Food processing strategies for quality

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Food processing is the set of methods and techniques used to transform raw ingredients into food or to transform food into other forms for consumption by humans or animals either in the home or by the food processing industry. Food processing typically takes clean, harvested crops or butchered animal products and uses these to produce attractive, marketable and often long shelf-life food products. Similar processes are used to produce animal feed.

Food processing encompasses all the steps that food goes through from the time it is harvested to the time it arrives on consumer’s plate. According to Food and Agriculture Organization (FAO), processed foods can be classified into three types (1) Primary (2) Secondary and (3) Tertiary. The primary processing includes basic cleaning, grading and packaging as in case of fruits and vegetables. Secondary processing includes alteration of the basic product to a stage just before the final preparation as in case of milling of paddy to rice. Tertiary processing leads to a high value-added ready-to eat food like bakery products, instant foods, health drinks, etc.

Traditional food processing had two functions: to make food more digestible and to preserve food during times of scarcity. Most crops are seasonal. There are times of the year when either glut can result in high levels of wastage or shortages can arise if adequate measures are not taken to preserve and store the foods. This is particularly important in areas that have a dry season or winter period when crops cannot be grown and animals are slaughtered because of a lack of fodder. In these situations stored dry grains or root crops provide energy; dried, salted or smoked meats, or cheeses provide a source of protein, vitamins and minerals; and processed fruits and vegetables such as pickles, chutneys or dried fruits or leaves provide

vitamins and minerals. A few crops, including cassava and some types of beans also contain poisons or anti-nutritional components, which must be removed by processing to make the food safe to eat. Hence, Food processing enables to maintain the health of the human beings throughout the year by increasing its food security.

By processing food, it can be customized to suit the nutritional requirements of groups such as the elderly, pregnant women, infants, young children and athletes. Such foods are characterized by a balanced composition of energy suppliers in the form of fats, carbohydrates and proteins, and by a cocktail of vitamins and minerals composed according to the current state of scientific knowledge. Food processing is a route to creating sustainable livelihoods and economic development for rural communities.

Sophisticated technologies define modern food production. They include many areas. Agricultural machinery, led by the tractor, has reduced the human labor in many areas of production. Biotechnology is driving much change, in areas as diverse as agrochemicals, plant breeding and food processing. Many other areas of technology are also involved, to the point where it is hard to find an area that does not have a direct impact on the food industry. Computer technology is also a central force, with computer networks and specialized software providing the support infrastructure to allow global movement of the myriad components involved.

Modern food processing has three major aims:

1. To make food safe (microbiologically, chemically)
2. To provide products of the highest quality (flavour, colour, texture)

3. To make food into forms that is convenient (ease of use)

The following table summarizes the item to be controlled in food processing and comments on the major approaches involved in this control.

To be Controlled

Heat

Cold

Chemicals

Active water

Mechanical

Micro-organisms

Prevents growth

Reduces growth rate

Preservatives retard growth

Do not grow below Aw of 0. 6

Reduces numbers

Enzymes

Destroyed by heat activity

Decrease reaction rate

Modify activity

Alters rate of enzyme activity

increase ES complex formation

Chemical Reactions

Increases chemical rate, browning, oxidation

Reduces reaction rate

May inhibit or activate

Can alter rate of reaction, like oxidation

Not applicable

Physical Structure

Increases effects

Decreases effects

May modify structure

High. Aw may cause caking

Can destroy structures

The significant benefits for different stakeholders involved in food processing are:

- Farmer – higher yield, better farm realization, lower risk

- Consumer – greater variety, lower prices, new products
- Companies – new business opportunities, demand growth
- Economy/Government – Employment generation, reduced rural migration

The emerging opportunities in food processing are interesting and challenging as well.

NEED FOR FOOD PROCESSING

Once food is harvested, it begins to deteriorate immediately due to the following factors:

- micro-organisms (yeast, mould, bacteria);
- intrinsic enzymes;
- temperature;
- moisture; and
- Insects and vermin

Because of the risk of spoilage, much of our food is processed in some way to increase its availability. A food is considered preserved once it is stabilized with respect to safety and quality.

