TRAINING MANUAL FOR FOOD SAFETY REGULATORS

Vol I – INTRODUCTION TO FOOD AND FOOD PROCESSING

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THE TRAINING MANUAL FOR FOOD SAFETY REGULATORS WHO ARE INVOLVED IN IMPLEMENTING FOOD SAFETY AND STANDARDS ACT 2006 ACROSS THE COUNTRY

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INDEX

TRAINING MANUAL FOR FOOD SAFETY OFFICERS

Food is one of the basic needs of the human being. It is required for the normal functioning of the body parts and for a healthy growth***. Food is any substance, composed of carbohydrates, water, fats and/or proteins, that is either eaten or drunk by any animal, including humans, for nutrition or pleasure.*** Items considered food may be sourced from plants, animals or another kingdom such as fungus.On the other hand , **Food science** is a study concerned with all technical aspects of food, beginning with harvesting or slaughtering, and ending with its cooking and consumption. It is considered one of the life sciences, and is usually considered distinct from the field of nutrition.

Food science is a highly interdisciplinary applied science. It incorporates concepts from many different fields including microbiology, chemical engineering, biochemistry, and many others.Some of the subdisciplines of food science include:

- **Food processing** - 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 safety -** the causes, prevention and communication dealing with foodborne illness
- **Food microbiology** - the positive and negative interactions between micro-organisms and foods
- **Food preservation** - the causes and prevention of quality degradation
- **Food engineering** - the industrial processes used to manufacture food
- **Product development** - the invention of new food products
- **Sensory analysis** - the study of how food is perceived by the consumer's senses
- **Food chemistry** - the molecular composition of food and the involvement of these molecules in chemical reactions
- **Food packaging** - the study of how packaging is used to preserve food after it has been processed and contain it through distribution
- **Food technology** - the technological aspects of food
- **Food physics** - the physical aspects of foods (such as viscosity, creaminess, and texture)

BASIC COMPOSITION OF FOOD

Our body requires carbohydrates, proteins, fats, enzymes, vitamins and minerals for a healthy growth. However, our body cannot produce all these nutrients. Hence, food is the only source to obtain these nutrients in an adequate quantity. If we don't get these nutrients in sufficient amount, then we may suffer from a number of health problems. So a balanced diet is always recommended which is defined as a diet containing carbohydrate, protein, fat, dietary fibres, vitamin & minerals in right proportion. Carbohydrates, proteins, and fats supply 90% of the dry weight of the diet and 100% of its energy. All three provide energy (measured in calories), but the amount of energy in 1 gram differs: 4 calories in a gram of carbohydrate or protein and 9 calories in a gram of fat. These nutrients also differ in how quickly they supply energy. Carbohydrates are the quickest, and fats are the slowest.

Carbohydrates, proteins, and fats are digested in the intestine, where they are broken down into their basic units: carbohydrates into sugars, proteins into amino acids, and fats into fatty acids and glycerol. The body uses these basic units to build substances it needs for growth, maintenance, and activity (including other carbohydrates, proteins, and fats).

WATER IN DIET

Water is a combination of hydrogen and oxygen. It is the basis for the fluids of the body.

Function

Water makes up more than two-thirds of the weight of the human body. Without water, humans would die in a few days. All the cells and organs need water to function.

Water serves as a lubricant and is the basis of saliva and the fluids surrounding the joints. Water regulates the body temperature through perspiration. It also helps prevent and alleviate constipation by moving food through the intestinal tract.

Food Sources

Some of the water in our body is obtained through foods we eat and some is the byproduct of metabolism. But drinking water is our main, and best, source of water.

We also obtain water through liquid foods and beverages, such as soup, milk, and juices. Alcoholic beverages and beverages containing caffeine (such as coffee, tea, and colas) are not the best choices because they have a diuretic (water-excreting) effect.

Side Effects

If adequate water is not consumed on a daily basis the body fluids will be out of balance, causing dehydration. When dehydration is severe, it can be life-threatening.

Recommendations

Six to eight 8-ounce glasses of water are generally recommended on a daily basis.

CARBOHYDRATES

A carbohydrate is an organic compound with the general formula $C_m(H_2O)_n$, that is, consisting only of carbon, hydrogen and oxygen. The carbohydrates (saccharides) are divided into four chemical groupings: monosaccharides, disaccharides, oligosaccharides, and polysaccharides. In general, the monosaccharides and disaccharides, which are smaller (lower molecular weight) carbohydrates, are commonly referred to as sugars.

Carbohydrates perform numerous roles in living things. Polysaccharides serve for the storage of energy (e.g., starch and glycogen) and as structural components (e.g., cellulose in plants and chitin in arthropods) Monosaccharides are the simplest carbohydrates in that they cannot be hydrolyzed to smaller carbohydrates. Monosaccharides are the major source of fuel for metabolism, being used both as an energy source (glucose being the most important in nature) and in biosynthesis. When monosaccharides are not immediately needed by many cells they are often converted to more space efficient forms, often polysaccharides. In many animals, including humans, this storage form is glycogen, especially in liver and muscle cells. In plants, starch is used for the same purpose. Sucrose, also known as table sugar, is a common disaccharide. It is composed of two monosaccharides: D-glucose (left) and D-fructose (right). Two joined monosaccharides are called a disaccharide and these are the simplest polysaccharides. Examples include sucrose and lactose. They are composed of two monosaccharide units bound together by a covalent bond known as a glycosidic linkage formed via a dehydration reaction, resulting in the loss of a hydrogen atom from one monosaccharide and a hydroxyl group from the other. Sucrose is the most abundant disaccharide, and the main form in which carbohydrates are transported in plants. It is composed of one D-glucose molecule and one D-fructose molecule. Lactose, a disaccharide composed of one D-galactose molecule and one D-glucose molecule, occurs naturally in mammalian milk.

Depending on the size of the molecule, carbohydrates may be simple or complex.

- **Simple carbohydrates:** Various forms of sugar, such as glucose and sucrose (table sugar), are simple carbohydrates. They are small molecules, so they can be broken down and absorbed by the body quickly and are the quickest source of energy. They quickly increase the level of blood glucose (blood sugar). Fruits, dairy products, honey, and maple syrup contain large amounts of simple carbohydrates, which provide the sweet taste in most candies and cakes.

- **Complex carbohydrates:** These carbohydrates are composed of long strings of simple carbohydrates. Because complex carbohydrates are larger molecules than simple carbohydrates, they must be broken down into simple carbohydrates before they can be absorbed. Thus, they tend to provide energy to the body more slowly than simple carbohydrates but still more quickly than protein or fat. Because they are digested more slowly than simple carbohydrates, they are less likely to be converted to fat. They also increase blood sugar levels more slowly and to lower levels than simple carbohydrates but for a longer time. Complex carbohydrates include starches and fibers, which occur in wheat products (such as breads and pastas), other grains (such as rye and corn), beans, and root vegetables (such as potatoes).

Carbohydrates may be refined or unrefined. Refined means that the food is highly processed. The fiber and bran, as well as many of the vitamins and minerals they contain, have been stripped away. Thus, the body processes these carbohydrates quickly, and they provide little nutrition although they contain about the same number of calories. Refined products are often enriched, meaning vitamins and minerals have been added back to increase their nutritional value. A diet high in simple or refined carbohydrates tends to increase the risk of obesity and diabetes.

If people consume more carbohydrates than they need at the time, the body stores some of these carbohydrates within cells (as glycogen) and converts the rest to fat. Glycogen is a complex carbohydrate that the body can easily and rapidly convert to energy. Glycogen is stored in the liver and the muscles. Muscles use glycogen for energy during periods of intense exercise. The amount of carbohydrates stored as glycogen can provide almost a day's worth of calories. A few other body tissues store carbohydrates as complex carbohydrates that cannot be used to provide energy.

Most authorities recommend that about 50 to 55% of total daily calories should consist of carbohydrates.

Glycemic Index: The glycemic index of a carbohydrate represents how quickly its consumption increases blood sugar levels. Values range from 1 (the slowest) to 100 (the fastest, the index of pure glucose). However, how quickly the level actually increases also depends on what other foods are ingested at the same time and other factors.
The glycemic index tends to be lower for complex carbohydrates than for simple carbohydrates, but there are exceptions. For example, fructose (the sugar in fruits) has little effect on blood sugar.

DIETARY FIBER

Introduction

Dietary fiber (fibre), sometimes called **roughage**, is the indigestible portion of plant foods having two main components — **soluble** (prebiotic, viscous) fiber that is readily fermented in the colon into gases and physiologically active byproducts, and **insoluble** fiber that is metabolically inert, absorbing water throughout the digestive system and easing defecation. It acts by changing the nature of the contents of the gastrointestinal tract, and by changing how other nutrients and chemicals are absorbed.

Food sources of dietary fiber are often divided according to whether they provide (predominantly) soluble or insoluble fiber. Plant foods contain both types of fiber in varying degrees according to the plant's characteristics.

Sources of fiber

Dietary fiber is found in plants. While all plants contain some fiber, plants with high fiber concentrations are generally the most practical source.Fiber-rich plants can be eaten directly. Or, alternatively, they can be used to make supplements and fiber-rich processed foods.

Soluble fiber is found in varying quantities in all plant foods, including:

- legumes (peas, soybeans, and other beans)
- oats, rye, chia, and barley
- some fruits and fruit juices (including plums, berries, bananas, and the insides of apples and pears)
- certain vegetables such as broccoli, carrots,
- root vegetables such as potatoes, sweet potatoes, and onions (skins of these vegetables are sources of insoluble fiber)
- psyllium seed husk (a mucilage soluble fiber).

Sources of **insoluble fiber** include:

- whole grain foods
- wheat and corn bran
- nuts and seeds
- potato skins
- flax seed
- lignans
- vegetables such as green beans, cauliflower, zucchini (courgette), celery, and nopal
- some fruits including avocado, and bananas
- the skins of some fruits, including tomatoes

Mechanism

The main action of dietary fiber is to change the nature of the contents of the gastrointestinal tract, and to change how other nutrients and chemicals are absorbed. Soluble fiber binds to bile acids in the small intestine, making them less likely to enter the body; this in turn lowers cholesterol levels in the blood. Soluble fiber also attenuates the absorption of sugar, reduces sugar response after eating, normalizes blood lipid levels and, once fermented in the colon, produces short-chain fatty acids as byproducts with wide-ranging physiological activities (discussion below).

Benefits of fiber intake

Research has shown that fiber may benefit health in several different ways.

Dietary fiber functions & benefits

Type of fibre	**Functions**	**Benefits**
Both soluble and insoluble fibre	Adds bulk to your diet, making you feel full faster	May reduce appetite
Soluble fibre only	Attracts water and turns to gel during digestion, trapping carbohydrates and slowing absorption of glucose	Lowers variance in blood sugar levels
Soluble fibre only	Lowers total and LDL cholesterol	Reduces risk of heart disease
Soluble fibre only	Regulates blood sugar	May reduce onset risk or symptoms of metabolic syndrome and diabetes
Insoluble fibre only	Speeds the passage of foods through the digestive system	Facilitates regularity
Insoluble fibre only	Adds bulk to the stool	Alleviates constipation
Soluble fibre only	Balances intestinal pH and stimulates intestinal fermentation production of short-chain fatty acids	May reduce risk of colorectal cancer

Fiber does not bind to minerals and vitamins and therefore does not restrict their absorption, but rather evidence exists that fermentable fiber sources improve absorption of minerals, especially calcium. Some plant foods can reduce the absorption of minerals and vitamins like calcium, zinc, vitamin C, and magnesium, but this is caused by the presence of phytate (which is also thought to have important health benefits), not by fiber.

Guidelines on fiber intake

Authorities generally recommend that about 30 grams of fiber be consumed daily. The average amount of fiber consumed daily is usually less because people tend to eat products made with highly refined wheat flour and do not eat many fruits and vegetables. Meat and dairy foods do not contain fiber. An average serving of fruit, a vegetable, or cereal contains 2 to 4 grams of fiber and should be the part of the diet.

FATS

Introduction

Fats consist of a wide group of compounds that are generally soluble in organic solvents and largely insoluble in water. **Chemically, fats are generally triesters of glycerol and fatty acids.** Fats may be either solid or liquid at room temperature, depending on their structure and composition. Although the words "oils", "fats", and "lipids" are all used to refer to fats, "oils" is usually used to refer to fats that are liquids at normal room temperature, while "fats" is usually used to refer to fats that are solids at normal room temperature. "Lipids" is used to refer to both liquid and solid fats, along with other related substances. The word "oil" is used for any substance that does not mix with water and has a greasy feel, such as petroleum (or crude oil) and heating oil, regardless of its chemical structure.

Examples of edible animal fats are lard (pig fat), fish oil, and butter or ghee. They are obtained from fats in the milk, meat and under the skin of the animal. Examples of edible plant fats are peanut, soya bean, sunflower, sesame, coconut, olive, and vegetable oils. Margarine and vegetable shortening, which can be derived from the above oils, are used mainly for baking. These examples of fats can be categorized into saturated fats and unsaturated fats.

Types of fats in food

- Unsaturated fat
  - Monounsaturated fat
  - Polyunsaturated fat
  - Trans fat
  - Cis fat
  - Omega fatty acids:
    - ω−3
    - ω−6
    - ω−9
- Saturated fat

Interesterified fat

Importance for living organisms

- Vitamins A, D, E, and K are fat-soluble, meaning they can only be digested, absorbed, and transported in conjunction with fats. Fats are also sources of essential fatty acids, an important dietary requirement.
- Fats play a vital role in maintaining healthy skin and hair, insulating body organs against shock, maintaining body temperature, and promoting healthy cell function.
- Fats also serve as energy stores for the body, containing about 37.8 kilojoules (9 calories) per gram of fat. They are broken down in the body to release glycerol and free fatty acids. The glycerol can be converted to glucose by the liver and thus used as a source of energy.
- Fat also serves as a useful buffer towards a host of diseases. When a particular substance, whether chemical or biotic—reaches unsafe levels in the bloodstream, the body can effectively dilute—or at least maintain equilibrium of—the offending substances by storing it in new fat tissue. This helps to protect vital organs, until such time as the offending substances can be metabolized and/or removed from the body by such means as excretion, urination, accidental or intentional bloodletting, sebum excretion, and hair growth.
- While it is nearly impossible to remove fat completely from the diet, it would be unhealthy to do so. Some fatty acids are essential nutrients, meaning that they can't be produced in the body from other compounds and need to be consumed in small amounts. All other fats required by the body are non-essential and can be produced in the body from other compounds.

Essential fatty acids

Essential fatty acids, or **EFAs**, are fatty acids that cannot be constructed within an organism (generally all references are to humans) from other components by any known chemical pathways, and therefore must be obtained from the diet. The term refers to fatty acids involved in biological processes, and not those which may just play a role as fuel.

There are two families of EFAs: ω-3 (or omega-3 or n−3) and ω-6 (omega-6, n−6). Fats from each of these families are essential, as the body can convert one omega-3 to another omega-

3, for example, but cannot create an omega-3 from omega-6 or saturated fats. They were originally designated as **Vitamin F** when they were discovered as essential nutrients in 1923. In 1930, work by Burr, Burr and Miller showed that they are better classified with the fats than with the vitamins.

Nomenclature and terminology

Fatty acids are straight chain hydrocarbons possessing a carboxyl (COOH) group at one end. The carbon next to the carboxylate is known as α, the next carbon β, and so forth. Since biological fatty acids can be of different lengths, the last position is labelled as a "ω", the last letter in the Greek alphabet. Since the physiological properties of unsaturated fatty acids largely depend on the position of the first unsaturation relative to the end position and not the carboxylate, the position is signified by (ω minus n). For example, the term ω-3 signifies that the first double bond exists as the third carbon-carbon bond from the terminal CH_3 end (ω) of the carbon chain. The number of carbons and the number of double bonds is also listed. ω-3 18:4 (stearidonic acid) or 18:4 ω-3 or 18:4 n−3 indicates an 18-carbon chain with 4 double bonds, and with the first double bond in the third position from the CH_3 end. Double bonds are *cis* and separated by a single methylene (CH_2) group unless otherwise noted.

Examples

The essential fatty acids start with the **short chain polyunsaturated fatty acids (SC-PUFA)**:

- ω-3 fatty acids:
  - α-Linolenic acid or ALA (18:3)
- ω-6 fatty acids:
  - Linoleic acid or LA (18:2)

These two fatty acids cannot be synthesised by humans, as humans lack the desaturase enzymes required for their production.

They form the starting point for the creation of longer and more desaturated fatty acids, which are also referred to as **long-chain polyunsaturated fatty acids (LC-PUFA)**:

- ω-3 fatty acids:
  - eicosapentaenoic acid or EPA (20:5)
  - docosahexaenoic acid or DHA (22:6)
- ω-6 fatty acids:
  - gamma-linolenic acid or GLA (18:3)
  - dihomo-gamma-linolenic acid or DGLA (20:3)
  - arachidonic acid or AA (20:4)

ω-9 fatty acids are not essential in humans, because humans generally possess all the enzymes required for their synthesis.

Essentiality

Human metabolism requires both ω-3 and ω-6 fatty acids. To some extent, any ω-3 and any ω-6 can relieve the worst symptoms of fatty acid deficiency. Particular fatty acids are still needed at critical life stages (e.g. lactation) and in some disease states. The human body can make some long-chain PUFA (arachidonic acid, EPA and DHA) from lineolate or lineolinate.

Traditionally speaking the LC-PUFA are not essential. Because the LC-PUFA are sometimes required, they may be considered "conditionally essential", or not essential to healthy adults.

A deficiency of essential fatty acids results in scaly dermatitis, hair loss, and poor wound healing.

Food sources

Almost all the polyunsaturated fat in the human diet is from EFA. Some of the food sources of ω-3 and ω-6 fatty acids are fish and shellfish, flaxseed (linseed), hemp oil, soya oil, canola (rapeseed) oil, pumpkin seeds, sunflower seeds, leafy vegetables, and walnuts.

Essential fatty acids play a part in many metabolic processes, and there is evidence to suggest that low levels of essential fatty acids, or the wrong balance of types among the essential fatty acids, may be a factor in a number of illnesses, including osteoporosis.

