimicrobial activity is affected by pH of medium The maximum inhibition occurs at pH value of 2.5 to 4.0 and it decreases when pH rises above 4.5.

The food products preserved with the benzoate include fruit juices and drinks, salads, jams and jellies, pickles, dried fruits and preserves, ketch up and sauce, syrup, carbonated beverages, bakery items, salad dressings, margarine and other fat spreads, spices.

Sulphur dioxide and sulfites

Sulphur dioxide (SO2) gas is one of the oldest antimicrobial agents. It is a colourless, nonflammable gaseous compound or liquid under pressure with a suffocating pungent odour. When dissolved in water of foods, it yields sulphurous acid and its ions, owing to its solubility in water.

Sulphite salts such as sodium sulphite, sodium bisulphite, potassium sulphite, potassium bisulphite, sodium metabisulphite, potassium metabisulphite used as preservatives. When dissolved in water, form sulphurous acid, bisulphite and ions. Sulphurous acid formed from these compounds is an active antimicrobial substance. The effectiveness of sulphurous acid is enhanced at low pH values. Antimicrobial activity of sulfites against yeasts, molds and bacteria is selective, with certain species being more sensitive to inhibition them others. Bacteria are generally more sensitive to inhibition than yeasts and molds. In addition to antimicrobial action, they are also used, to prevent enzymatic and non enzymatic changes as well as discoloration in some foods. Sulphur dioxide and sulphites are used in fruit products such as fruit juice concentrate, squashes, pickles and chutneys.

Sorbic acid and its salts

Sorbic acid and its salts (calcium, potassium or sodium salts) are effective antimicrobial agents against yeast and molds, as well as bacteria. They are less effective against bacteria. Sorbate has an upper pH limit for activity around 6.0-6.5. The food products preserved with sorbates are carbonated beverages, salad dressings, tomato products, jams, jellies, syrup, candy and chocolate syrup, cheese, sausages, smoked fish, fruit juices, grains, breads and cakes.

Propionic acid and its salts

Propionic acid & its salts (Ca & Na) are used most extensively in the prevention of mold growth and rope development in baked goods and for mold inhibition in many cheese foods and spreads. They are more effective against molds as compared to yeasts and bacteria. Propionates has an upper pH limit for activity around 5 to 6.

Lactic acid and its salts

Lactic acid is formed during fermentation of lactose by lactic acid bacteria. Lactic acid & its salts are not very common & not easily available. It can be used in pickles (with acetic acid), fermented dough crispy biscuits, some beverages, dairy products & meat & meat products. Calcium lactate is used as a firming agent in pickles, fruits & vegetables. Na & K lactate are also recommended with sodium diacetate for control of food poisoning & other bacteria in meat product.

Acetic acid

Acetic acid has antimicrobial properties. The action tends to be static rather than cidal. It is more effective against bacteria & yeast then molds. A 5 to 10 % solution of acetic acid is known as Vinegar. Acetic acid in the form of vinegar is used in mayonnaise, pickles, sauce, pickled sausage etc.

Sodium chloride (common salt)

Antimicrobial action of NaCl arises from its lowering water activity (aw) of the food product. This reduces available water in food to the extent which renders condition unfavorable for microbial growth. At higher concentration it has a pronounced bacteriostatic action. The 10% NaCl inhibits the growth of most bacteria. Delaying action upon microorganisms- Creates dehydration of microbial cell—by osmosis—altering results into plasmosis of the cell. Reduction in solubility of oxygen in water decreases oxygen level in food—reduce growth of aerobic microorganisms. It is more effective against bacteria & mold compare to yeast.

One of the traditional method of food preservation. Mainly used to preserve pickles, meat & fish. Fish is usually salted by immersing in brine or by mixing with dry salt. High important as a preservative for cheese & table butter. Depending upon type of cheese salt content varied from 1 to 5 %. In table butter salt is added at a max concentration as 3%.

Sucrose (sugar)

More effective against bacteria & mold compared to yeast. Antimicrobial action of sucrose arises from, lowering water activity (aw) of the food product—reduce the available water in food to the extent which renders condition unfavourable for microbial growth. This creates dehydration of microbial cell—by osmosis results into plasmosis of the cells. The food products preserved with sugar are fruit products (jam, jellies, squash etc.), dairy products (sweetened condensed milk, sweets).