Nearly every food preparation process reduces the amount of nutrients in food. In particular, processes that expose foods to high levels of heat, light, and/or oxygen cause the greatest nutrient loss. Nutrients can also be “ washed out” of foods by fluids that are introduced during a cooking process. For example, boiling a potato can cause much of the potato’s B and C vitamins to migrate to the boiling water. We can still benefit from these nutrients if we consume the liquid (i. e. if the potato and water are being

turned into potato soup), but not if we throw away the liquid. Similar losses also occur when we broil, roast, or fry in oil, and then drain off the drippings.

It’s important to note that no type of food processing can transform poor quality raw materials into good ones. It can only increase the product’s shelf life. To ensure that product meets high standards:

- use the highest quality raw ingredients;
- establish good processing techniques-and follow them; and
- Maintain an appropriate product environment after processing.
- Not all processing methods are applied to foods to achieve preservation. Some are also used to change or stabilize food texturally.

Microorganisms require water, nutrient, oxygen and a suitable temperature for optimal growth and reproduction.

Microorganism can only survive in condition with optimum pH and solute concentration as these will not destroy them. Food can be preserved by destroying the microorganism present in the food or by stopping the activities of these microorganisms

FOOD PROCESSING METHODS USED FOR FOOD PRESERVATION

Methods of processing food can be divided into two main categories-chemical and physical.

Chemical Processing Methods

The following techniques use the chemical approach in processing food.

Intermediate Moisture Foods (IMF)

Binding the water that is present preserves intermediate moisture foods-for example, cookies, cake and bread. This reduces the availability of the water for deteriorative reactions.

Water is immobilized by adding permissible humectant additives such as glycerol, glycols, sorbitol, sugars and salts.

Generally, IMFs possess water activities that range from 0. 6 to 0. 85. This enables the food to be stable at room temperature, because the growth of most micro-organisms is inhibited at these levels.

Water Activity (aw)

Water is the most important factor in controlling the rate of deterioration of a food. However, knowledge of the moisture content of a food is not sufficient to predict its stability. It is the availability of water for microbial, enzymatic, or chemical activity that determines the shelf life of foods. This water availability is measured as water activity (aw).

Water activity is measured on a scale of 0 to 1, where 0 indicates no water and 1 indicates all water. Food spoilage micro-organisms, in general, are inhibited in food where the water activity is below 0. 6. However, if the pH of the food is less than 4. 6, micro-organisms are inhibited when the water activity is below 0. 85.

Addition of Chemicals

The addition of some chemicals inhibits microbial growth in foods. These chemicals include not only those classified as preservatives. Salt, sugars, wood smoke and some spices also inhibit the growth of micro-organisms.

PH Control

Almost every food, with the exception of egg whites and soda crackers, has a pH value of less than 7. Foods can be broadly categorized on the basis of their pH as high acid, acid, medium acid or low acid. Examples of each category include:

- high acid (3. 7) : apples, lemons, raspberries
- acid (3. 7 to 4. 6) : oranges, olives, tomatoes (some)
- medium acid (4. 6 to 5. 3) : bread, cheese, carrots
- low acid (over 5. 3) : meat, fish, most vegetables

Most micro-organisms grow best in the pH range of 6. 5 to 7. 5. Yeasts and moulds are capable of growing over a much broader pH range than bacteria. Few pathogens will grow below pH 4. 0. This information is important, because it will help us in determining food stability with respect to microbial spoilage.

Physical Processing Methods

A number of physical methods are available to you for processing foods.

Sterilization (Retorting)

A pathogen is any microorganism that causes illness. Food pathogens cause food-borne illnesses such as food poisoning or food intoxication.

Sterilization destroys all pathogenic and spoilage micro-organisms in foods and inactivates enzymes by heating. All canned foods are sterilized in a retort (a large pressure cooker). This process enables food to have a shelf life of more than two years.

Foods that have a pH of more than 4. 6, such as meat and most vegetables must undergo severe heating conditions to destroy all pathogens. These foods are heated under pressure to 121°C for varying times.