Plant sources of ω-3 contain neither eicosapentaenoic acid (EPA) nor docosahexaenoic acid (DHA). The human body can (and in case of a purely vegetarian diet often must, unless certain algae or supplements derived from them are consumed) convert α-linolenic acid (ALA) to EPA and subsequently DHA. This however requires more metabolic work, which is thought to be the reason that the absorption of essential fatty acids is much greater from animal rather than plant sources.

Human health

Almost all the polyunsaturated fats in the human diet are EFAs. Essential fatty acids play an important role in the life and death of cardiac cells.

Trans fat

Trans fat is the common name for unsaturated fat with *trans*-isomer fatty acid(s). Trans fats may be monounsaturated or polyunsaturated but never saturated.

Unsaturated fat is a fat molecule containing one or more double bonds between the carbon atoms. Since the carbons are double-bonded to each other, there are fewer bonds connected to hydrogen, so there are fewer hydrogen atoms, hence "unsaturated". *Cis* and *trans* are terms that refer to the arrangement of chains of carbon atoms across the double bond. In the *cis* arrangement, the chains are on the same side of the double bond, resulting in a kink. In the *trans* arrangement, the chains are on opposite sides of the double bond, and the chain is straight.

The process of hydrogenation adds hydrogen atoms to *cis*-unsaturated fats, eliminating a double bond and making them more saturated. These saturated fats have a higher melting point, which makes them attractive for baking and extends shelf-life. However, the process frequently has a side effect that turns some cis-isomers into *trans*-unsaturated fats instead of hydrogenating them completely.

There is another class of trans fats, vaccenic acid, which occurs naturally in trace amounts in meat and dairy products from ruminants.

Unlike other dietary fats, trans fats are not essential, and they do not promote good health. The consumption of trans fats increases the risk of coronary heart disease by raising levels of "bad" LDL cholesterol and lowering levels of "good" HDL cholesterol. Health authorities worldwide recommend that consumption of trans fat be reduced to trace amounts. Trans fats from partially hydrogenated oils are more harmful than naturally occurring oils.

Presence in food

Milk and meat from cows and other ruminants contains naturally occurring trans fats in small quantities.

A type of trans fat occurs naturally in the milk and body fat of ruminants (such as cattle and sheep) at a level of 2–5% of total fat. Natural trans fats, which include conjugated linoleic acid (CLA) and vaccenic acid, originate in the rumen of these animals. It should be noted that CLA has two double bonds, one in the *cis* configuration and one in *trans*, which makes it simultaneously a *cis*- and a *trans*-fatty acid.

Animal-based fats were once the only trans fats consumed, but by far the largest amount of trans fat consumed today is created by the processed food industry as a side-effect of partially hydrogenating unsaturated plant fats (generally vegetable oils). These partially-hydrogenated fats have displaced natural solid fats and liquid oils in many areas, notably in the fast food, snack food, fried food and baked goods industries.

Partially hydrogenated oils have been used in food for many reasons. Partial hydrogenation increases product shelf life and decreases refrigeration requirements. Many baked foods require semi-solid fats to suspend solids at room temperature; partially hydrogenated oils have the right consistency to replace animal fats such as butter and lard at lower cost. They are also an inexpensive alternative to other semi-solid oils such as palm oil.

Foods containing artificial trans fats formed by partially hydrogenating plant fats may contain up to 45% trans fat compared to their total fat. Baking shortenings generally contain 30% trans fats compared to their total fats, while animal fats from ruminants such as butter contain up to 4%. Margarines not reformulated to reduce trans fats may contain up to 15% trans fat by weight.

Trans fats are used in shortenings for deep frying in restaurants, as they can be used for longer than most conventional oils before becoming rancid. In the early twenty first century non-hydrogenated vegetable oils became available that have lifespan exceeding that of the frying shortenings. As fast food chains routinely use different fats in different locations, trans fat levels in fast food can have large variations.

Uses of Fats and Oils

Culinary uses

Many vegetable oils are consumed directly, or used directly as ingredients in food and dogfood - a role that they share with some animal fats, including butter and ghee. The oils serve a number of purposes in this role:

- **Shortening** - to give pastry a crumbly texture .
- **Texture** - oils can serve to make other ingredients stick together less.
- **Flavor** - while less-flavorful oils command premium prices, oils such as olive oil or almond oil may be chosen specifically for the flavor they impart.
- **Flavor base** - oils can also "carry" flavors of other ingredients, since many flavors are present in chemicals that are soluble in oil.

Secondly, oils can be heated, and used to cook other foods. Oils that are suitable for this purpose must have a high flash point. Such oils include the major cooking oils - canola, sunflower, safflower, peanut etc. Tropical oils, like palm oil, coconut oil and rice bran oil, are particularly valued in Asian cultures for high temperature cooking, because of their unusually high flash point.

Health risks

Partially hydrogenated vegetable oils have been an increasingly significant part of the human diet for about 100 years (particularly since the latter half of the 20th century and in the West where more processed foods are consumed), and some deleterious effects of trans fat consumption are scientifically accepted.

Obesity

Obesity is a medical condition in which excess body fat has accumulated to the extent that it may have an adverse effect on health, leading to reduced life expectancy and/or increased health problems. Body mass index (BMI), a measurement which compares weight and height, defines people as overweight (pre-obese) when their BMI is between 25 kg/m^2 and 30 kg/m^2, and obese when it is greater than 30 kg/m^2.

Obesity increases the likelihood of various diseases, particularly heart disease, type 2 diabetes, breathing difficulties during sleep, certain types of cancer, and osteoarthritis. Obesity is most commonly caused by a combination of excessive dietary calories, lack of physical activity, and genetic susceptibility, although a few cases are caused primarily by genes, endocrine disorders, medications or psychiatric illness.Obesity is a leading preventable cause of death worldwide, with increasing prevalence in adults and children, and authorities view it as one of the most serious public health problems of the 21st century.

Fat in the Diet

Authorities generally recommend that fat be limited to less than 30% of daily total calories (or fewer than 90 grams per day) and that saturated fats and trans fats should be limited to less than 10%. When possible, monounsaturated fats and polyunsaturated fats, particularly omega-3 fats, should be substituted for saturated fats and trans fats. People with high cholesterol levels may need to reduce their total fat intake even more. When fat intake is reduced to 10% or less of daily total calories, cholesterol levels tend to decrease dramatically

PROTEINS

Another very important constituent of food, proteins are found in all cells and in almost all parts of cell. They contribute to almost half of the body dry weight. Proteins are major organic constituents of protoplasm and a number of extra cellular components. These are important dietary constituents and perform a wide range of functions like providing structure to the body, transporting oxygen and other substances within an organism, regulating the body chemistry etc. Proteins are essential not only as constituents of food but they also have a significant role to play in the processing and preparation of food. This is primarily due to their water binding capacity and ability to coagulate on heating. Proteins find applications as gel formers, emulsifiers and foaming agents etc.

Protein is a nutrient that the body needs to grow and maintain itself. Next to water, protein is the most plentiful substance in our bodies. Just about everyone knows that muscles are made of protein. Actually, every single cell in the body has some protein. In addition, other important parts of the body like hair, skin, eyes, and body organs are all made from protein.

Many substances that control body functions, such as enzymes and hormones, also are made from protein. Other important functions of protein include forming blood cells and making antibodies to protect us from illness and infections.

Enzymes are also proteins, and they work as catalysts in carrying out the biological reactions. Several enzymes like amylase, invertase, pectinases, proteases etc. find applications in food processing.

Generally, a protein has approximately the following composition:

Carbon, 53%; Hydrogen, 7%; Oxygen, 23%; Nitrogen, 16%; and Sulfur, 1%

Foods that Contain Protein

Animal Sources

Foods that provide all the essential amino acids are called **high quality** proteins. Animal foods, like meat, fish, poultry, eggs, and dairy products, are all high quality protein sources. These are the foods people usually think of when they want to eat protein. The essential amino acids in animal products are in the right balance.

Protein Content of Some Animal Foods

S.No.	**Source**	**Protein (%)**
1	Meat	18-22
2	Milk	3.5
3	Egg white	12
4	Fresh water fish	13-25

Plant Sources

Foods that do not provide a good balance of all the essential amino acids are called **lower quality** proteins. Plant foods contain lower quality proteins. Most fruits and vegetable are poor sources of protein. Other plant foods, like baked beans, split peas and lentils, peanuts and other nuts, seeds, and grains like wheat, are better sources. They contribute a lot to our protein intake. However, each type of plant protein is low in one or more of the essential amino acids. This makes them a lower quality protein. Animal proteins contain a better balance of the essential amino acids than plant proteins. Cereals like wheat and rice are important sources of protein and are the staple foods of the populations in India. On average, wheat has 12-13% protein while rice has 7-9% protein. Gluten proteins are responsible for the unique bread making property of wheat. Legumes (pulses) and oil seeds are major sources of vegetable proteins. Besides, nuts like cashew nuts, almond nuts, coconuts, walnuts, etc. are the excellent sources of proteins.

Protein Content of some Pulses, Oilseeds and Fresh Vegetables

Sources	**S. No.**	**Name**	**Protein (%)**
***Dals* and Pulses**	1	Bengal gram dal	20.8
	2	Black gram dal	24.6
	3	Green gram dal	24.5
	4	Lentil	25.1
	5	Dry bean	24.9
	6	Dry pea	19.7
Fresh vegetables	7	Fresh bean	2
	8	Fresh pea	6
	9	Carrot	1
Oilseeds	10	Ground nut	26.7

Sources	S. No.	Name	Protein (%)
	11	Soybean	43.2
	12	Sesame	18.3
	13	Cotton seed	19.5
	14	Sunflower seed	12.5

Combinations

People who do not eat animal products should eat different types of plant foods together or within the same day to get the proper balance and amount of essential amino acids their bodies need. Combining beans and rice, or beans and corn, or peanut butter and bread will provide all of the essential amino acids in the right amounts. These food combinations mix foods from different plant groups to complement the amino acids provided by each.

Combining foods from any two of the following plant groups will make a higher quality protein:

- **Legumes,** such as dry beans, peas, peanuts, lentils, and soybeans
- **Grains,** such as wheat, rye, rice, corn, oats, and barley
- **Seeds and nuts,** such as sunflower and pumpkin seeds, pecans, and walnuts

Any of the following products eaten with any one of the plant groups listed above also will make a higher quality protein:

- **Eggs**
- **Milk products,** such as milk, cheese, and yogurt
- **Meat,** such as beef, poultry, fish, lamb, and pork

A small amount of animal product mixed with a larger amount of plant product can also meet a person's protein needs.

Amino Acids

Structurally proteins are polymers of α- amino acids, which join together through peptide bonds. These polymeric molecules acquire different arrangements depending on their composition and the nature of amino acids constituting them. These arrangements are stabilized with the help of different types of interactions.

There are 20 amino acids in the protein that we eat every day. The body takes these amino acids and links them together in very long strings. This is how the body makes all of the different proteins it needs to function properly.

Essential and Non-essential Amino Acids

Eight of the amino acids are called **essential** because bodies cannot make them.

The requirement of essential amino acids **(g per kg dietary protein)**

1. Isoleucine: 42
2. Leucine: 48
3. Lysine: 42
4. Methionine: 22

5. Phenylalanine: 28
6. Threonine: 28
7. Tryptophan: 14
8. Valine: 42

The classification of an amino acid as essential or non-essential does not reflect its importance as all the twenty amino acids are necessary for normal functioning of the body. It simply reflects whether or not the body is capable of synthesizing a particular amino acid. The requirement of essential amino acids per kilogram of the dietary protein is called the **reference pattern** of the amino acids and acts as a standard to determine the quality of the protein being consumed.

The net protein utilization of a human eating only one protein source (only wheat, for instance) is affected by the **limiting amino acid** content (the essential amino acid found in the smallest quantity in the foodstuff) of that source.

Protein source	**Limiting amino acid**
Wheat	lysine
Rice	lysine
Legumes	tryptophan or methionine (or cysteine)
Maize	lysine and tryptophan
Egg, chicken	none; the reference for absorbable protein

Biological value

Biological value (**BV**) is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body. It summarises how readily the broken down protein can be used in protein synthesis in the cells of the organism. This method assumes protein is the only source of nitrogen and measures the proportion of this nitrogen absorbed by the body which is then excreted. The remainder must have been incorporated into the proteins of the organisms body. A ratio of nitrogen incorporated into the body over nitrogen absorbed gives a measure of protein 'usability' - the BV.

Egg whites have been determined to have the standard biological value of 100 (though some sources may have higher biological values), which means that most of the absorbed nitrogen from egg white protein can be retained and used by the body. The biological value of plant protein sources is usually considerably lower than animal sources. For example, corn has a BA of 70 while peanuts have a relatively low BA of 40.Due to experimental limitations BV is often measured *relative* to an easily utilizable protein. Normally egg protein is assumed to be the most readily utilizable protein and given a BV of 100.

Adults need to eat about 60 grams of protein per day (0.8 grams per kilogram of weight or 10 to 15% of total calories). Adults who are trying to build muscle need slightly more. Children also need more because they are growing.

Deficiency

Protein deficiency is a serious cause of ill health and death in developing countries. Protein deficiency plays a part in the disease kwashiorkor.

If enough energy is not taken in through diet, as in the process of starvation, the body will use protein from the muscle mass to meet its energy needs, leading to muscle wasting over time. If the individual does not consume adequate protein in nutrition, then muscle will also waste as more vital cellular processes (e.g. respiration enzymes, blood cells) recycle muscle protein for their own requirements.

METABOLIZABLE ENERGY (ME)

Food energy is the amount of energy available from food that is available through respiration.

Like other forms of energy, food energy is expressed in calories or joules. Some countries use the food calorie, which is equal to 1 kilocalorie (kcal), or 1,000 calories. The kilojoule is the unit officially recommended by the World Health Organization and other international organizations.

Fiber, fats, proteins, organic acids, polyols, and ethanol all release energy during respiration - this is often called, 'food energy'. It is only when the food (providing fuel) reacts with oxygen in the cells of living things that energy is released. A small amount of energy is available through anaerobic respiration.

Each gram of food (fuel) is associated with a particular amount of energy (released when the food is respired). Fats and ethanol have the greatest amount of food energy per gram, 9 and 7 kcal/g (38 and 30 kJ/g), respectively. Proteins and most carbohydrates have about 4 kcal/g (17 kJ/g). Carbohydrates that are not easily absorbed, such as fiber or lactose in lactose-intolerant individuals, contribute less food energy. Polyols (including sugar alcohols) and organic acids have fewer than 4 kcal/g.

VITAMINS AND MINERALS

Whereas vitamins are organic substances (made by plants or animals), minerals are inorganic elements that come from the soil and water and are absorbed by plants or eaten by animals.

VITAMINS

A **vitamin** is an organic compound required as a nutrient in tiny amounts by an organism. Vitamins are classified by their biological and chemical activity, not their structure.

Vitamins have diverse biochemical functions. Some have hormone-like functions as regulators of mineral metabolism (e.g. vitamin D), or regulators of cell and tissue growth and differentiation (e.g. some forms of vitamin A). Others function as antioxidants (e.g. vitamin E and sometimes vitamin C). The largest number of vitamins (e.g. B complex vitamins) function as precursors for enzyme cofactors, that help enzymes in their work as catalysts in metabolism. In this role, vitamins may be tightly bound to enzymes as part of prosthetic groups: for example, biotin is part of enzymes involved in making fatty acids. Alternately, vitamins may also be less tightly bound to enzyme catalysts as coenzymes, detachable molecules which function to carry chemical groups or electrons between molecules. For example, folic acid carries various forms of carbon group – methyl, formyl and methylene - in the cell.

Vitamins are classified as either **water-soluble** or **fat soluble**. In humans there are 13 vitamins: 4 fat-soluble (A, D, E and K) and 9 water-soluble (8 B vitamins and vitamin C). Water-soluble vitamins dissolve easily in water, and in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption.

Because they are not readily stored, consistent daily intake is important. Many types of water-soluble vitamins are synthesized by bacteria. Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Because they are more likely to accumulate in the body, they are more likely to lead to hypervitaminosis than are water-soluble vitamins.

Role of Vitamins

Vitamins are essential for the normal growth and development of a multicellular organism. For the most part, vitamins are obtained with food, but a few are obtained by other means. For example, microorganisms in the intestine—commonly known as "gut flora"—produce vitamin K and biotin, while one form of vitamin D is synthesized in the skin with the help of the natural ultraviolet wavelength of sunlight. Humans can produce some vitamins from precursors they consume. Examples include vitamin A, produced from beta carotene, and niacin, from the amino acid tryptophan.

Once growth and development are completed, vitamins remain essential nutrients for the healthy maintenance of the cells, tissues, and organs.

Deficiencies

Because human bodies do not store most vitamins, humans must consume them regularly to avoid deficiency. Deficiencies of vitamins are classified as either primary or secondary. A **primary deficiency** occurs when an organism does not get enough of the vitamin in its food. A **secondary deficiency** may be due to an underlying disorder that prevents or limits the absorption or use of the vitamin, due to a "lifestyle factor", such as smoking, excessive alcohol consumption, or the use of medications that interfere with the absorption or use of the vitamin. People who eat a varied diet are unlikely to develop a severe primary vitamin deficiency.

Well-known human vitamin deficiencies involve thiamine (beriberi), niacin (pellagra), vitamin C (scurvy) and vitamin D (rickets).

Side effects and overdose

In large doses, some vitamins have documented side effects that tend to be more severe with a larger dosage. The likelihood of consuming too much of any vitamin from food is remote, but overdosing from vitamin supplementation does occur. At high enough dosages some vitamins cause side effects such as nausea, diarrhea, and vomiting.