Antioxidants

The free radical pathway fThe oxidation process spoils most food, especially those with a high fat content. Fats quickly turn rancid when exposed to oxygen. Antioxidants prevent or inhibit the oxidation process. The most common antioxidant additives are ascorbic acid (vitamin C) and ascorbates Thus, antioxidants are commonly added to oils, cheese, and chips. Other antioxidants include the phenol derivatives BHA, BHT, TBHQ and propyl gallate. These agents suppress the formation of hydroperoxides. Other preservatives include ethanol and methylchloroisothiazolinone

Drying

Main article: Food drying

In ancient times the sun and wind naturally dried out foods. Middle Eastern and Oriental cultures started drying foods in 1,200 B.C. in the sun. The Romans used a lot of dry fruit. In the Middle Ages, people made “still houses” where fruits, vegetables, and herbs could dry out in climates that did not have strong sunlight. Sometimes fires were made to create heat to dry foods. Drying prevents yeasts and bread molds (*Rhizopus*) from growing by removing moisture so bacteria cannot grow.

Freezing

Main article: Frozen food

Cellars, caves, and cool streams were used for freezing. American estates had ice houses built to store ice and food on the ice. The icehouse was then converted to an "icebox". The Icebox was converted in the 1800s to mechanical refrigeration. Clarence Birdseye found in the 1800s that freezing meats and vegetables at a low temperature made them taste better

Fermenting

Main article: Fermentation in food processing

Fermenting was discovered when a few grains of barley were left in the rain and turned into beer. Microorganisms ferment the starch-derived sugars into alcohols. This is also how fruits are fermented into wine and cabbage into Kimchi or sauerkraut. Anthropologists believe that as early as 10,000 B.C people began to settle and grow barley. They began to make beer and believed that it was a gift from gods. It was used to preserve foods and to create more nutritious foods from less desirable ingredients. Vitamins are produced through fermentation by microorganisms making the end product more nutritious.

Pickling

Main article: Pickling

Pickling occurs when foods are placed in a container with vinegar or another acid. It is thought that pickling came about when people used to place food in wine or beer to preserve it due to them having a low pH.

Containers had to be stoneware or glass (vinegar will dissolve metal from pots). After the food was eaten, the pickling brine had other uses. Romans would make a concentrated pickle sauce called “garum”. It was very concentrated and the dish that it would be used in would only need a few drops to get the fish taste. Due to new foods arriving from Europe in the 16th century, food preservation increased. Ketchup originated from Europe as an oriental fish brine and when it made it to America, sugar was added. Pickling sauces were soon part of many recipes such as chutneys, relish, piccalilli, mustard, and ketchup when different spices were added to them.

Curing

Main articles: Curing (food preservation) and Salting (food)

The beginning of curing was done through dehydration. Salting was used by early cultures to help desiccate foods. Many different salts were used from different places such as rock salt, sea salt, spiced salt, etc.. People began to experiment and found in the 1800s that some salts gave meat an appealing red color instead of the grey that they were used to. During their experimenting in the 1920s they realized this mixture of salts were nitrates (saltpeter) that prevented *Clostridium botulinum* growth.

Jam and Jelly

Main article: Fruit preserves

Early cultures also used honey or sugar as a preservatives. Greece used a quince and honey mixture with a slight amount of drying and then tightly packed into jars. The Romans used the same technique but instead cooked the honey and quince mixture to make a solid texture. Indian and Oriental traders brought sugarcane to the northern climates where housewives were then able to make preservatives by heating fruit with the sugarcane.

Canning

Main article: Canning

Canning started in 1790 from a French confectioner, Nicolas Appert, when he found that by applying heat to food in sealed glass bottles, the food is free from spoilage. Appert's ideas were tried by the French Navy with meat, vegetables, fruit, and milk in 1806. An Englishman, Peter Durand decided to use Appert's method on tin cans in 1810. Even though Appert found a method that worked, he did not understand why it worked because many believed that the lack of air caused the preservation. In 1864 Louis Pasteur linked food spoilage/illness to microorganisms. Different foods are placed into jars or cans and heated to a microorganism and enzyme inactivating temperature. They are then cooled forming a vacuum seal which prevents microorganisms from contaminating the foods.