Severe conditions are applied to ensure that Clostridium botulinum spores are destroyed during processing. These spores produce the deadly botulinum toxin under anaerobic conditions (that is, where there’s no oxygen). The spores are destroyed by heat or are inhibited at pH values of less than 4. 6. Therefore, a food with a pH of less than 4. 6 that is packaged anaerobically, such as spaghetti sauce, doesn’t need to undergo such a severe heat treatment.

Pasteurization

Pasteurization is the process of heating a food-usually a liquid-to or below its boiling point for a defined period of time. The purpose is to destroy all pathogens, reduce the number of bacteria, inactivate enzymes and extend the shelf life of a food product.

Foods with a pH of less than 4. 6, such as milk and spaghetti sauce, can be pasteurized.

Permanent stability-that is, shelf life of about two years-is obtained with foods that can withstand prolonged heating, such as bottled juices.

There is a greater loss of flavour from foods that are exposed to a longer time-temperature relationship. Therefore, temporary stability (that is, limited shelf life) is only obtained with some foods where prolonged heating would destroy its quality. These foods, such as milk, usually require subsequent refrigeration.

“ High temperature short time” (HTST) and “ ultra high temperature” (UHT) processes have been developed to retain a food’s texture and flavour quality parameters.

Blanching

Blanching is a slight heat treatment, using hot water or steam that is applied mostly to vegetables before canning or freezing.

Blanching is used before freezing to inactivate enzymes present that cause deteriorative reactions to foods during frozen storage. These reactions include colour and texture changes, off-flavours and a decrease in nutritional value.

Blanching is used before canning for different reasons, because enzymes will inevitably be destroyed during canning. Blanching induces a vacuum in canned goods, and it’s also used to control the fill into containers (for example, spinach).

Microwaving

Microwave ovens are rarely used for processing large quantities of food. They are mainly of interest if you cater to the convenience food market.

Microwave ovens use electromagnetic radiation to excite water molecules in food. The actual waves penetrate only about 10 inches from the source of the radiation. Within the food, the waves only penetrate 3. 4 to 1 inch on all sides. As a result, the actual ovens must be limited in size. Heat is produced within the food by the friction of water molecules, which spreads to the centre of the food by conduction.

Small portions are cooked rapidly in microwave ovens. As the quantity of food increases, however, the efficiency is lost.

Frying

Frying differs from other methods of heat processing in that the cooking medium is hot oil. Because of the big difference between the temperature of the oil and the food, as well as the small size of the food pieces, cooking is completed in a relatively short time-anywhere from 20 seconds to six minutes.

Fried foods are known for their characteristic crispy outer surface as well as their high fat content. The fat that is absorbed by the food product varies from 10 percent to 40 percent, depending on the time the food is immersed in the oil. Continuous fryers are often used in the food industry.

Refrigeration

Refrigerators should be set to below 4°C to control the growth of micro-organisms in foods. This lowered temperature also reduces the respiration rate of fruits and vegetables, which retards reactions that promote spoilage.

Refrigeration is generally used to:

- reduce spoilage during distribution of perishable foods;
- increase the holding period between harvesting and processing
- Extend the storage life of commercially processed foods.

Not all foods benefit from cold temperatures. For example, bananas turn black and bread goes stale when refrigerated.

Freezing

While many home freezers are held at -10°C, commercial freezers are under -18°C. At this temperature, the growth of micro-organisms is almost stopped. Deteriorative microbial reactions will still occur, but over a much longer time.

In addition, deteriorative enzymatic reactions will still take place during frozen storage. Uncooked fruits and vegetables must be blanched before freezing to prevent these reactions.

During freezing, the water in food forms ice crystals. The rate of this phenomenon has a big impact on the quality of frozen foods:

Slow freezing (e. g. home freezer)

- Large ice crystals formed, which puncture cell walls
- Cellular fluid released
- Results in shrunken appearance of thawed food

Rapid freezing (e. g. blast freezer)

- small, numerous ice crystals formed
- no change to cell structure

The shelf life of frozen foods is largely dependent on storage conditions. Under ideal conditions, frozen foods can have a shelf life of one year.