Table 1. Functions, Major Food Source and Deficiency diseases of various vitamins

Vitamin	Functions	Significant food source	Deficiency Diseases
A (retinol)	Supports vision, skin, bone and tooth growth, immunity and reproduction	Mango, Broccoli, ButterNut squash, Carrots, Tomato juice, sweet potatoes, pumpkin, cod liver	Night- blindness and Keratomalacia
B1 (thiamin)	Supports energy metabolism and nerve function	Spinach, Green peas, tomato juice, Watermelon, Sunflower seeds, Lean ham, Pork chops, Soy milk	Beriberi, Wernicke-Korsakoff syndrome
B2 (riboflavin)	Supports energy metabolism, normal vision and skin health	Spinach, Broccoli, Mushrooms, Eggs, Milk, Liver, Oysters, Clams	Ariboflavinosis
B3 (niacin)	Supports energy metabolism, skin health, nervous system and digestive system	Spinach, Potatoes, Tomato juice, Lean ground beef, Chicken breast, Tuna (canned in water), Liver, Shrimp	Pellagra
Biotin	Energy metabolism,	Widespread in foods	Dermatitis, Enteritis

	fat synthesis, amino acid metabolism, glycogen synthesis		
B5 Pantothenic Acid	Supports energy metabolism	Widespread in foods	Paresthesia
B6 (pyridoxine)	Amino acid and fatty acid metabolism, red blood cell production	Bananas, Watermelon, Tomato juice, Broccoli, Spinach, Acron squash, Potatoes, White rice, Chicken breast	Anemia peripheral neuropathy
Folate	Supports DNA synthesis and new cell formation	Tomato juice, Green beans, Broccoli, Spinach, Asparagus, Okra, Black-eyed peas, Lentils, Navy, Pinto and Garbanzo beans	Deficiency during pregnanct is associated with birth defects, such as neural tube defects
B12	Used in new cell synthesis, helps break down fatty acids and amino acids, supports nerve cell maintenance	Meats, Poultry, Fish, Shellfish, Milk, Eggs	Megaloblastic anemia
C (ascorbic acid)	Collagen synthesis, amino acid metabolism, helps iron absorption, immunity, antioxidant	Spinach, Broccoli, Red bell peppers, Snow peas, Tomato juice, Kiwi, Mango, Orange, Grape fruit juice, Strawberries	Scurvy
D	Promotes bone mineralization	Self- synthesis via sunlight, Fortified milk, Egg yolk, Liver, Fatty fish	Rickets in children and Osteomalacia in adult
E	Antioxidant, regulation of oxidation reactions, supports cell membrane stabilization	Polyunsaturated plant oils (soyabean, corn and canola oils), Wheat germ, Sunflower seeds, Tofu, Avacado, Sweet potatoes, Shrimp, Cod	Deficiency is very rare; mild haemolytic anemia in newborn infants
K	Synthesis of blood-clotting proteins, regulates blood calcium	Brussels sprouts, Leafy greens vegetables, Spinach, Broccoli, Cabbage, Liver	Bleeding diathesis Increases clotting time of blood

MINERALS

Dietary minerals are the chemical elements required by living organisms, other than the four elements carbon, hydrogen, nitrogen, and oxygen present in common organic molecules. The dietary focus on dietary minerals derives from an interest in supporting biochemical reactions with the required elemental components. Appropriate intake levels of certain chemical elements are thus required to maintain optimal health.

Essential dietary minerals

Some sources state that sixteen dietary minerals are *required* to support human biochemical processes by serving structural and functional roles as well as electrolytes. Sometimes a distinction is drawn between this category and micronutrients. Most of the dietary minerals are of relatively low atomic weight.

Our body needs larger amounts of some minerals, such as calcium, to grow and stay healthy. Other minerals like chromium, copper, iodine, iron, selenium, and zinc are called **trace minerals** because we only need very small amounts of them each day.

Table 2. Functions, Food Source and Deficiency diseases of major Minerals

Mineral	Functions	Significant food sources	Deficiency Diseases
Potassium	Maintains fluid and Electrolyte balance, cell integrity, muscle contractions and nerve impulse transmission	Potatoes, acron squash, antichoke, spinach, broccoli, carrots, green beans, tomato juice, avocado, grapefruit juice, watermelon, banana, strawbwrries, cod, milk	Nausea, anorexia, muscle weakness, irritability. (Occurs most often in persons with prolonged diarrohea).
Calcium	Formation of bones and teeth, supports blood clotting	Milk, yoghurt, cheddar cheese, Swiss cheese, tofu, sardines, green beans, spinach, brocolli	Rickets in children and Osteomalacia in adult
Phosphorus	Formation of cells, bones and teeth, maintains acid-base balance	All animal foods(meat, fish, poultry, eggs, milk)	Weakness; bone pain; Anorexia
Magnesium	Supports bone mineralization, protein building, muscular contraction, nerve impulse transmission, immunity	Artichoke, parsley, spinach, broccoli, green beans, tomato juice, navy beans, pinto beans, black-eyed peas, sunflower seeds, tofu, cashews, halibut	Nausea, irritability, muscle weakness; twitching; cramps, cardiac arrhythmias
Iron	Part of protein haemoglobin (carries oxygen throughout body's cells)	Artichoke, parsley, spinach, broccoli, green beans, tomato juice, tofu, clams, shrimp, beef liver	Skin pallor; weakness; fatigue; headaches; shortness of breath (all signs of iron-deficiency anemia)
Zinc	A part of many enzymes, involved in production of genetic material and proteins, transports vitamin A, taste perception, wound healing, sperm production and the normal development of the foetus	Spinach, broccoli, green peas, green beans, tomato juice, lentils, oysters, shrimp, crab, turkey (dark meat), lean ham, lean ground beef, lean sirloin steak, plain yoghurt, Swiss cheese, tofu, ricotta cheese	Slow healing of wounds; loss of taste; retarded growth and delayed sexual development in children
Selenium	Antioxidant, works with vitamin E to protect body from oxidation	Seafood, meats and grains	Impaired thyroid function, impaired cardiac function, enlarged heart, Necrosis of liver
Iodine	Component of thyroid hormones that help regulate growth, development and metabolic rate	Salt, seafood, bread, milk, cheese	Goitre – enlargement of thyroid gland
Copper	Necessary for the absorption and utilization of iron, supports formation of haemoglobin and several enzymes	Meats, water	Rare in adults. Infants may develop a type of anemia marked by abnormal development of bones, nerve tissue and lungs

Effects of Food Processing on Food Nutrition

Freezing, Drying, Cooking, and Reheating

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. You'll still benefit from those nutrients if you consume the liquid (i.e. if the potato and water are being turned into potato soup), but not if you throw away the liquid. Similar losses also occur when you broil, roast, or fry in oil, and then drain off the drippings.

Consuming raw foods

The amount of nutrient loss caused by cooking has encouraged some health-conscious consumers to eat more raw foods. In general, this is a positive step. However, cooking is also beneficial, because it kills potentially harmful microorganisms that are present in the food supply. In particular, poultry and ground meats (e.g. hamburger) should always be thoroughly cooked, and the surface of all fruits and vegetables should be carefully washed before eating.

Grilling meats

Outdoor grilling is a popular cooking method, primarily because of the wonderful taste it imparts on meats. It can also be a healthy alternative to other cooking methods, because some of the meat's saturated fat content is reduced by the grilling process. However, grilling also presents a health risk. Two separate types of carcinogenic compounds are produced by high-temperature grilling:

- **Heterocyclic Amines (HCAs)**
  HCAs form when a meat is directly exposed to a flame or very high-temperature surface. The creatine-rich meat juices react with the heat to form various HCAs, including amino-imidazo-quinolines, amino-imidazo-quinoxalines, amino-imidazo-pyridines, and aminocarbolines. HCAs have been shown to cause DNA mutation, and may be a factor in the development of certain cancers.

- **Polycyclic Aromatic Hydrocarbons (PAHs)**
  PAHs form in smoke that's produced when fat from the meat ignites or drips on the hot coals of the grill. Various PAHs present in the resulting smoke, including benzo[a]pyrene and dibenzo[a,h]anthracene, adhere to the outside surface of the grilled meat. PAH exposure is also believed to be linked to certain cancers.

Effect of Food Processing on Vitamins and Minerals

The freshness, appearance, and nutritive value of foods changes when they are stored for long time. People in food industry work for procedures which make the foods retain their nutritive value even after a long time. The conversion of raw food materials into the acceptable food product by a variety of means is referred to as food processing. The techniques followed include, dehydration, freezing, heating at high temperatures, exposure to radiation (i.e. irradiation), fermentation, chemical preservation etc.

Processing of food has advantages and disadvantages both. We know that it results into desirable changes like enhancement of flavours, improvement of texture, and increase in shelf life etc. However, it may lead to some undesirable changes too. These include changes in colour, flavour, nutritional properties and development of toxicity.

Effect of Food Processing on Vitamins

Dehydration i.e. removal of water under controlled conditions is one of the ways of lowering water activity and preserving foods. However, dehydration results in decrease of vitamin levels. In fruits, β-carotene and B-group vitamins do not get altered significantly but vitamin C is lost to a good extent. However, pickling of vegetables leads to acidic pH, which stabilizes vitamin C. Freezing fruits, and vegetables also do not result in a substantial loss of vitamin A and β-carotene. The B-group vitamins also remain unaffected.

Heating at high temperatures, another important food process, results into a number of changes. For example, the heating process employed in industry for the sterilization of milk-based formulations greatly reduces their vitamin B6 content, thiamin may be lost to the extent of 30-50%. Baking of cereals and cereal products also cause loss of B-group vitamins to different extent. For example, the baking of white bread may result in thiamin loss of about 20%. The vitamin B12 on the other hand is not destroyed to a great extent by cooking, unless boiled in alkaline solution. The vitamin like vitamin A, vitamin B, thiamin, riboflavin, pantothenic acid and nicotinic acid do not get affected by frying of egg.

The heat treatment and leaching are the factors affecting vitamin C destruction during processing. Further, the rate of destruction of vitamin C is increased by the action of metals especially Cu and Fe and also by the action of enzymes. Considerable vitamin C is lost by cooking, preservation, drying and storage of the foods commodities.

On irradiation the nutrients in meats and poultry are also affected. It has been found that thermal processing and radiation sterilization of pork have comparable losses of thiamine. Blanching of vegetables and cooking of meat do not cause folic acid losses.

Vitamin A is relatively stable to heat in the absence of oxygen. Vitamin A and carotenoids have good stability during various food processing operations. Losses may occur at high temperatures in the presence of oxygen.

Vitamin D is extremely stable and little or no loss is experienced in processing and storage. Vitamin D in milk is not affected by pasteurization, boiling or sterilization. Frozen storage of milk or butter also had little or no effect on vitamin D levels.

Substantial tocopherol losses may occur on processing and storage of foods. Baking of white bread results in a loss of ~50% of the tocopherols in the crumb.

Effect of Food Processing on Minerals

Minerals are comparatively stable under food processing conditions such as heat, light, use of oxidizing agents and extremes in pH. Therefore processing does not usually reduce the mineral contents. However, these minerals can be removed from foods by leaching or by physical separation. Cooking in water would result in some losses of minerals since many minerals have significant solubility in water. In general, boiling the vegetables in water causes greater loss of minerals from them as against steaming them. Canned foods such as fruit juices may take up metals from the container-tin and iron from the tin plate and tin and lead from the soldering.

During cooking sodium may be lost but the other minerals are well retained. Many selenium compounds are volatile and can be lost by cooking or processing. Further, it has been found that milling of cereals cause considerable loss of minerals. Since minerals are mainly concentrated in the bran layers and in the germ, during milling after removal of bran and germ, only pure endosperm remains, which is poor in minerals. For example, when wheat is milled to obtain refined flour, the losses in mineral content are to the extent of 76% in case of iron, 78% in zinc, 86% in manganese, 68% for copper, and 16% for selenium. Similar losses occur during milling of rice and other cereals.

As mentioned above, the minerals are quite stable to heat and pH during processing. However change in temperature, pH and concentration or dehydration may lead to the change in the status in food system. For example in milk 1/3rd 1/4th of the calcium and phosphorous is associated with casein while 66 to 80% are present as dissolved calcium and phosphorous. On heating these minerals change from the dissolved to the colloidal state. On the other hand, cooling of milk shift the colloidal calcium and phosphorous to the dissolved state. Decrease in pH from the normal value towards isoelectric side (pH 4.6) will caused the solubilization of these minerals while an increase in pH will causes a shift of colloidal calcium, magnesium and phosphorus to the dissolved state.

The minerals in meat products are in the non-fatty portions, when liquid is lost from meat, the maximum loss is of sodium and calcium, phosphorus and potassium are lost to a lesser extent. During cooking also, sodium is lost but other minerals are well retained. In fact, cooking dissolves some calcium from bone and enriches the meat with this mineral.

The table below compares the typical maximum nutrient losses for common food processing methods.

Typical Maximum Nutrient Losses (as compared to raw food)					
Vitamins	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Vitamin A	5%	50%	25%	35%	10%
Retinol Activity Equivalent	5%	50%	25%	35%	10%
Alpha Carotene	5%	50%	25%	35%	10%
Beta Carotene	5%	50%	25%	35%	10%
Beta Cryptoxanthin	5%	50%	25%	35%	10%
Lycopene	5%	50%	25%	35%	10%
Lutein+Zeaxanthin	5%	50%	25%	35%	10%
Vitamin C	30%	80%	50%	75%	50%
Thiamin	5%	30%	55%	70%	40%
Riboflavin	0%	10%	25%	45%	5%
Niacin	0%	10%	40%	55%	5%
Vitamin B6	0%	10%	50%	65%	45%

Folate	5%	50%	70%	75%	30%
Food Folate	5%	50%	70%	75%	30%
Folic Acid	5%	50%	70%	75%	30%
Vitamin B12	0%	0%	45%	50%	45%
Minerals	**Freeze**	**Dry**	**Cook**	**Cook+Drain**	**Reheat**
Calcium	5%	0%	20%	25%	0%
Iron	0%	0%	35%	40%	0%
Magnesium	0%	0%	25%	40%	0%
Phosphorus	0%	0%	25%	35%	0%
Potassium	10%	0%	30%	70%	0%
Sodium	0%	0%	25%	55%	0%
Zinc	0%	0%	25%	25%	0%
Copper	10%	0%	40%	45%	0%

Effect of Food Processing on Carbohydrates

Food processing or cooking can have significant effect on the constituent carbohydrates. During cooking soluble carbohydrates are dissolved e.g. sucrose. Some polysaccharides get hydrolyzed. This may alter the rate and extent of digestion of starch and the properties of dietary fibre.

Effect on Starch

Heating the food to cook it and cooling thereafter before consuming have a significant effect on the starchy components of the food. These can be understood in terms of two important phenomena. These are as follows.

Gelatinization: On heating starch in the presence of water, the crystalline structure of the starch granules is lost irreversibly by a process called gelatinization. It is due to absorption of water by starch granules and turning into a jelly like substance. In this process, amylopectin forms the gel and amylase comes into solution. When heating is continued in excess water, more soluble components of starch come into solution and a paste results. In the food processing, the starch granules are not completely dissolved however, their partial gelatinization is sufficient to allow a good part of the starch to be digested rapidly. In the steaming of food, the process of gelatinization occurs to a small extent whereby a large proportion of slowly digestible starch is preserved.

Retrogradation: The process of re-association of the starch granules on cooling of the gelatinized starch or the starch paste is called retrogradation. It depends on the relative proportions of amylose and amylopectin in starch as linear amylose molecules re-associate faster than the highly branched amylopectins. Reheating starchy foods also influences this process. The digestibility of starch in the small intestine is reduced by the degree of processing and retrogradation. The staling of bread is due to retrogradation of starch and the rate of staling is temperature dependent.

Effect on Dietary Fibre

The cereal grains are usually milled to form refined flours, which are processed to prepare food products. The milling process removes the fiber-rich outer layers of the grain, and diminishes the total fiber content. The flours of wheat, rye, and maize contain large amounts of cellulose and hemicelluloses. Oat and barley also lose some dietary fiber in the process of milling. Besides the heat treatment can also influence the physical structure and the functional properties of the dietary fiber. The pectic substances cause thickening of juices, also these are also responsible for mushy nature of vegetables.

Deteriorative Changes in Fats and Oils and their Prevention

Food processes like heating and frying lead to polymerization of fats that leads to change in molecular weight, colour, viscocity and refractive index of the fat or the oil used. The presence of enzymes, atmospheric oxygen and application of high temperature are the factors responsible for such changes. The deteriorative changes in fats and oils are termed **rancidity**. In some cases containing high content of PUFA (Linolenic acid) lose the flavour giving a taste to it. This is called **flavour reversion**. It is of great economic concern to the food industry because it leads to the development of various off-flavours and off-odours in edible oils and fat-containing foods, which render these foods less acceptable.

Lipid oxidation is one of the major causes of food spoilage. Oxidative reactions can decrease the nutritional quality of food and certain oxidation products are potentially toxic. On the other hand, under certain conditions, a limited degree of lipid oxidation is sometimes desirable, as in aged cheeses and in some fried foods.

Auto-oxidation, Lypolysis and Thermal Decomposition

Oxidation via a self-catalytic mechanism is the main reaction, which takes place in oil becoming rancid. This is called the oxidative deterioration of lipids or **'auto-oxidation'**. The auto-oxidation follows a free radical mechanism and can be visualised to be consisting of three stages as follows.

a) Initiation

In the first step of auto-oxidation process called initiation, hydrogen is removed from the fatty acid chain to yield a free radical. The reaction can be shown as below.

RH ------------------> $R^{\cdot}$ + $H^{\cdot}$ (R and H are free radicals)

b) Propagation

Once a free radical is formed, it combines with oxygen to form a peroxy free radical which can remove hydrogen from another unsaturated molecule yielding a peroxide and a new free radical. This is called 'propagation reaction' and may repeat up to several thousand times in a kind of chain reaction

$R^{\cdot}$ + O_2 --------> $RO_2^{\cdot}$

$RO\dot{}_2$ + RH -------> ROOH + $R^{\cdot}$

(peroxide)

c) Termination

The propagating chain reactions are terminated through a reaction between the free radicals to yield non-active products

$R^{\cdot}$ + $R^{\cdot}$ -----> R - R

$R^{\cdot}$ + RO_2 -----> RO_2R

nRO_2 -----> $(RO_2)_n$

Lipolysis: Rancidity in presence of enzymes, heat and moisture causes the hydrolysis of ester bonds in lipids. This is called lipolysis. These resulting peroxides then breakdown to yield low molecular weight aldehydes and ketones which vaporize to give the peculiar off flavour. The flavour threshold for these is as low as 1ppb. Lipolysis occurs during deep fat frying due to large amount of water released from the food and the high temperature. Release of short chain fatty acids by hydrolysis is responsible for the development of an undesirable rancid flavour in raw milk. This is called **hydrolytic rancidity**. However, controlled and selective lipolysis is used in the manufacture of food items as yogurt and bread.

Thermal Decomposition leading to fat deterioration is a result of high temperature heating of fats in the presence of oxygen. This deterioration is due to the oxidative reactions of saturated and unsaturated fatty acids and interaction of nutrients among themselves. The compounds formed are cyclic and ayclic dimers, long chain alkanes, aldehydes, ketones etc. As a consequence of these reactions, the oil not only loses its flavour and taste but also becomes nutritionally less valuable.

INTRODUCTION TO FOOD SAFETY

Concern for the supply of food that is safe for the consumer has increased over the years. Rising liberalization of agro-industrial markets and the world-wide integration of food supply chains require new approaches and systems for assuring food safety. Food processors and retailers are sourcing their ingredients worldwide and it can be hard to track the region let alone the producer of the ingredient. Retailers are buying their produce from all over the globe. International trade in high-value food products (fresh and processed fruits and vegetables, fish, live animals and meat, and nuts and spices) has expanded enormously in the last twenty five years. It is in particular, these products for which food safety plays an important role.
At present, concern over food safety is at an all-time high. With each food "scare" reported – from banned dyes in multiple products to links between animal and human diseases – consumer concern grows. In response, the public and the private sector have developed new process standards and require suppliers of food products to follow them. Both, the market and legislations in importing countries demand for comprehensive and transparent schemes reaching "**from farm to fork".**

Definition

Food Safety can be defined as the assurance that food will not cause harm to the consumer when it is prepared and or eaten according to its intended use (WHO).

All conditions and measures that are necessary during production, processing, storage, distribution and preparation of food that when ingested does not represent an appreciable risk to health.

GLOBAL TRENDS AND THEIR IMPACT ON FOOD SAFETY

The days of locally produced food being processed, distributed and consumed in the same locality have significantly decreased in recent decades. The regional, national and global food chain has required parallel changes in food science and technology, including preservation. At the same time, there have been social changes such as an increasing number of meals being consumed outside the home environment and also an ageing population. Public exposure to a food-borne pathogen may change due to changes in processing, changes in consumption patterns and the globalization of the food supply chain. Many risk factors influence host (our) susceptibility to infection. These may be:

- Pathogen (microbes)-related : ingested dose, virulence
- Host-related: age, immune status, personal hygiene, genetic susceptibility.
- Diet-related nutritional deficiencies, ingestion of fatty or highly buffered foods.

The globalization of the food supply is recognized as a major trend contributing to food safety problems. Pathogenic micro-organisms are not contained within a single country's borders. Additionally, tourism and increased cultural interests may lead to new eating habits, such as the consumption of 'sushi' (origin in Japan) or our very own 'tandoori tikka masala' in Western countries. The continuous increase in international trade has been achievable partly through advances in food manufacturing and processing technologies together with improvements in transportation. Regional trade arrangements and the overall impact of the *Uruguay Round Agreements* have reduced many tariff and subsidy-related constraints to free trade, encouraging increased production and export from the countries with the most cost-effective production means. However, many exporting countries do not have the infrastructure to ensure high levels of hygienic food manufacture.

The continuing integration and consolidation of agriculture and food industries and the globalization of food trade are changing the patterns of food production and distribution as well as supply and demand. The pressure to produce food for export is very significant in developing economics and can lead to improper agricultural practices. The consequences may include the following:

- accidental or sporadic low level microbial contamination of a single product, which can result in a major epidemic of food-borne illness.
- high levels of mycotoxins, often resulting from poor storage and handling conditions
- high pesticides residues food
- industrial contamination of food with metals and chemicals such as polychlorinated biphenyls (PCBs) and dioxins.

Eating away from home is a major trend of recent years. Many of the meals eaten away from home require extensive food handling and /or are cold foods that are not cooked before consumption. Subsequently this leads to the potential for transmission of food-borne diseases from food handlers to consumers. Several studies have documented an increasing lack of knowledge related to personal hygiene, the use of clean utensils and storage of food at the correct temperature. Thus, the changing trend has increased the importance that food be handled in a sanitary manner. With volume processing and preparation of food, effects of contamination are accentuated if sanitary practices are not followed. Added mechanization and larger volume operations of food processing and preparation have increased the need for workers in all segments of the food industry to have an understanding of sanitary practices and how hygienic conditions can be attained and maintained. Yet, if workers are expected to abide by these practices, it is necessary to impart a certain amount of appreciation of the reasoning behind the required practices and biological basis for the reasoning.

FOOD SAFETY ISSUES

Specific food safety concerns differ markedly and include:

- Additives, colours and flavors
- Drug residues
- Fertilizers and other growing aids
- Irradiation
- Microbiological contamination
- Naturally occurring food toxicants
- Food supplements
- Pesticides
- Pollutants
- Processing ,packaging and labeling
- Adulteration and Misbranding

Consumers are most concerned about pesticides and additives as both are linked in the consumer's mind to cancer. It is also interesting, perhaps even alarming, that most consumers are not concerned about microbiological contamination, despite solid evidence that, of all the hazards, it is the one most likely to occur. Many homes have unsafe food storage and preparation practices. Consumers rarely consider their own food practices a hazard. Food industry, however, is most concerned about the microbiological safety of its products. In addition, many quality control checks are made to ensure that foods are free of extraneous matter such as glass, machine fillings and insect parts. Large food companies in many parts of the world adhere to a code of manufacturing practice known as 'Good Manufacturing Practice (GMP)'. This code helps to assure that products are manufactured under conditions of proper storage and sanitation. Many also employ an elaborate system known as 'Hazard Analysis and Critical Control points (HACCP)' to make sure that there is no chance of contamination or error during processing.

FACTORS AFFECTING FOOD SAFETY

Food hazards are the factors, which are the biggest threat to food safety. ***A hazard is defined as: a biological, chemical, or physical agent in a food, or condition of a food, with the potential to cause an adverse health effect.***

A. Biological hazards are living organisms, including bacteria, viruses, fungi and parasites

B. Chemical hazards are in two categories: naturally occurring poisons and chemicals or deleterious substances. The first group covers natural constituents of foods that are not the result of environmental, agricultural, industrial or other contamination. Examples are aflatoxins and shellfish poisons. The second group covers poisonous chemicals or deleterious substances which are intentionally or unintentionally added to foods at some point in the food chain. This group of chemicals can include pesticides and fungicides and well as lubricants and cleaners.

C. Physical hazard is any physical material not normally found in food which causes illness or injury. Physical hazards include glass, wood, stones and metal which may cause illness and injury. Examples of hazards are given in Table 1.

Hazards associated with food

Biological	**Chemical**	**Physical**
Macro biological	Veterinary residues, antibiotics	Glass , Hair
Microbiological	Growth stimulants	Metal
Pathogenic Bacteria	Plasticisers and packaging migration	Stones
• Sporeforming • Non sporeforming	Chemical residues, pesticides, cleaning fluids	Wood Plastic Parts of pests
Parasites and protozoa	Allergens	Insulation material
Viruses	Toxic metals; Lead and cadmium	Bone
Mycotoxins	Food chemicals; preservatives, processing aids, polychlorinated biphenyls (PCBs), printing inks, Prohibited substances	Fruit pits

Because most foods are grown in the open environment, they can become contaminated with natural and human-derived environmental toxicants. Lead, in most cases, is one such toxicant. PCBs, dioxin, and other pollutants resulting from human activity are further examples. In addition to environmental pollutants, foods become contaminated with trace toxicants which are unintentionally or intentionally added to foods. The use of pesticides to control insects, unwanted plants, or fungi can result in trace residues of the pesticide in the food. In some cases, components of packaging materials migrate from the package to foods. Oils from processing machinery or other processing aids can leave trace residuals in foods. These substances are sometimes called processing aids and are regulated for safety. Traces of drugs which are given to food-producing animals to treat diseases in these animals or make them grow more quickly could, under some circumstances, remain in the food. Traces of antibiotics in milk are one example. These are also considered trace toxicants.

The increasing number and severity of food poisoning outbreaks worldwide has considerably increased public awareness about food safety. Public concern on food safety has been raised due to well publicized incidences such as *food irradiation, BSE, E. coli O157:H7 and genetically modified foods.*

DEFINITION OF SAFE FOOD

What is "safe" food? This question invokes different answers depending upon who is asked. Essentially, the different definitions would be given depending upon what constitutes a significant risk. The general public might consider that 'safe food' means zero risk (no risk at all). Whereas the food manufacturer would consider 'what is an acceptable risk?'

The opinion expressed is that *zero risk is not feasible* given the range of food products available, the complexity of the distribution chain and human nature. Nevertheless, the risks of food poisoning should be reduced during food manufacture to an 'acceptable risk'. Unfortunately (there is no public consensus on what constitutes an acceptable risk).

A difficulty that arises in manufacturing 'safe' food is that the consumer is a mixed population with varying degrees of susceptibility and general life style. Additionally, food with 'high' levels of *preservatives* to reduce microbial growth is undesirable by the consumer and perceived as *'over processed'* with *'chemical additives'*! The consumer pressure is for greater varieties of fresh and minimally processed foods, natural preservatives with a *guarantee of absolute safety.*

MANUFACTURE OF SAFE FOOD

The manufacture of safe food is the responsibility of everyone in the food chain, and food factory, from the operative on the conveyor belt to the higher management. The production of safe food requires the following:

- Control at source
- Product design and process control
- Good hygienic practice during production. processing, handling and distribution, storage, sale, preparation and use
- Preventatives approach because effectiveness of microbial end-product testing is limited.

Control of food borne pathogens at source is not always easy. Many pathogens survive in the environment for long periods of time. They can be transmitted to humans by a variety of routes – water, soil, sewage, crops etc.

INTEGRATED APPROACH TO FOOD SAFETY

The safe food production requires an all-encompassing approach involving the food operatives at the shop floor through to the management. Hence a number of management safety tools as mentioned underneath need to be implemented. Although industry and national regulators strive for production and processing systems which ensure that all food is *'safe and wholesome'*, complete freedom from risks is an unattainable goal. Safety and wholesomeness are related to a level of risk that society regards as reasonable in the context, and in comparison with other risks in everyday life. The safety of foods (especially microbiological) can be principally assured by:

1. The application of good hygienic practices during production, processing (including labeling), handling, distribution, storage, sale, preparation and use.
2. The above in conjunction with the application of the Hazard Analysis Critical Control Point (HACCP) system. This preventative system offers more control than end-product testing, because the effectiveness of microbiological examination in assessing the safety of food is limited.

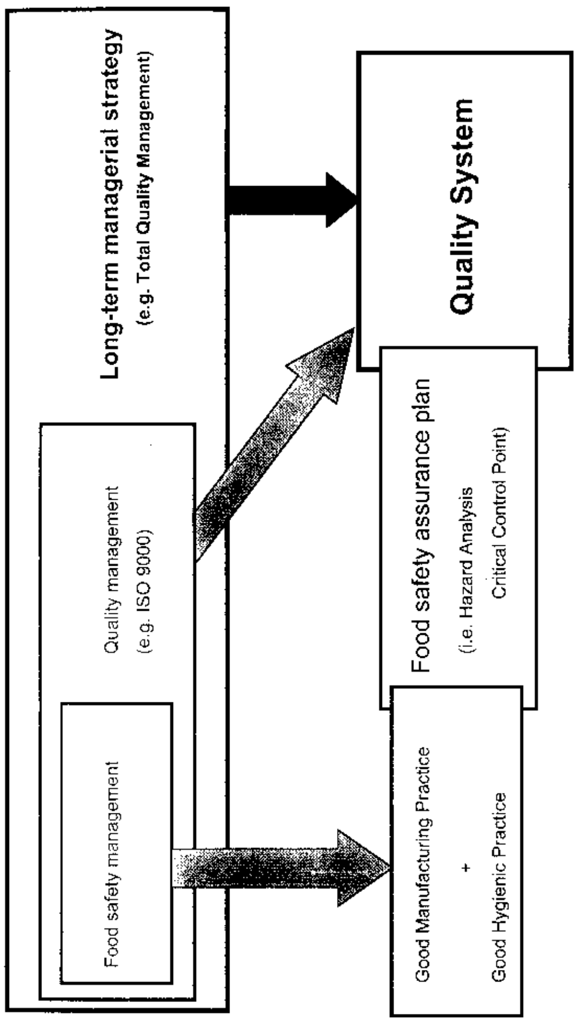


Figure 1. Food safety management tools *(adapted from Jouve et. al 1998).*

Consideration of safety needs to be applied to the complete food chain, from food production on the farm, or equivalent, through to the consumer. To achieve this integration of following food safety tools is required.

- Good Hygienic Practice (GHP)
- Good Manufacturing Practice (GMP)
- Hazard Analysis Critical Control Point (HACCP)
- Microbiological Risk Assessment (MRA)
- Quality management: ISO series
- Total Quality Management (TQM)

Figure 1 presents the food safety tools. These tools can be implemented worldwide, which can ease communication with food distributors and regulatory authorities especially at port of entry.

IMPORTANCE OF SAFE FOOD

A safe food supply that will not endanger consumer health and good quality food is essential for proper nutrition. It would ensure prevention of food borne diseases, provide consumer unadulterated food of good quality. It also promotes participation in International trade in food products and stimulates economic development.

Maintaining food safety and quality is essential in the entire chain of food production ranging from i) primary food production at the level of farmers; ii) primary food processing at the farm, dairy, abattoir and grain mills; iii) secondary food processing level such as canning, freezing, drying and brewing; iv) food distribution, both at National and International level of import/export; v) Food retailing and Food catering and also vi) Domestic Food preparation level.

During recent years, newer challenges such as globalization of trade in food, urbanization, changes in life style, international travel, environmental pollution, deliberate adulteration and natural and man-made disasters have arisen which need to be addressed to help ensure food safety and quality. For example, greater numbers of people go out and eat meals in catering establishments including partaking street foods. The boom in food service establishments is not matched by effective food safety education and control. Unhygienic preparation of food provides plenty of opportunity for contamination, growth or survival of food borne pathogens. Also in the developed countries, a considerable public interest has been shown with regard to genetically modified foods, and the possible risk of transmission of “mad cow” disease through the consumption of beef.

Consumer confidence in the safety and quality of the food supply is an important requirement and consumers are demanding protection for the whole food supply chain from primary producer to the end consumer, often described **as from farm or pond to the plate approach.** It is absolutely essential for countries to protect the safety and quality of their foods entering international trade. Also it is necessary to ensure that imported foods are of good quality and safe to eat. The new world order and global environment for food trade places considerable obligation on the part of both importing and exporting countries to ensure safety and quality of food. The International agencies like Food and Agriculture Organization and World Health Organization as well as the Codex Alimentarius Commission, with a membership of 165 countries, recommends risk analysis approach which includes risk assessment, risk management and risk communication. The perception of what constitutes a risk depends on a person's culture, education and past experience. But while what is perceived as a risk may differ, the basic scientific principles for dealing with risk are the same.

Education and Training plays an important role in improving the safety and quality of food. It is essential to acquire the know-how and skills necessary to understand and manage food safety hazards. Both education and training are needed for the purpose. While education aims at influencing the way of life and empowering people to make a choice, training is a process by which one is enable to acquire a skill. Any successful food safety programme will always need a shared responsibility among producers, industry, trade, government and the consumer.

FOOD CONTAMINATION

What is food contamination?

Food contamination refers to the presence of harmful chemicals and microorganisms in food which can cause consumer illness. A **food contaminant** has been defined as any substance not intentionally added to food, which is present in such food as a result of the production, manufacture, processing, preparation, treatment, packing, transport or storage of such food as a result of environmental contamination.

It is important to protect food from risk of contamination to prevent food poisoning and the entry of foreign objects.
There are three main ways in which food can become contaminated:
(i) Microbial Contamination;
(ii) Physical Contamination;
(iii) Chemical Contamination.

(i) Microbial Contamination
If food is consumed that has been contaminated by certain, harmful bacteria (pathogenic bacteria) or their toxins (poisons produced by some of these bacteria), food poisoning may result. Bacteria are responsible for most food poisoning cases. Symptoms of food poisoning may include vomiting, diarrhoea, fever and abdominal pain. The symptoms may take some time to occur depending on the type of bacteria (incubation period).
In general, the bacteria must grow in the food to produce sufficient numbers to infect the body, multiply within the intestine and cause illness. Alternatively, toxins may be produced in the foodstuff or within the intestine, to produce symptoms very soon after ingestion.
It is important to remember that foods contaminated with pathogenic bacteria will look, taste and smell perfectly normal. Steps must therefore be taken to prevent pathogenic bacteria getting onto food and multiplying to levels that will cause food poisoning.
Food poisoning /food- intoxication due to microbes is very common; some of the foods borne diseases are given below-

S.No.	Causal organism	Disease
1.	*Staphylococcus aureus*	Gastroenteritis
2.	*Clostridium botulinum*	Botulism
3.	*Bacellus cereus*	Diarrhea
4.	*Salmonella typhi*	Enteric fever typhoid, food borne salmonellosis
5.	*Escherichia coli*	Gastroenteritis, diarrhea

Controls
• Prevent cross-contamination. Cross-contamination occurs when bacteria are transferred onto
food either directly (e.g. when raw and cooked food come into direct contact, sneezing or coughing onto food) or indirectly (e.g. via a vehicle such as from dirty utensils, pests, hands etc.)

• Prepared and cooked foods should be stored separate to raw foods and unprepared vegetables to reduce the risk of cross-contamination. If this is not possible, raw food and unprepared vegetables should always be stored at the base of the refrigerator.
• Keep stored foods covered.
• Prevent animals and insects entering the food room.
• Keep food preparation areas and utensils clean.
• Wash hands frequently, particularly after using the toilet, handling raw foods, handling refuse, blowing your nose, combing your hair and after smoking.
• Keep cuts, boils etc., covered with a waterproof dressing (preferably coloured).
• Do not handle food if suffering from symptoms of diarrhoea or vomiting and notify your supervisor immediately.
• To multiply, bacteria require food, warmth, moisture and time. By removing one or more of these criteria the growth of bacteria can be slowed or even stopped. Therefore store foods at safe temperatures (either cold below 8°C or hot above 63°C); cook food thoroughly; do not prepare food too far in advance; avoid keeping food at room temperature for any longer than necessary, if food has to be reheated, heat thoroughly and stir contents during heating; cool cooked food within 1½ hours and refrigerate; prevent dry foods becoming moist.