However, if foods are continuously exposed to warmer temperatures, such as the opening and closing of freezer doors, then heat shock occurs. Heat shock is when ice melts and re-forms into larger ice crystals. The best example is ice cream, which has a gritty texture if large ice crystals have developed.

Irradiation

Irradiation is the controversial process of applying low doses of gamma radiation to food products. Research have shown that the process exhibits no safety hazard. As a result, irradiation is permitted in some countries to:

- Prevent sprouting in potatoes and onions
- Control insect infestation of wheat flour; and
- Reduce the microbial load of ground spices

If irradiation becomes more widespread among various other food products, it is expected to replace fumigation, ensure hygienic quality and reduce the dependence on refrigeration.

Batch vs. Continuous Processing

Food is processed in either discrete batches or a continuous system. Although there are advantages and disadvantages to each method, choice in the matter is restricted only to those replacing or setting up a new processing line. Generally, batch systems are used to produce small quantities of food, whereas larger volumes are required for continuous systems.

Advantages of Batch Processing

Advantages of Continuous Processing

- Greater flexibility to change product
- formulation and rates
- Lower operation and labour costs
- Lower equipment costs
- Less floor space required
- Easier operation and control
- Greater product uniformity

Evaporation

Evaporation is the partial removal of water from liquid foods by boiling. When the operation is done under vacuum, boiling is avoided and the food’s flavour qualities are retained.

Some of the foods that have undergone evaporation are evaporated milk, tomato paste and juice concentrates.

This process is carried out for three main reasons:

1. To reduce the weight and, therefore, reduce storage and transport costs
2. To preserve foods by decreasing the water activity and increasing the solids content
3. To provide consumers with convenient foods

Dehydration

Dehydration-or drying-is the nearly complete removal of water from solid foods. One of the oldest methods of food preservation, it was traditionally carried out by the sun.

This application is used for the same reasons that liquid foods undergo evaporation-preservation, convenience and cost savings. Dried soup mixes, dried fruit, powdered milk and spices are just a few examples of dehydrated foods.

Spray drying and freeze drying are two drying methods used widely today. Spray drying is when a liquid food is atomized into a fine, dry powder. Examples include natural and artificial flavours and milk powders. Freeze drying involves first freezing the food and then driving off the ice, leaving a high quality, porous dried food such as instant coffee.

Emulsions

An emulsion is a system containing two liquid phases that don’t mix, where one phase (dispersed phase) is distributed throughout the other phase (continuous phase) in the form of very small droplets. Generally there are two types of emulsions:

1. oil in water (O/W)
2. water in oil (W/O)

An example of an O/W emulsion is salad dressing, and an example of a W/O emulsion is butter.

Homogenization

Homogenization is used to stabilize an emulsion. More specifically, it is the reduction in size and the increase in number of droplets of the dispersed phase by the application of intense shearing forces.

Generally, homogenization is applied to change the functional properties or improve the texture of emulsions. For example, most fluid milk sold at the retail level is homogenized to improve its stability, and most caramel fillings are homogenized to increase their smoothness.

Extrusion

Extrusion is the process in which a food is compressed and worked to form a semi-solid mass. This mass is then forced through a restricted opening, or die, to create a desired texture or shape. The purpose of this application is simply to provide a greater variety of textured foods to consumers.

Food may also be cooked while extruded. This is referred to as extrusion cooking, or hot extrusion.

Some extruded food products are licorice, puffed wheat and cornflakes.

Hurdle or Combination Processing

Hurdle technology is a concept that was developed to address the consumer demand for more natural, fresh-like foods. It is a way for food processors to employ only mild preservation techniques to their food products.

The idea is to use deliberate low-level combinations of existing and novel preservation techniques (“ hurdles”) to eliminate the growth of micro-organisms. Lower-intensity individual methods can be used because of the

collective effect of the combined methods. Some of the more common hurdles include:

- pasteurization
- water activity (aw)
- salt
- blanching
- freezing; modified atmosphere packaging (MAP)
- pH
- preservatives
- refrigeration
- Irradiation

Some micro-organisms present will be able to survive the individual treatments applied. However, no microorganism will be able to overcome all of the combined hurdles. Thus the food is stable and safe.