Food can also be contaminated with fungus which includes:

Mycotoxin: Toxic substances produced by moulds or fungi are called as Mycotoxin.some mycotoxins are mutagenic and carcinogenic in nature.Of these mycotoxins , Aflatoxin is of most common occurrence in the agricultural produce/ food.
Aflatoxins are produced by a fungus – *Aspergillus flavus* and *Aspergillus parasiticus*. At least 18 closely related toxins are known. Of these aflatoxin B1, B2, M1, M2, G1, G2 are most commonly occurring in the farm produce/food. Most susceptible food grains are Maize , Paddy/Rice, Jowar ,Ground nut ,Wheat ,Barley ,Soybean, and their products. These toxins are heat labile, so there toxicity remains unaffected even after cooking at high temperature. Other important mycotoxins are Citrinin, Ochratoxin, Patulin etc which are produced by *Penicillium s*pecies.
In general, **maximum** tolerance limit of mycotoxins including aflatoxin in stored food grains has been recommended at **30 micrograms per Kg** (this limit is considered by CWC/SWC/FCI). **Ergot :Ergotin** is another mycotoxin produced by fungi Claviceps purpurea on rye/bajra, where this fungus causes **Ergot** disease.
Mycotoxins are produced at high moisture content and in temperature range of 12°C to 40° C. Therefore, the best way of coming over this food hazard is to dry the farm produce properly and moisture level should be always within the prescribed range.

(ii) Physical Contamination
Physical contamination can occur at any stage of the food chain and therefore all reasonable precautions must be taken to prevent this type of contamination. While harvesting, farm produce comes into contact with variety of external material called as physical contaminant. Physical contamination consists of two major groups viz., organic matter and inorganic matter. The former includes plant parts, debris, weed seeds, poisonous seeds of Dhatura and Akra, other food grains, dead insects, excreta, damaged grains, broken, fragments, nooks, rodent hair, uric acid etc, while the latter consists of lump of earth, pebbles, stones, dust etc. The proportion of these contaminants in the sample determines the quality of the produce and also the shelf life. However, the produce must be cleaned, graded and packed in suitable gunny bags/ packing material free from any infestation before storing or marketing the same.

Examples of physical contamination include:-
• Pieces of machinery which can fall into food during manufacture. Most manufacturers protect against this type of contamination by installing metal detectors on the production lines which reject food if anything metallic is present.
• Stones, pips, bones, twigs, pieces of shell.
• Foreign objects can enter food during handling so care must be taken to adhere to good food handling practices (e.g. do not wear jewellery or smoke in a food room).

(iii) Chemical Contamination
Contamination may occur through environmental pollution of the air, water and soil, such as the case with toxic metals, PCBs and dioxins, or through the intentional use of various chemicals, such as pesticides, animal drugs and other agrochemicals. Chemicals, including pesticides, bleach and other cleaning materials can contaminate food if not used carefully. For example, store cleaning fluids separate to foods to prevent tainting and contamination if there is a spillage. The impact of chemical contaminants on consumer health and well-being is often apparent only after many years of prolonged exposure at low levels (e.g. cancer). Chemical contaminants present in foods are often unaffected by thermal processing (unlike most microbiological agents). Chemical contaminants can be classified according to the source of contamination and the mechanism by which they enter the food product.

Agrochemicals are chemicals used in agricultural practices and animal husbandry with the intent to increase crops and reduce costs. Such agents include pesticides (e.g. insecticides, herbicides, rodenticides), plant growth regulators, veterinary drugs (e.g. nitrofuran, fluoroquinolones, malachite green, chloramphenicol), and bovine somatotropin (rBST).

Environmental contaminants are chemicals that are present in the environment in which the food is grown, harvested, transported, stored, packaged, processed, and consumed. The physical contact of the food with its environment results in its contamination. Possible sources of contamination are:

- **Air**: radionuclides (^{137}Caesium, ^{90}Strontium), polycyclic aromatic hydrocarbons (PAH).
- **Water**: arsenic, mercury.
- **Soil**: cadmium, nitrates, perchlorates.
- Polychlorinated biphenyls (PCB) , dioxins, and polybrominated diphenyl ethers (PBDE) are ubiquitous chemicals, which are present in air, water, soil, and the entire biosphere.
- **Packaging materials**: antimony, tin, lead, perfluorooctanoic acid (PFOA), semicarbazide, benzophenone, isopropylthioxanthone (ITX), bisphenol A.
- **Processing/cooking equipment**: copper, or other metal chips, lubricants, cleaning and sanitizing agents.
- **Naturally occurring toxins**: mycotoxins, phytohaemagglutinin, pyrrolizidine alkaloids, grayanotoxin, mushroom toxins, scombrotoxin (histamine), ciguatera, shellfish toxins (see shellfish poisoning), tetrodotoxin, among many others.

Processing contaminants are generated during the processing of foods (e.g. heating, fermentation). They are absent in the raw materials, and are formed by chemical reactions between natural and/or added food constituents during processing. **Examples** are: nitrosamines, polycyclic aromatic hydrocarbons (PAH), heterocyclic amines, histamine, acrylamide, furan, benzene, trans fat, monochloropropanediol (MCPD), semicarbazide, 4-hydroxynonenal (4-HNE), and ethyl carbamate.

RESTRICTED PESTICIDES (India)

1. Aluminium phosphide
2. BHC/Lindane
3. Captafol
4. DDT
5. Dieldrin
6. Ethylene dibromide
7. Methyl bromide
8. Phenyl mercuric acetate

FOOD CONTAMINANTS RENDERING FOOD UNSAFE FOR HUMAN CONSUMPTION

PHYSICAL	CHEMICAL		BIOLOGICAL
	INORGANIC	ORGANIC	
Foreign matter: Lumps of earth ,pebbles Stones,dust,plant parts, Stem,chaff etc	Heavy metals: Lead, Mercury, Arsenic, Cadmium Sulphur,	Pesticide Residue Water	
Unhygienic Packaging Material		Uric Acid Excreta, Rodent hair	Insects and Rodents
Unhygienic Processing			
Moisture		Mycotoxins eg., Aflatoxin, ergot, and alkaloids form Karnal Bunt,Smut affected grains	Fungus
			Bacteria
Unhygienic handling			Human being suffering from contagious disease
		B-Oxalyl Amino Acid(BOAA), produced by Lathyrus sativus (Khesari Dal) and Alkaloids in the oil from Argemone mexicana	
		Non food grade Colour and preservatives	

Emerging food contaminants

While many food contaminants have been known for decades, the formation and presence of certain chemicals in foods has been discovered relatively recently. These are the so-called **emerging food contaminants**, e.g. acrylamide, furan, benzene, perchlorate, perfluorooctanoic acid (PFOA), 3-monochloropropane-1,3-diol (3-MCPD), 4-hydroxynonenal and (4-HNE).

Safety and regulation

Acceptable Daily Intake (ADI) levels and tolerable concentrations of contaminants in individual foods are determined on the basis of the "No Observed Adverse Effect Level" (NOAEL) in animal experiments, by using a safety factor (usually 100). The maximum concentrations of contaminants allowed by legislation are often well below toxicological tolerance levels, because such levels can often be reasonably achieved by using good agricultural and manufacturing practices.

CONCLUSION

The best way to combat the food borne problems is to maintain good hygienic conditions around the storage, packing, processing and marketing places. Precautions should be taken in handling the produce so that there is no damage to the containers and contents remain intact & unexposed to the atmosphere. In case of, agricultural products high sanitary conditions are prerequisite for quality &shelf life. Besides this, sterilization of the packaging material and pasteurization of the product / vacuum packing are other suitable methods to prevent the food from the microbial attack.

FOOD ADULTERATION

Food Adulteration, Food adulteration takes into account not only the intentional addition or substitution or abstraction of substances which adversely affect the nature, substances and quality of foods, but also their incidental contamination during the period of growth, harvesting, storage, processing, transport and distribution.

A food adulterant may be defined as any material which is added to food or any substance which adversely affects the nature, substance and quality of the food.

WHEN FOOD IS CONSIDERED ADULTERATED?

Any article of food shall be considered as adulterated under the PFA Act (1954):

a. If the article sold by a vendor is not of the nature, substance or quality demanded by the purchaser or if not of the nature, substance or quality which it ought to be. Thus for e.g. , if a sweet vendor leads his customer to believe that his sweets are prepared in pure desi ghee and actually he uses a mixture of hydrogenated vegetable oils and ghee his sweets will be considered to be adulterated.
b. If he article contains or processing has produced in it injurious ingredients, for instance during the process of hydrogenating oil to prepare vanaspati, nickel is used as a catalyst. If not properly removed, this metal can prove to be hazard.
c. If any inferior or cheap substance has been substituted holly or in par for the article e.g. starch powder has been mixed in milk powder.
d. If any constituent of the article has been wholly or in part abstracted e.g. natural flavours or essential oils have been removed from spices before selling them.
e. If the article has been prepared packed or kept under unsanitary conditions or it has become contaminated or injurious to health ;
f. If the article has any filth, putrid rotten, decompose or diseased animal or vegetable substances or is insect infected or is otherwise unfit for human consumption;
g. If the article is obtained from a diseased animal;
h. If the article contains any poisonous or other ingredient which render it injurious o health;
i. If the container of the articles composed of poisonous or deleterious substances which render its content injurious to health. For example, harmful chemicals can leach into the food kept in the container made from poor quality plastics.
j. If it contains un-permitted colours or if he amount of the prescribed colouring matter are not within the prescribe limits. For instance, only 100 ppm of colour can be added to ice cream and the colour is to be chosen from a list of eight approved by the PFA at.
k. If the article contains any prohibited preservatives or an excessive amount of permitted ones.
l. If it does not satisfy the prescribed standards laid down by the authorities and which makes the article injurious o health. For e.g. an article of food should not have more than the permitted level of pesticides. If it does, the sugar is adulterated but such an adulteration is not injurious to health.
m. If it does not satisfy the prescribed standards laid down by the authorities' but the article does not become injurious to health. For e.g. sugar should not have more than 0.5 % by weight of moisture. If it does, the sugar is adulteration but such an adulteration is not injurious to health.

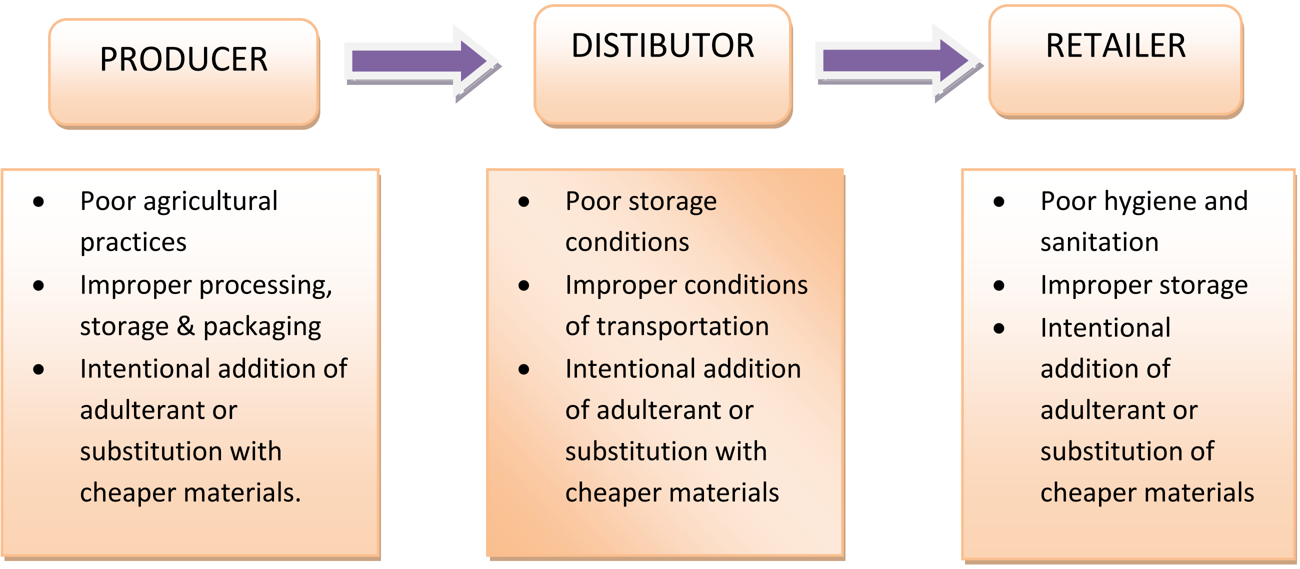
COMMONLY ADULTERATED FOODS

- Any commodity is either expensive or sells more is a target for adulteration.
- Foods which are in a powder, minced or paste form are more likely to be adulterated.
- Adulteration of foods sold loose by the retailer is also more common as compared to packaged foods.
- Foods commonly adulterated include:
- Food grains like wheat, rice, pulses and their products like wheat flour, semolina, gram flour (besan).
- Edible oils and fats e.g. sunflower oil, safflower oils, mustard oil, vanaspati.
- Spices, both whole and ground, like red chilli powder, turmeric powder and coriander powder.
- Milk and milk products e.g ghee and milk powder.
- Coffee and tea.
- Sweetening agent like sugar and honey.
- Non- alcoholic beverages like aerated rinks, squashes, juices, sherbets
- Miscellaneous items like confectionary, jams, sauces, ice creams and prepared foods items like sweets, ladoos, jalebi and burfi.

STAGES AT WHICH ADULTERATION OCCURS

There are three stages at which food gets adulterated:

1. Producer
2. Distributor
3. Retailer



COMMON ADULTERANTS

The following table gives a compilation of the types of adulterants (excluding microbial contaminants) detected in different food items.

FOOD ITEMS	ADULTERANT DETECTED
Milk	Antibiotics residues, formalin, boric acid, pesticide residues, neutralizers like sodium bi- carbonate, urea, water, sugar, starch, foreign fat.
Milk powder	Pesticide residues, sugar, starch, fat, deficiency, excessive moisture.
Ghee and Vanaspati	Extraneous colour, animal body fat, hydrogenated vegetable oils, excessive moisture.
Edible oils	Castor oils, mineral oil, argemone oil, triorthocresyl phosphate, oil soluble colours, aflatoxin, pesticide residues, and cheaper vegetable oils.
Spices	Non- permitted colours, mineral oil coating, husk starch, foreign seeds/ resins, extraneous matter, exhausted spices.
Non alcoholic beverages	Saccharin, dulcin, brominates vegetable oil, non permitted colours, and excessive permitted colours.
Confectionary, sweets and savouries	Non- permitted colours, aluminium foil, permitted colour ore than prescribed limit.
Coffee	Chicory, date or tamarind seeds, artificial colour.
Tea	Colour, iron filings, foreign leaves, exhausted leaves.
Pulses and their products like besan	Foreign pulses like lathyrus sativus, vicia sativa, lens esculenta, artificial colours, talc, foreign starch, extraneous matter
Cereals and their products like maida, suji, flour	Fungal infestation, pesticide residues, sand, dirt, foreign starch, powdered chalk, iron filings.

Although simple forms of adulteration like addition of water to milk and coloured starch to turmeric are still prevalent, newer forms and types of adulteration are emerging such as pesticides residues, coating insect- infested dry ginger with ultramarine blue to cover holes and other damage; urea in puffed rice to improve texture; injecting colour into poor quality fruits, vegetables.

HARMFUL EFFECTS OF ADULTERANTS

- There are many adulterants which might prove to be a hazard to our health especially if consumed over a long period of time.
- Chemicals like urea, sodium carbonate, sodium hydroxide, formaldehyde and hydrogen peroxide added to increased shelf life of milk can be harmful when ingested. They can damage the intestinal lining irritating it.
- Un- permitted food additives or permitted food additives added in excess; both can cause serious damage of health. Whether they are flavouring, colourings, preservatives, antioxidants etc. They are all chemicals which are safe only if eaten in very small quantities.
- The use of certain colours has been banned as they are well known or their toxicity in experimental animals. Non- permitted colours like auramine, Rhodamine B, Sudan red, malachite green, Orange II lead to retardation of growth and affects the proper functioning of vital organs like liver, kidneys, heart spleen, lungs, bones and the immune systems. The commonly used metanil yellow could be injurious to the stomach, ileum, rectum, liver, kidney, ovary and testis. All he non- permitted

colours can also bring about changes in genes, most having been identified as potential cancer- causing agents.
- Toxicity of permitted colours is also well demonstrated as allergic response to these colours e.g. Tartrazine.

IMPACT OF ADULTERATION ON ECONOMIC SECTOR

- Economic losses involve value of food rendered unfit for consumption. In addition there is the cost of treating people who have fallen sick, been disabled or the heavy cost of lives lost.
- If exported foods do not meet rigorous quality standards, they would have to be recalled, cases would be filed in court and the product would loose credibility in the local and international market.

METHODS FOR DETECTION OF COMMON ADULTERANTS

There are three types of simple tests for detecting adulterants. These are:

- Simple visual tests;
- Simple physical tests;
- Simple chemical tests.

Simple visual tests for detecting adulterants

S.No.	Food	Adulterant	Method of detection
1.	Pulses, whole and split	Kesari dal	Kesari dal is wedge shaped, with a slant on one side and a square face on the other side.
2.	Mustard seeds	Argemone seeds	Argemone seeds have a rough surface with a little tail at one end. Mustard seeds are smooth. Upon pressing, mustard seeds are yellow inside while argemone seeds are white.
3.	Black pepper	Papaya seeds	Papaya seeds are comparatively shrunken, oval, and greenish brown to brownish black in color.