The only way to ensure that the correct combination of hurdle technologies is used is to make sure that a qualified resource conducts quality and safety shelf-life studies. For a list of product development laboratories that can do these studies, see the Resources section of this guide.

Examples of hurdle processing can be found in traditional and recently developed foods, such as yogurt and pre-packaged fresh salads. The hurdles employed in yogurt manufacture include low temperatures, high acid and competitive microbial flora. Those used to prepare pre-packaged fresh salads include low temperatures and modified atmospheres.

GLOBAL FOOD PROCESSING INDUSTRY

The global processed food industry is estimated to be valued around EUR 2. 5 trillion and accounts for three-fourth of the global food sales. The global food industry is ever changing and evolving. However, health, convenience and value continue to be the key value propositions in this industry.

Despite the large size of the industry, only 6 percent of processed foods are traded across borders compared to 16 percent of major bulk agricultural commodities. The United States and European Union together account for over 60 percent of total retail processed food sales in the world.

Trade liberalization policies through multi-lateral and regional trade agreements have led to a rapid growth in food processing. In the Asian region, Japan is the largest food processing market, but India and China are likely to grow at a faster rate in the next decade. The processed food industry is strong in Japan and South Korea, as they are the leading meat importing countries in the world and consumption of meat is high in these countries. The Australian processed food industry is one of the most technically advanced in the world and it produces products of international standards at comparatively lower prices for the world market. The U. S. continues to live up to its reputation as the “ breadbasket to the world”. Countries in the Sub-Sahara African region, Latin America and parts of Asia continue to be on the lower-end of technology prowess in food items and are inclined to their staple diets, whereas, those in Europe, North America, and Japan are on the higher-end of technology, with a sharper shift towards convenience and diet foods.

Apart from the current large size of the processed foods, the growth trends reported are very encouraging. According to a study done by AC Nielsen, “ What’s Hot around the globe in F&B in 2006”, the growth in the global Food and Beverages (F&B) was estimated at 4 %. The most interesting aspect of the study is the growth in emerging markets like India, where the estimated growth is over 13% year over year. Further, the study reports that the world’s major food processors are looking for low cost sourcing options with proven quality standards, strong backward and forward linkages to ensure uninterrupted, traceable and quality products to the discerning world customers.

INDIAN FOOD PROCESSING INDUSTRY

The food processing industry is one of the largest industries in India and ranks fifth in size. The Indian food processing industry has an estimated size of $70 bn (Ministry of Food Processing, Government of India). The industry’s contribution to the country’s GDP in 2005 was about 7. 3% and had a share of 7% in the total industrial production. It employs 1. 6 million workers directly. India is endowed with the second largest arable land, second largest irrigated land under cultivation in the world and advantage of diverse agro-climatic zones across its geographical spread. The country’s world ranking as a producer vis-à-vis other nations is indicated in table below.

India can become the leading food supplier to the world and at the same time it has vast growing domestic market with over a billion people and population growing at a rate of 1. 6% per annum with food being the single largest component of private consumption expenditure accounting for 53% of the total expenditure. India’s large market size, ravenous appetite for food

with growing incomes and changing life styles create incredible market opportunities for food producers, Food processors, machinery makers, food technology and service providers

An overview of Indian Agriculture

Production side (Comparative advantages):

- Second largest arable land in the world
- Diverse agro-climatic zones across the country,
- Round the year sunshine
- Potential to cultivate a vast range of agricultural products
- Large marketable surpluses and abundant raw material for processing
- Vast pool of skilled manpower in research and extension

These advantages should be leveraged by India to be a leading food supplier to the world.

Domestic markets scenario (Infrastructure for marketing of perishables)

- Primary grading/ collection centers – non existent
- Warehousing and cold storage – inadequate
- Cold chain – non existent
- Quality certification system – non existent
- Transportation for perishables – non existent
- Rural markets – complete lack of infrastructure
- Wholesale markets – in government control, lack modern facilities
- Private / direct markets – not permitted

India offers very favourable factor conditions to enable the food processing sector to flourish because of the following factors-

1. High availability of land – India ranks first in the world in irrigated land area and second in overall arable land area
2. Ample availability of marine and fresh water fish- through the long coast line of over 7, 000 kilometres, several large rivers and lakes
3. Cattle population- India ranks first in availability of cattle
4. Low cost of labour – production costs in India are estimated to be 40 per cent lower than in developed markets

These factors have not only helped the domestic market to grow, but have also boosted exports.