Simple physical tests for detecting adulterants

S. No.	Food	Adulterant	Method of detection
1.	Milk	Water	Measures the specific gravity with a lactometer by immersing it in milk kept in a deep vessel. The normal value lie between 1.028-1.032. lower value indicates added water. But this is not a foolproof method as in addition to water, sugar, urea may have been added to the milk to increase its specific gravity.
2.	Tea leaves, *suji*	Iron fillings	Easily separated by passing a magnet over surface of food.
3.	Honey	Sugar solution	A cotton wick dipped in pure honey burns smoothly when lighted. If water is present it will not allow the honey to burn. Even if it does, a crackling sound is produced. (The test is for waterwhich is there in the sugar solution added as an adulterant to honey).
4.	Coffee	Chicory	Sprinkle coffee powder on the surface of water in a glass. Coffee floats while chicory starts sinking leaving a trail of color, due to a large amount of caramel.
5.	Tea	Artificial color	Put the tea leaves on a moistened blotting paper. Artificially dyed tea will impart color to the moistened blotting paper immediately.
6.	Milk	Developed acidity	Place a test tube containing 5 ml of the milk sample in a boiling water bath and hold for about 5 minutes. Remove

			thye tube and rotate in an almost horizontal position. The film of milk on the side of the test tube is examined for any precipitated particles. Formation of clots is indicative of developed acidity in the milk due to microbial spoilage. Such milk is unsuitable for consumption.

Simple chemical tests for detecting adulterants

S. No.	Food	Adulterant	Method of detection
1.	Milk, milk products, powdered spices	Starch	Mix sample in the test tube with water, add a few drops of iodine solution. Blue color indicates the presence of starch.
2.	Milk, milk powder	Neutralizers like carbonates	To about 5 ml of milk in a test tube, add 5 ml of alcohol and a few drops of rosalic acid solution and mix the contents of the test tube. A rose red color is obtained in the presence of a carbonate whereas pure milk shows only a brownish colouration.
3.	*Ghee*, butter	Margarine or *vanaspati*	In one tea spoon-full of completely melted sample, add 5 ml concentrated hydrochloric acid. Shake for 5 minutes; add a pinch of sugar or furfural. Appearance of pink color in the acid layer indicates added *vanaspati*.
4.	Sweetmeats, ice cream and beverages, *sela* rice, pulses, spices	Metanil yellow	Extract color with leukwarm water from food samples and add a few drops of concentrated hydrochloric acid. A magenta color indicates the presence of metanil yellow.
5.	Pulses, whole and split, *besan*	*Kesari dal*	Put a sample in dilute hydrochloric acid. Pink color develops indicating the presence of *kesari dal*.
6.	Silver foil	Aluminium foil	To metal foil add 2 drops of concentrated nitric acid in a test tube. The silver foil will completely dissolve whereas the aluminium foil remains undissolved.

FOOD ADDITIVES

Food additives are substances added to food to preserve flavour or improve its taste and appearance. Some additives have been used for centuries; for example, preserving food by pickling (with vinegar), salting, as with bacon, preserving sweets or using sulphur dioxide as in some wines. With the advent of processed foods in the second half of the 20th century, many more additives have been introduced, of both natural and artificial origin.

A food additive may be defined as any substance or a mixture of substances other than the basic foodstuff which is present in food as a result of any aspect of production, processing, storage or packaging. Food additives are added intentionally to foods and are not naturally a part of the food.

Different countries have different countries have different laws pertaining to which food additives can be used and in which foods e.g. PFA Act and Rules in India. These laws specify the amounts and names of food additives which can be added to certain foods.

FUNCTIONS OF FOOD ADDITIVES

- Maintaining product consistency;
- Improving or maintaining nutritive value;
- Maintaining palatability and wholesomeness;
- Improving flavour or imparting desired color;
- Providing leavening or controlling acidity acidity/alkalinity.

CLASSIFICATION OF FOOD ADDITIVES

Food additives are classified based on their function in food i.e. the purpose for which the additive has been added to the food.

The various classes of food additives include:

- Antioxidants;
- Preservatives;
- Food colors;
- Food flavours;
- Emulsifiers and stabilizers;
- Artificial sweeteners;
- Miscellaneous: Anti-caking agents; sequesterants; acids, bases, and buffers; anti-foaming agents, enzymes, leavening agents.

Broadly speaking, these food additives can be classified as:

- Direct food additives and
- Indirect food additives.

Direct food additives are added to a food for a specific purpose in that food e.g. synthetic color. Indirect food additives become part of the food in trace amounts due to packaging, storage or other handling. Additives used in raw ingredients or any other material with which foods may come in contact may find their way into the finished food product. Antioxidants, for example, used in edible oil may be found in chips or any food item prepared with this oil. This is known as the “carry over” principle.

FUNCTIONAL ROLE OF ADDITIVES

S.No.	**Additives**	**Functional Role**
1.	Antioxidants	Chemical additive which when added to food retards or prevents oxidative deterioration of food e.g. lecithin, ascorbic acid, tocopherol. Butylated hydroxyanisole (BHA) can be added to ghee, butter, fat spread only.
2.	Preservatives	Substances added to food to retard, inhibit or arrest the activity of microorganisms. Class I preservatives can be used without restriction e.g. salt, sugar, spices, vinegar. Class II preservative use is restricted to only certain foods and the amount of the preservative which can be added to these foods is also specified under PFA rules. The presence of a Class II preservative has to be declared on the packaging/ label e.g. sulphites, nitrates and nitrites, benzoic acid, sorbic acid.
3.	Food colours	Substances used to correct loss of colour due to food processing or to correct natural variations in food colour. Use of colour is restricted to only specific items of food. Caramel can be used without label declaration- other natural colours must be declared e.g. beta carotene, chlorophyll, riboflavin, annatto,saffron, curcumin or turmeric. Synthetic food colors permitted for use in india include: Ponceau 4R, Carmoisine, Erythrosine (red); Tartrazine, Sunset Yellow FCF (Yellow); Indigo Carmine, Brilliant Blue FCF (blue); Fast Green FCF (Green). Synthetic food colours are permitted only in certain foods such as ice cream, biscuits, cakes, canned peas, fruit squashes.
4.	Flavouing agents	Add flavour or correct losses in flavour. Natural flavours are those exclusively obtained by physical processes from vegetables, sometimes animal raw materials, Nature – identical flavouring substances are chemically isolated from raw materials or obtain synthetically. They are chemically identical to the substances present in natural products. Artificial flavouring substances are those which have not been identified in natural product and are chemically synthesized. Monosodium glutamate is permitted in restricted amounts and its addition needs to be declared on the label with a warning that the food is un-suitable for children below 12 months of age. Addition of any extraneous flavouring o a food has to e declared on the label.
5.	Emulsifying and stabilizing agents	Substances capable of facilitating a uniform dispersion of oils and fats in aqueous media or vice versa and / or stabalizing such emulsions. No emulsifying or stabilizing agent can be used in any food except where use of emulsifying or stabalizing agent is specially permitted under PFA rules. Commonly used emulsifying / or stabilizing agent include agar, alginates, dextrin, sorbitol, pectin, cellulose, mono glycerides or diglycerides of fatty acids. Modified starches are being used the world over by the food processing industry as thickeners, binders and stabilizers. These starches make sauces thick, potato chips crisp, pudding smooth in texture. Edible gums are used as thickening agent in jams, gravies and sauces: jellying agent in pudding desserts: encapsulating agent to stabilize flavours
6.	Sweetening agents	Include calorie sweeteners, low- calorie sweeteners and non-calorie sweeteners (which contain little or no calories). Calorie sweeteners contribute 4 Kcal?gram and have been associated with dental problems like caries and gum disorders (e.g. cane

		sugar, glucose syrup, jiggery, honey, dextrose, invert sugar). Low calorie sweeteners are relatively less sweet than sucrose (sugar) and provide energy between 1 and 3 Kcal per gram (e.g. sugar alcohols or polyols). They occur naturally but are often manufactured on a commercial scale. Use of polyols not only aids diet control by reducing calorie intake, they also do not cause dental caries. Non- calorie sweeteners may be natural or synthetic. Synthetic high intensity sweeteners are more popular as they are very sweet, so needed in very small quantities e.g. saccharin, aspartame, acesulfame, potassium. Acesulfame can be used in cooking. Phenylketonuria patients must not consume aspartame. Sucralose is derived from ordinary sugar, is not broken down by the body and is poorly absorbed. It is 600 times sweeter than sugar.
7.	Anti- caking agents	Anti- caking agents are anhydrous substances that can pick up moisture without themselves becoming wet and these are added to products such as table salt and dry mixes. "Free flowing" salt has anti- caking agents added to prevent formation of lumps. Anti- caking agents permitted in India include carbonates of calcium, magnesium; silicates, myristates, palmitates or stearates. In addition, calcium, potassium or sodium ferrocyanide may also be used as anti- caking agents in common salt, iodized salt and iron-fortified salt.
8.	Sequesterants	Substances that form a complex with transition metal ions like copper, iron, cobalt and nickel. These metals are powerful catalysts in the auto-oxidation processes and their binding helps in eliminating / retarding the oxidative breakdown of foods which would otherwise result in decolorization, rancidity and production of an off taste. Examples are citric acid, phosphoric acid, tartaric acid, ethylene diamine tetra acetate (EDTA).
9.	Buffering agents (Acids, bases, salts)	Buffering agents are materials used to counter acidic and alkaline changes during storage or processing of food, thus improving flavour and increasing stability of foods. Examples are acetic acid, calcium oxide, ammonium phosphate monobasic, ammonium carbonate (bread improver in flour), citric acid, malic acid, DL lactic acid, L (+) tartaric acid (acidulants).
11.	Anti- foaming agents	Reduce foaming on heating, slow down deteriorative changes e.g. dimethyl polysiloxane in edible oils and fats for deep-fat frying.
12.	Enzymes	Mainly used inh industry to split carbohydrates, proteins, lipids, usedf in cheese, bread production, tenderizing meat.
13.	Leavening agents	Introduction of gas in batter or dough leading to its expansion, improves appearance, texture and taste of foods. With yeast, the fermentation process was slightly difficult to control and at times could lead to undesirable flavours. Chemical leavening agents like baking soda (sodium bicarbonate) do not have this problem. The vast majority of chemical leavening systems are based on reaction of an acid with sodium bicarbonate to release carbon dioxide. There are a number of acids which might be used and they differ in the speed at which they release the leavening gas e.g. cream of tartar (rapid release), sodium aluminium phosphate or sulphate (slow release), anhydrous monocalcium phosphate (for an intermediate speed of release).

The food additives classification, as per Codex Alimentarius

Functional classes (for Labelling purposes)	Definition	Sub-classes (Technological functions)
1. Acid	Increases the acidity and/or imparts a sour taste to a food	Acidifier
2. Acidity Regulator	Alters or controls the acidity or alkalinity of a food	acid, alkali, base, buffer, buffering agent, pH adjusting agent
3. Anti caking agent	Reduces the tendency of particles of food to adhere to one another	anticaking agent, antistick agent, drying agent, dusting powder, release agent
4. Antifoaming agent	Prevents or reduces foaming antioxidant, antioxidant synergist,	antifoaming agent
5. Antioxidant	Prolongs the shelf-life of foods by protecting against deterioration caused by oxidation, such as fat rancidity and colour changes	Antioxidant, antioxidant synergist, sequestrant
6. Bulking agent	A substance, other than air or water, which contributes to the bulk of a food without contributing significantly to its available energy value	bulking agent, filler
7. Colour	Adds or restores colour in a food	Colour
8. Colour retention agent	Stabilizes, retains or intensifies the colour of a food	Colour fixative, colour stabilizer
9. Emulsifier	Forms or maintains a uniform mixture of two or more immiscible phases such surface as oil and water in a food	emulsifier, plasticizer, dispersing agent, surface active agent, surfactant, wetting agent
10. Emulsifying salt	Rearranges cheese proteins in the manufacture of processed cheese, in order to prevent fat separation	melding salt, sequestrant
11. Firming agent	Makes or keeps tissues of fruit or vegetables firm and crisp, or interacts with gelling agents to produce or strengthen a gel	firming agent
12. Flavour enhancer	Enhances the existing taste and/or odour of a food	flavour enhancer, flavour modifier, tenderizer
13. Flour treatment agent	A substance added to flour to improve its baking quality or colour	bleaching agent, dough improver, flour improver

NUMBERING

To regulate these additives, and inform consumers, each additive is assigned a unique number. Initially these were the "E numbers" used in Europe for all approved additives. This numbering scheme has now been adopted and extended by the Codex Alimentarius Commission to internationally identify all additives, regardless of whether they are approved for use.

E numbers are all prefixed by "E", but countries outside Europe use only the number, whether the additive is approved in Europe or not. For example, acetic acid is written as E260 on products sold in Europe, but is simply known as additive 260 in some countries. Additive 103, alkanet, is not approved for use in Europe so does not have an E number, although it is approved for use in Australia and New Zealand. Since 1987 Australia has had an approved system of labelling for additives in packaged foods. Each food additive has to be named or numbered. The numbers are the same as in Europe, but without the prefix 'E'.

The United States Food and Drug Administration listed these items as "Generally recognized as safe" or GRAS and these are listed under both their Chemical Abstract Services number and FDA regulation listed under the US Code of Federal Regulations.

SAFETY ISSUES

- A large number of substances in use today as food additives are “generally recognised as safe” or GRAS substances. GRAS substances are those whose use is generally recognized by experts as safe, based on their extensive history of use in food or based on published scientific evidence. Salt, sugar, spices, vitamins are classified as GRAS substances.
- Although most food additives are considered to be without any potential adverse effects, there have been problems concerning the safety of some of these chemicals.
    - The safety of the antioxidant BHA has been questioned in the light of the fact that its consumption leads to cancer in rodents.
    - Sensitive asthmatics have been reported to develop allergic responses to the food color tartrazine. Allergies have been reported to cause even fatal shock. Nitrites can form cancer-causing nitrosamines in foods in which they are added as preservatives.
    - MSG intake of 1.5g or more can result in acute illness characterized by burning or tingling sensation on face, neck and head, tightness, stiffness or pressure in chest and facial muscles. This is the “Chinese Restaurant Syndrome” because these symptoms have been seen in people who had consumed Chinese food.
    - High levels of erythrosine intake have been associated with thyroid tumors.
    - Ponceau 4R, Tartrazine and Sunset Yellow FCF have provoked allergic reactions in several individuals even at loe levels of intake. The allergic responses vary rashes to swelling and worsening of the condition of patients with asthma.
    - One should choose foods that are free of additives or at least select those brands of processed foods which have a minimum number of additives. Foods with artificial or synthetic colors and Class II preservatives should specially be avoided. The label of the food product declares the presence of the additives used in the product. Hence only properly labelled foods should be selected.
- With the increasing use of processed foods since the 19th century, there has been a great increase in the use of food additives of varying levels of safety. This has led to legislation in many countries regulating their use.
- For example, boric acid was widely used as a food preservative from the 1870s to the 1920s, but was banned after World War I due to its toxicity, as demonstrated in animal and human studies. During World War II the urgent need for cheap, available food preservatives led to it being used again, but it was finally banned in the 1950s.[2] Such cases led to a general mistrust of food additives, and an

application of the precautionary principle led to the conclusion that only additives that are known to be safe should be used in foods.

- In the USA, this led to the adoption of the Delaney clause, an amendment to the Federal Food, Drug, and Cosmetic Act of 1938, stating that no carcinogenic substances may be used as food additives. However, after the banning of cyclamates in the USA and Britain in 1969, saccharin, the only remaining legal artificial sweetener at the time, was found to cause cancer in rats.
- There has been significant controversy associated with the risks and benefits of food additives. Some artificial food additives have been linked with cancer, digestive problems, neurological conditions in addition to ADHD, and diseases like heart disease or obesity.
- Even "natural" additives may be harmful in certain quantities (table salt, for example) or because of allergic reactions in certain individuals. Safrole was used to flavour root beer until it was shown to be carcinogenic. Due to the application of the Delaney clause, it may not be added to foods, even though it occurs naturally in sassafras and sweet basil.[7]

Standardization of its derived products

ISO has published a series of standards regarding the topic and these standards are covered by ICS 67.220.

FOOD PACKAGING AND LABELLING

Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging also refers to the *process* of design, evaluation, and production of packages. Packaging can be described as a *coordinated system* of preparing goods for transport, warehousing, logistics, sale, and end use. Packaging contains, protects, preserves, transports, informs, and sells. In many countries it is fully integrated into government, business, institutional, industrial, and personal use.

Package labelling (en-GB) or **labelling** (en-US) is any written, electronic, or graphic communications on the packaging or on a separate but associated label.

History

The first packages used the natural materials available at the time: Baskets of reeds, wineskins (Bota bags), wooden boxes, pottery vases, ceramic amphorae, wooden barrels, woven bags, etc. Processed materials were used to form packages as they were developed: for example, early glass and bronze vessels. The study of old packages is an important aspect of archaeology.

Iron and tin plated steel were used to make cans in the early 19th century. Paperboard cartons and corrugated fiberboard boxes were first introduced in the late 19th century.

Packaging advancements in the early 20th century included Bakelite closures on bottles, transparent cellophane overwraps and panels on cartons, increased processing efficiency and improved food safety. As additional materials such as aluminum and several types of plastic were developed, they were incorporated into packages to improve performance and functionality.

The purposes of packaging and package labels

Packaging and package labelling have several objectives:

- **Physical protection** - The objects enclosed in the package may require protection from, among other things, shock, vibration, compression, temperature, etc.
- **Barrier protection** - A barrier from oxygen, water vapor, dust, etc., is often required. Permeation is a critical factor in design. Keeping the contents clean, fresh, sterile and safe for the intended shelf life is a primary function.
- **Containment or agglomeration** - Small objects are typically grouped together in one package for reasons of efficiency. For example, a single box of 1000 pencils requires less physical handling than 1000 single pencils. Liquids, powders, and granular materials need containment.
- **Information transmission** - Packages and labels communicate how to use, transport, recycle, or dispose of the package or product. With pharmaceuticals, food, medical, and chemical products, some types of information are required by governments. Some packages and labels also are used for track and trace purposes.
- **Marketing** - The packaging and labels can be used by marketers to encourage potential buyers to purchase the product. Package graphic design and physical design have been important and constantly evolving phenomenon for several decades. Marketing communications and graphic design are applied to the surface of the package and (in many cases) the point of sale display.
- **Security** - Packaging can play an important role in reducing the security risks of shipment. Packages can be made with improved tamper resistance to deter tampering and also can have tamper-evident features to help indicate tampering. Packages may include authentication seals and use security printing to help indicate that the package and contents are not counterfeit. Packages also can include anti-theft devices, such as dye-packs, RFID tags, or electronic article surveillance tags that can be activated or

detected by devices at exit points and require specialized tools to deactivate. Using packaging in this way is a means of loss prevention.