The food processing sector is highly fragmented industry, it widely comprises of the following sub-segments: fruits and vegetables, milk and milk products, beer and alcoholic beverages, meat and poultry, marine products, grain processing, packaged or convenience food and packaged drinks. A huge number of entrepreneurs in this industry are small in terms of their production and operations, and are largely concentrated in the unorganized segment. This segment accounts for more than 70% of the output in terms of volume and 50% in terms of value. Though the organized sector seems comparatively small, it is growing at a much faster pace.

Structure of the Indian Food Processing Industry

Food Processing Units in Organized Sector (numbers)

Source: Ministry of Food Processing Industries, Annual Report 2003-04

The industry is composed of six key segments-

- Dairy Product- India is the largest producer of milk in the world. Milk and Milk products contribute to nearly 17 per cent of the total country’s expenditure on food.
- Fruits and vegetables- India is the second largest producer of fruits (50 million Tons) and vegetables (100 million Tons) in the world.
- Meat and Poultry- Size of 4. 3 million tonnes annually. Only 1 per cent of the meat production is converted into value added products.
- Fisheries
- Packaged Food
- Beverages
- Milk and Milk Products

India is with highest livestock populations in the world, it accounts 50% of the buffaloes and 20% of the world’s cattle population, most of which are milch cows and milch buffaloes. India’s dairy industry is considered as one of the most successful development industry in the post-Independence era.

In 2005-06 total milk productions in the country was over 90 million tonnes with a per capita availability of 229 gms per day. During 1993-2005, the dairy industry recorded an annual growth of 4%, which is almost 3 times the average growth rate of the dairy industry in the world. The total milk processing in India is around 35%, of which the organized dairy industry accounts for 13% while remaining is either consumed at farm level, or sold as fresh, non-pasteurized milk through unorganized channels. In 2009-10 milk production reached 110 million tonnes annual milk production.

In an organized dairy industry, dairy cooperatives account for the major share of processed liquid milk marketed in India. Milk is processed and

marketed by 170 Milk Producers' Cooperative Unions, which federate into 15 State Cooperative Milk Marketing Federations. Over the years, several brands have been created by cooperatives like Amul (GCMMF), Vijaya (AP), Verka (Punjab), Saras (Rajasthan). Nandini (Karnataka), Milma(Kerala) and Gokul (Kolhapur).

The milk surplus states in India are Uttar Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. The manufacturing of milk products is very much concentrated in these states due to the availability of milk in huge quantity.

According to the Ministry of Food Processing Industries, exports of dairy products have been growing at the rate of 25% per annum in terms of quantity and 28% in terms of value since 2001. Significant investment opportunities exist for the manufacturing of value-added milk products like milk powder, packaged milk, butter, ghee, cheese and ready-to-drink milk products.

As the largest single dairy producing country in the world, India's output continues to grow strongly in the 3-4 percent range, largely in response to internal demand growth and sustained by increasing productivity. India will account for nearly half the 226 million ton total milk output of Asia.

Amul is set to become the largest liquid milk brand in the world after the consolidation of Gujarat's milk cooperatives, which envisages bringing all district milk brands under the Amul umbrella brand. Until now, Amul's marketer GCMMF claims, it is Asia's largest milk brand.

Fruits & Vegetables

The installed capacity of fruits and vegetables processing industry has doubled from 1. 1 mn tonnes in January 1993 to 2. 1 mn tonnes in 2006. The major processed items in this segment are fruit pulps and juices, fruit based ready-to-serve beverages, canned fruits and vegetables, jams, squashes, pickles, chutneys and dehydrated vegetables. The new arrivals in this segment are vegetable curries in retortable pouches, canned mushroom and mushroom products, dried fruits and vegetables and fruit juice concentrates.

The fruits