- **Convenience** - Packages can have features that add convenience in distribution, handling, stacking, display, sale, opening, reclosing, use, dispensing, and reuse.
- **Portion control** - Single serving or single dosage packaging has a precise amount of contents to control usage. Bulk commodities (such as salt) can be divided into packages that are a more suitable size for individual households. It is also aids the control of inventory: selling sealed one-liter-bottles of milk, rather than having people bring their own bottles to fill themselves.

Packaging types

Packaging may be looked at as being of several different types. For example a **transport package** or **distribution package** can be the shipping container used to ship, store, and handle the product or inner packages. Some identify a **consumer package** as one which is directed toward a consumer or household.

Packaging may be described in relation to the type of product being packaged: medical device packaging, bulk chemical packaging, over-the-counter drug packaging, retail food packaging, military materiel packaging, pharmaceutical packaging, etc.

It is sometimes convenient to categorize packages by layer or function: "primary", "secondary", etc.

- **Primary packaging** is the material that first envelops the product and holds it. This usually is the smallest unit of distribution or use and is the package which is in direct contact with the contents.
- **Secondary packaging** is outside the primary packaging, perhaps used to group primary packages together.
- **Tertiary packaging** is used for bulk handling, warehouse storage and transport shipping. The most common form is a palletized unit load that packs tightly into containers.

These broad categories can be somewhat arbitrary. For example, depending on the use, a shrink wrap can be primary packaging when applied directly to the product, secondary packaging when combining smaller packages, and tertiary packaging on some distribution packs.

Symbols used on packages and labels

Many types of symbols for package labelling are nationally and internationally standardized. For consumer packaging, symbols exist for product certifications, trademarks, proof of purchase, etc. Some requirements and symbols exist to communicate aspects of consumer use and safety. Examples of environmental and recycling symbols include: Recycling symbol, Resin identification code (below), and Green Dot (symbol).

Bar codes (below), Universal Product Codes, and RFID labels are common to allow automated information management in logistics and retailing. Country of Origin Labelling is often used.

FOOD PRODUCT

Shipping container labelling

"Print & Apply" corner wrap UCC (GS1-128) label application to a pallet load

Technologies related to shipping containers are identification codes, bar codes, and electronic data interchange (EDI). These three core technologies serve to enable the business functions in the process of shipping containers throughout the distribution channel. Each has an essential function: identification codes either relate product information or serve as keys to other data, bar codes allow for the automated input of identification codes and other data, and EDI moves data between trading partners within the distribution channel.

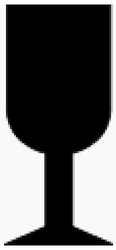
Elements of these core technologies include UPC and EAN item identification codes, the SCC-14 (UPC shipping container code), the SSCC-18 (Serial Shipping Container Codes), Interleaved 2-of-5 and UCC/EAN-128 (newly designated GS1-128) bar code symbologies, and ANSI ASC X12 and UN/EDIFACT EDI standards.

Small parcel carriers often have their own formats. For example, United Parcel Service has a MaxiCode 2-D code for parcel tracking.

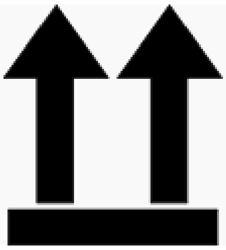
RFID labels for shipping containers are also increasing in usage. A Wal-Mart division, Sam's Club, has also moved in this direction and is putting pressure on on its suppliers for compliance.

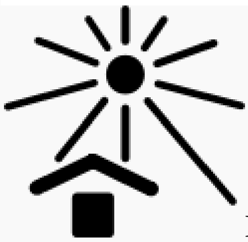
Shipments of hazardous materials or dangerous goods have special information and symbols (labels, plackards, etc) as required by UN, country, and specific carrier requirements. Two examples are below:

With transport packages, standardised symbols are also used to communicate handling needs. Some common ones are shown below while others are listed in ASTM D5445 "Standard Practice for Pictorial Markings for Handling of Goods" and ISO 780 "Pictorial marking for handling of goods".

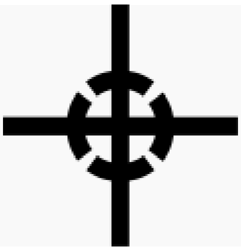

Fragile


Do not use hand hooks

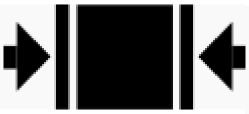

This way up


Keep away from sunlight

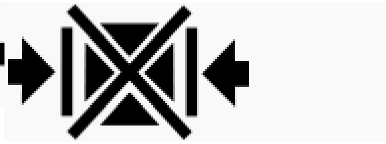
Keep away from water



Centre of gravity



Clamp as indicated



Do not clamp as indicated

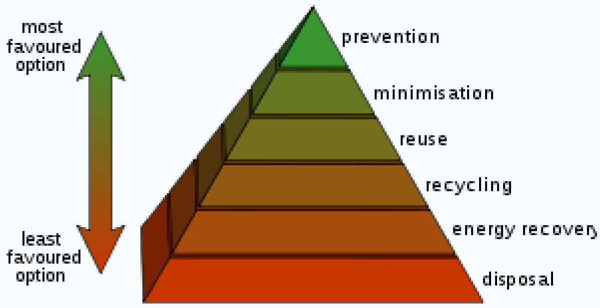
Package development considerations

Package design and development are often thought of as an integral part of the new product development process. Alternatively, development of a package (or component) can be a separate process, but must be linked closely with the product to be packaged. Package design starts with the identification of all the requirements: structural design, marketing, shelf life, quality assurance, logistics, legal, regulatory, graphic design, end-use, environmental, etc. The design criteria, time targets, resources, and cost constraints need to be established and agreed upon.

Transport packaging needs to be matched to its logistics system. Packages designed for controlled shipments of uniform pallet loads may not be suited to mixed shipments with express carriers.

Package development involves considerations for sustainability, environmental responsibility, and applicable environmental and recycling regulations. It may involve a life cycle assessment which considers the material and energy inputs and outputs to the package, the packaged product (contents), the packaging process, the logistics system, waste management, etc. It is necessary to know the relevant regulatory requirements for point of manufacture, sale, and use.

The traditional "three R's" of reduce; reuse, and recycle are part of a waste hierarchy which may be considered in product and package development.



The waste hierarchy

- Prevention – Waste prevention is a primary goal. Packaging should be used only where needed. Proper packaging can also help prevent waste. Packaging plays an important part in preventing loss or damage to the packaged-product (contents). Usually, the energy content and material usage of the product being packaged are much greater than that of the package. A vital function of the package is to protect the product for its intended use: if the product is damaged or degraded, its entire energy and material content may be lost.
- Minimization – (also "source reduction") The mass and volume of packaging (per unit of contents) can be measured and used as one of the criteria to minimize during the package design process. Usually "reduced" packaging also helps minimize costs. Packaging engineers continue to work toward reduced packaging.

- Reuse – The reuse of a package or component for other purposes is encouraged. Returnable packaging has long been useful (and economically viable) for closed loop logistics systems. Inspection, cleaning, repair and recouperage are often needed. Some manufacturers re-use the packaging of the incoming parts for a product, either as packaging for the outgoing product[18] or as part of the product itself.
- Recycling – Recycling is the reprocessing of materials (pre- and post-consumer) into new products. Emphasis is focused on recycling the largest primary components of a package: steel, aluminum, papers, plastics, etc. Small components can be chosen which are not difficult to separate and do not contaminate recycling operations.
- Energy recovery – Waste-to-energy and Refuse-derived fuel in approved facilities are able to make use of the heat available from the packaging components.
- Disposal – Incineration, and placement in a sanitary landfill are needed for some materials. Certain states within the US regulate packages for toxic contents, which have the potential to contaminate emissions and ash from incineration and leachate from landfill.[20] Packages should not be littered.

Development of sustainable packaging is an area of considerable interest by standards organizations, government, consumers, packagers, and retailers.

Packaging machines

A choice of packaging machinery includes: technical capabilities, labor requirements, worker safety, maintainability, serviceability, reliability, ability to integrate into the packaging line, capital cost, floor space, flexibility (change-over, materials, etc.), energy usage, quality of outgoing packages, qualifications (for food, pharmaceuticals, etc.), throughput, efficiency, productivity, ergonomics, return on investment, etc.

Packaging machines may be of the following general types:

- Blister packs, skin packs and Vacuum Packaging Machines
- Bottle caps equipment, Over-Capping, Lidding, Closing, Seaming and Sealing Machines
- Box, Case and Tray Forming, Packing, Unpacking, Closing and Sealing Machines
- Cartoning Machines
- Cleaning, Sterilizing, Cooling and Drying Machines
- Converting Machines
- Conveyor belts, Accumulating and Related Machines
- Feeding, Orienting, Placing and Related Machines
- Filling Machines: handling liquid and powdered products
- Inspecting, Detecting and Check weigher Machines
- Label dispensers Help peel and apply labels more efficiently
- Package Filling and Closing Machines
- Palletizing, Depalletizing, Unit load assembly
- Product Identification: labeling, marking, etc.
- Shrink wrap Machines
- Form, Fill and Seal Machines
- Other speciality machinery: slitters, perforating, laser cutters, parts attachment, etc.

FOOD LABELLING

Introduction:

Grocery store aisles are avenues to greater nutritional knowledge. With today's food labels, consumers generally get the following information:

- Nutrition information about almost every food
- Distinctive, easy-to-read formats that enable consumers to more quickly find the information to make healthful food choices.
- Information on the amount per serving of saturated fat, cholesterol, dietary fibre and other nutrients of major health concern.
- Nutrient reference values, expressed as % Daily values that help consumers see how a food fits into an overall daily diet.
- Uniform definition for terms that describe a food's nutrient content – such as "light", "low fat" and "high fibre" to ensure that such terms mean the same for any product on which they appear.
- Claims about the relationship between a nutrient or food and diseases or health-related condition such as calcium & osteoporosis, and fat & cancer. These are helpful for people who are concerned about eating foods that may help keep them healthier longer.
- Standardized serving sizes that make nutritional comparison of similar products easier.
- Declaration of total percentage of juice in fruit drinks to enable consumers to know its quantity.

A food label may literally be a label- a piece (or pieces) of printed paper attached to a food package- or it may compromise all or part of the printed or lithographed exterior surface of the package.

Codex Alimentarius published a document on the food labelling which is supposed to be followed by the food industry internationally. Nevertheless, there are general laws which should be implied on any food product:

- **Name** – Must also inform the customer the nature of the product. It may also be necessary to attach a description to the product name. However, there are certain generic names which must be only used for their conventional uses, for example: Muesli, Coffee, prawns.

- **Ingredients** – All ingredients of the food must be stated under the heading 'Ingredients' and must be stated in descending order of weight. Moreover, certain ingredients such as preservatives must be identified as such by the label 'Preservatives', a specific name, e.g. "sodium nitrite", and the corresponding European registration number colloquially known as an "E number", e.g. "E250".

- **Nutritional Information**– Although it is a legal requirement to declare Nutritional information on the pre-packaged product, if the manufacturer makes claims that the product is 'Low in Sugar', it must be supported with nutritional information (normally in tabulated form). However, as a rule it is recommended to declare nutritional information as consumers more than ever are investigating this information before making a purchase. Moreover, there are two European nutritional labelling standards which must be adhered to if nutritional information is shown.

- **Medicinal or Nutritional Claims** – Medicinal and Nutritional claims are tightly regulated, some are only allowed under certain conditions while others are not authorized at all. For example, presenting claims the food product can treat, prevent or cure diseases or other 'adverse conditions' are prohibited. While claiming the food is reduced in fat or rich in vitamins require the food to meet compulsory standards and grades, in addition, the terms must be used in a form specified in regulations.

- **Date Tagging** – There are two types of date tagging:
    - **Use by Date** – 'Use by date' must be followed by a day or/and month which the product must be consumed by. To be employed on perishable foods that usually would be kept cold, for example, fish, meat, dairy products and 'ready to eat' salads.
    - **Best Before Date** – 'Best before date is used as an indicator of when the product will begin to degrade from optimal quality: this includes when the food becomes stale, begins to taste 'off' or decays, rots or goes mouldy. There are also regulations on which type of best before date must be applied:
        - Best before + Day for foods with a shelf life of up to 3 months.
        - Best before end + Month for foods with more than a 3 month shelf life.
        - Best before end + Year for food with more than an 18 month shelf life.

- **Storage Conditions** – If there are any particular storage conditions for the product to maintain its shelf life, these must be pointed out. However, as a rule it is recommended to always describe the necessary storage conditions for a food product.

- **Business Name and Address** – In addition to the business name and address, it is necessary to indicate the manufacturer or packager, if independent to the main business and the seller established within the European Union.

- **Place of Origin** – The food is required to specify its place of origin, especially if the name or trademark is misleading - such as if the product is called 'English Brie Cheese' when it is produced in France.

- **Instruction for Use** – This is only necessary if it is not obvious how to use or prepare the product, in which case the consumer's own initiative must be used.

- **Presentation** – The label must be legible and easy to read, also it must be written in English, however, the manufacturer may also include other languages.

- Batch identifier, such as **Lot Mark** or **Batch Code** – It must be possible to identify individual batches with a lot mark or batch code - the code must be prefixed with the letter 'L' if it cannot be distinguish from other codes, however, the date mark can be used as a lot mark, Manufacturers must bear in mind that the smaller the size of a batch, the smaller financial consequences in the case of a product recall.

- **Sectioning** – All of the following must be in the same field of vision:
    - Product name
    - Date mark
    - Weight
    - Quantity
    - Alcohol strength (if applicable).

- **Standard specification** - Indicate the level of the standard compliances which the product are manufactured and packaging are completed against, and the specification limits if the standard is not publicly available, especially for those of
  - Microbial limits
  - Heavy metal limits
  - The limits of pesticide residuals
  - The limits of preservatives, artificial flavouring and colouring etc.

- **Food additives** - with a best practice, the items should be presented by their approved names (i.e. domestically), functional classes, and numbers of International Numbering System (INS) or equivalent.

However, there are many other Laws and European regulations for different types of food products.

UNDERSTANDING LABELLING RULES

Consumers should be able to be confident with their choice of foods and be able to buy according to their particular requirements, be it for diet and health, personal taste and preferences, or cost. They want to be able to make comparisons with similar products, knowing the information on the label is correct.

They have a right to expect that the food bought matches the description given on the label and that they get what they pay for. Part of the Food Standards Agency's role is to help prevent mislabelling or misdescription of foods. Mislabelling does not normally give rise to safety issues; nevertheless, when done deliberately it constitutes the crime of fraud.

In some cases, the names of foods we buy are protected by law, and must comply with certain compositional regulations. In other cases, such as fish fingers, there may be no such standards, but the food still needs to be described accurately and should not be misleading.

Food authenticity is all about whether a food matches its description. If food is misdescribed, not only is the consumer being deceived, but it can also create unfair competition with the honest manufacturer or trader. The description of food refers to the information given as to its name, its ingredients, its origin or processes undergone. In the past, basic foods such as flour, spices and beer were adulterated with cheaper ingredients.

FORMS OF MISDESCRIPTION:

Not having the necessary composition for a legal name – in order to be called 'chocolate', for example, the food must have a certain amount of cocoa solids. Similarly, in order to be called a 'sausage', it must have certain amount of meat in it.

Substitution with cheaper ingredients – adding low cost ingredients to a more expensive product, such as diluting olive oil with vegetables oils.

Extending a food – perhaps with water or other fillers, such as adding water to orange juice, or offal to meat products and not declaring it.

Incorrect origin – incorrectly labelling the true origin of the food or ingredients in terms of:

- **Animal species** – misdescribing the meat species in a product or not declaring other meat present
- **Plant variety** – adding cheaper varieties to a premium rice such as Basmati
- **Geographical origin or country** – giving the incorrect country or floral origin of a honey or region for a wine

Incorrect or failure to describe a process or treatment – not declaring if food has been irradiated or previously frozen, or the use of mechanically separated meat (MSM).

Incorrect quantitative declaration – giving the wrong amount of an ingredient e.g. declaring the wrong amount of meat in burger.

Falsely describing, advertising or presenting food is an offence, and there are a number of laws that help protect consumers against dishonest labelling and misdescription.
Legally, there are a number of areas that regulate labelling:

Regulations:

FSS Act (2006) defines labelling as, "labelling" includes any written, printed or graphic matter that is present on the label accompanying the food. Regulation 4.1.1 explains the general labelling requirements as:
1) Every prepackaged food to carry a label.
2) Prepackaged food shall not be described or presented on any label or in any labelling manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect.
3) Label in prepackaged foods shall be applied in such a manner that they will not become separated from the container.
4) Contents on the label shall be clear, prominent, indelible and readily legible by the consumer under normal condition of purchase and use.
5) Where the container is covered by a wrapper, the wrapper shall carry the necessary information or the label on the container shall be readily legible through the outer wrapper or not obscured by it.

As per FSS Act (2006); clause 23
(1) No person shall manufacture, distribute, sell or expose for sale or dispatch or deliver to any agent or broker for the purpose of sale, any packaged food products which are not marked and labelled in the manner as may be specified by regulations:
Provided that the labels shall not contain any statement, claim, design or device which is false or misleading in any particular concerning the food products contained in the package or concerning the quality or the nutritive value implying medicinal or therapeutic claims or in relation to the place of origin of the said food products.
(2) Every food business operator shall ensure that the labelling and presentation of food, including their shape, appearance or packaging, the packaging materials used, the manner in which they are arranged and the setting in which they are displayed, and the information which is made available about them through whatever medium.

NUTRITIONAL LABELLING

USA has comprehensive rules under Nutrition Labelling and Education Act, 1999 (NLEA) which requires nutrition labelling for most foods (except meat and poultry) and authorizes the use of nutrient content claims appropriate FDA- approved health claims.

Codex Alimentarius Commission has published guidelines on Nutrition labelling, CAC/GL 2-1985 (Rev. 1-1993); guidelines for use of Nutrition claims, CAC/GL 23-1997 and guidelines on claim CAC/GL 1-1979 (Rev. 1-1991).

Under NLEA, some foods are **exempt** from nutrition labelling. These include:

- Foods served for immediate consumption as in cafeterias, airplanes, food service vendors and vending machines.

- Ready-to-eat food that is not for immediate consumption but is primarily prepared onsite – eg., bakery, candy store items.
- Foods shipped in bulk, as long as it is not for sale in that form to consumers.
- Medical foods such as those used to address the needs of patients with certain diseases.
- Plain coffee and tea, some spices, and other foods that contain no significant amounts of any nutrients.

Nutrition information panel:

Under the labels "Nutrition Facts" panel, manufacturers are required to provide information on certain nutrients. The mandatory (underlined) and voluntary components and the order in which they must appear are:

- Total calories
- Calories from fat
- Calories from saturated fat
- Total fat
- Saturated fat
- Polyunsaturated fat
- Monounsaturated fat
- Cholesterol
- Sodium
- Potassium
- Total carbohydrates
- Dietary fibre
- Soluble fibre
- Insoluble fibre
- Sugars
- Sugar alcohol
- Protein
- Vitamin A
- Percent of vitamin A percent as β-carotene
- Vitamin C
- Iron
- Other essential vitamins and minerals

If a claim is made about any of the optional components, or if a food is fortified or enriched with any of them, nutrition information for these components becomes mandatory.

The required nutrients were selected because they address today's health concerns. The order in which they must appear reflects the priority of current dietary recommendations.

Nutrition Panel Format:

All nutrients must be declared as percentage of the Daily values which are label reference values. The amount in gm or mg of macronutrients (eg., fat, cholesterol, sodium, carbohydrates, & protein) are listed to the immediate right of these nutrients. A column headed "% Daily value" appears on the far right side. Declaring nutrients as a percentage of the Daily values is intended to prevent misinterpretations that arise with quantitative values.

Nutritional Panel Footnote:

The % Daily value listing carries a footnote saying that the percentage are based on a 2000-calorie diet. Some nutrient labels – at least those on larger packages have these additional footnotes:

- Person's individual nutrient goals are based on his/her calorie needs
- Lists of the daily values for selected nutrients for a 2000- and 2,500- calories diet.

An optional note for packages of any size is the number of calories per gram of fat (9), carbohydrates (4) and protein (4).

Calculation of Energy:

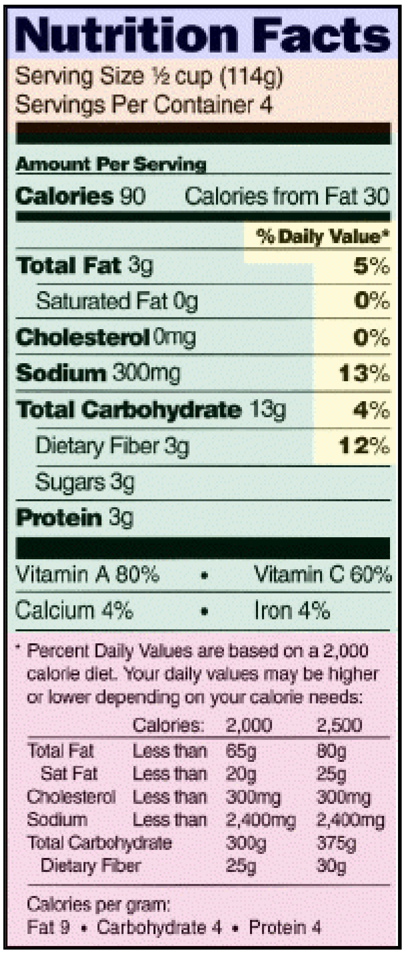
Carbohydrates	:	4 K.cal/g	-	17 Kj
Protein	:	4 K.cal/g	-	17 Kj
Fat	:	9 K.cal/g	-	37 Kj
Alcohol	:	7 K.cal/g	-	29 Kj
Organic acid	:	3 K.cal/g	-	13 Kj
Dietary fibre	:	1.9 K.cal/g	-	8 Kj

Protein = Total kjeldahl Nitrogen x 6.25

Format modifications:

For children under 2, Infant formula may not carry information about saturated fat, monounsaturated fat, cholesterol and calories from fat. Children do not require restriction about fat intake.

Some foods qualify for simplified label format. This format is allowed when the food contains insignificant amounts of seven or more of the mandatory nutrients and total calories. Insignificant means that a declaration of zero could be made in the nutrition labelling or total carbohydrates, dietary fibre and protein, the declaration states "less than 1g".


Nutrition Facts

Serving Size ½ cup (114g)
Servings Per Container 4

Amount Per Serving	
Calories 90	Calories from Fat 30
	% Daily Value*
Total Fat 3g	5%
Saturated Fat 0g	0%
Cholesterol 0mg	0%
Sodium 300mg	13%
Total Carbohydrate 13g	4%
Dietary Fiber 3g	12%
Sugars 3g	
Protein 3g	
Vitamin A 80% •	Vitamin C 60%
Calcium 4% •	Iron 4%

* Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

Serving sizes:

The serving size is the basis for reporting each food's nutrient content. It is the amount a food is customarily eaten at one time.

Daily values:

Daily values comprise two sets of dietary standards: Daily Reference Values (DRVs) and Reference Daily Intakes (RDIs). Only the Daily value term appears on the label.

DRVs have been established for macronutrients that are sources of energy: fat, saturated fat, total carbohydrates (including fibre), and protein: and for cholesterol, sodium and potassium which do not contribute calories.
DRVs for the energy-producing nutrients are based on the number of calories consumed per day.

DRVs for the energy-producing nutrients are calculated as follows:

- Fat based on 30% of calories
- Saturated fat based on 10% of calories
- Carbohydrates based on 60% of calories
- Protein based on 10% of calories
- Fibre based on 11.5g of fibre per 1000 calories.

Upper limits of DRVs are based on public health considerations,

- Total fat: less than 65g
- Saturated fat: less than 20g
- Cholesterol: less than 300mg
- Sodium: less than 2400mg

Reference Values for Nutrition Labelling (Based on a 2000 Calorie intake, for adults and children - 4 or more years of age)

Nutrient	Unit	Daily value		
		US – FDA	Codex	ICMR
Total fat	gm	US – FDA		
Saturated fatty acids	gm	Codex		
Cholesterol	mg	ICMR		
Sodium	mg	US – FDA		
Carbohydrates	gm	Codex		
Dietary fibre	gm	ICMR		
Protein	gm	US – FDA		
Vitamin A	IU	5000	2660	2660
Vitamin C	mg	60		
Calcium	mg	1000	800	800
Iron	mg	18	14	28

Nutrient Content Claims:

Free: means the product contains no amount or only trivial or "physiologically inconsequential" amounts of fat, saturated, cholesterol, sodium, sugars & calories.

Eg., calorie-free means less than 5 calories per serving; sugar-free & fat-free means less than 0.5g per serving.

Low:

Low-fat: 3g or less per serving

Low-saturated fat: 1g or less per serving

Low-sodium: 140gm or less per serving

Very low-sodium: 35mg or less per serving

Low-cholesterol: 20mg or less per serving

Low-calories: 40 calories or less per serving

Health Claims:

In India, at present health-claims are not permitted. Codex & US-FDA have following guidelines for health claims:

- Claims for 10 relationships between a nutrient or a food at the risk of a disease or health-related conditions are allowed.
- An appropriate claim is: "while many factors affect heart diseases, diets low in saturated fat and cholesterol may reduce the risk of this disease".

The allowed nutrient-disease relationship claims are:

- Calcium & Osteoporosis:
  - Food should contain 20% or more of DV for calcium (200mg) per serving
- Fat and Cancer:
  - Food should be 'low-fat' and meat be 'extra lean'
- Saturated fat & cholesterol and CHD:
- Fibre containing foods and cancer:
- Fibre containing foods and CHD:
  - Food should be with high fibre
- Sodium and Hypertension:
  - Food with low sodium foods
- Fruits & Vegetables and Cancer:
  - Good source for Vitamin A or C.
- Folic acid and neural tube defects:
  - diets with sufficient amounts of folate
- Dietary sugar alcohols and dental caries:
  - Foods such as candy, gums, containing sugar alcohols
- Soluble fibre and heart disease: Fenugreek preparations

Ingredient Labelling:

- Ingredient declaration is required on all foods that have more than one ingredient
- Additives to be mentioned by name
- Sources of protein hydrolysates
- Declaration of caseinates as a milk derivative in ingredients list of foods that claim to be non-dairy such as coffee-whiteners.

Labelling Requirements for Prepackaged Foods

1) CODEX STANDARDS:

1985 (Rev.1-1991) of Codex Alimentarius Commission has brought out Codex General Standard for the labelling of prepackaged foods.

Salient features of the guidelines are:

1. Prepackaged food shall not be described in a manner that amounts to mislead / deceive the consumer.
2. The label shall not have any words, pictures or other devices which directly or indirectly give the impression of any other product.
3. The name of food – it shall be specific and not generic.
4. List of ingredients: All ingredients under the title 'Ingredient' - shall be mentioned in the descending order of ingoing weight at the time of manufacture of the food.
5. The following foods and ingredient are known to cause hypersensitivity and shall always be declared:
    - Cereals containing gluten; i.e., wheat, rye, barley, oats, spelt or their hybridized strains and products of these;
    - Crustacea and products of these;
    - Eggs and egg products;
    - Fish and fish products;
    - Peanuts, soybeans and products of these;
    - Milk and milk products (lactose included);
    - Tree nuts and nut products; and
    - Sulphite in concentrations of 10 mg/kg or more.

A specific name shall be used for ingredients in the list of ingredients except that;

a) For ingredients falling in the respective classes, the following class tittles may be used, namely.

— Edible vegetable oil / Edible vegetable fat or both hydrogenated or partially.
— Hydrogenated oil.
— Starch.
— Fish.
— Poultry meat.
— Cheese.
— Spices herbs / condiments or mixed spices / herbs / condiments as appropriate.
— Gum base.
— Sugar.
— Dextrose or Glucose.
— Caseinates.
— Cocoa butter.
— Crystallized fruit.
— Milk solids.
— Cocoa solids.

The ingredients of pork fat, lard and beef fat or extract thereof shall always be declared by their specific manner.

When any article of food contains whole or part of any animal including birds, fresh water or marine animals or egg or product of any animal origin, but not including milk or milk products, as ingredient, a declaration to this effect shall be made by a symbol consisting of a brown colour filled circle.

Similarly in case of food product of vegetarian category, a symbol of green colour filled circle shall be given on the label.

The label shall also contain:

- Name and Address.
- Country of origin.
- Lot of identification.
- Pali marking and storage instruction.
- Instruction for use.

Numerical information on vitamins and minerals shall be expressed in metric units and / or as a percentage of the Nutrient Reference Value per 100g or per 100ml or per package. If the package contains only a single portion. In addition, this information may be given per serving as quantified on the label or per portion provided the number of portions contained in the package is stated.

Nutrition Claim

Nutrition Claim means any representation which states, suggests or implies that a food has particular nutritional properties including but not limited to the energy value and to the content of protein, fat and carbohydrates, as well as the content of vitamins and minerals.

The following nutrition claims shall be prohibited:

- Claims stating that any given food will provide an adequate source of all essential nutrients, except in the case of well defined products for which a standard regulates such claims as admissible claims
- Claims implying that a balanced diet or ordinary foods cannot supply adequate amounts of nutrients.
- Claims which cannot be substantiated.
- Claims as to the stability of a food for use in the prevention, attenuation, treatment or cure of a disease, disorder or particular physiological condition.
- Claims which could give rise to doubt about the safety of similar food or which could arouse or exploit fear in the consumer.
- Claims that a food has special characteristics.

— When all such foods have the same characteristics shall not be used.

— Terms such as ‘natural’, ‘pure’, ‘fresh’, ‘home made’, ‘organically grown’ and ‘biologically grown’ shall not be used.

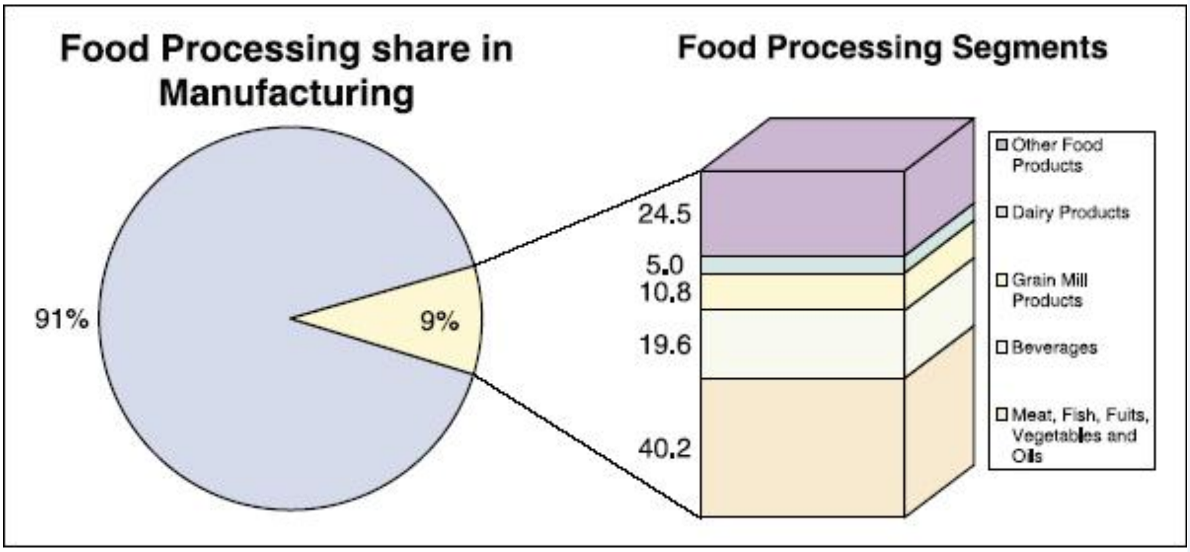
— The term ‘incomplete’, ‘comparative’, ‘superlative’, ‘wholesome’, ‘healthful’ and ‘sound’ shall not be used.

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 either in the home or by the food processing industry. Food processing typically takes clean, harvested crops or slaughtered and butchered animal products and uses these to produce attractive, marketable and often long shelf-life food products.

Food processing is a way or technique implemented to convert raw food stuff into well-cooked and well preserved eatables for both the humans and the animals. All these methods are used by food processing industry to give out processed or preserved foods for our daily consumption. Best quality harvested, slaughtered and butchered and clean constituents are used by food processing industry to manufacture very nutritious and easy to cook food products.

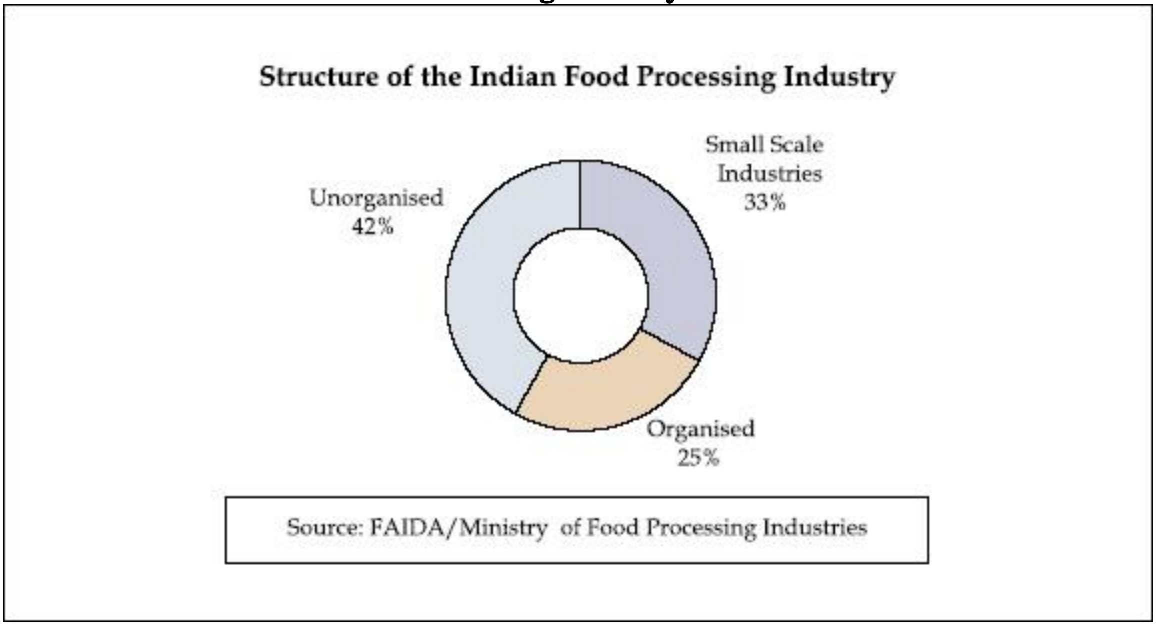
FOOD PROCESSING SECTOR – AN INDIAN SCENARIO

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.



Source: D&B Research

Structure of the Indian Food Processing Industry



Food Processing Units in Organized Sector (numbers)

Flour Mills	516
Fish Processing Units	568 (+482 cold storage units)
Fruit & Vegetable processing units	5293
Meat Processing units	171
Sweetened & aerated water units	656
Milk products units	266
Sugar Mills	429
Solvent extract units	725
Rice mills	139208
Modernised rice mills	35088

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

Industry Sub-Segments

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. Presently, the processing of fruits and vegetables is estimated to be around 2.2% of the total production in the country. 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 and vegetable processing industry is rather fragmented. A large number of units are in household and small-scale sector, having low capacities of up to 250 tonnes per annum. From the year 2000 onwards the industry has seen a significant growth in ready-to-serve beverages, pulps and fruit juices, dehydrated and frozen fruits and vegetable products, pickles, processed mushrooms and curried vegetables, and units engaged in these segments are export oriented.

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 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.

Meat & Poultry

Since 1995, production of meat and its products has been significantly growing at a rate of 4% per annum. Presently the processing level of buffalo meat is estimated at 21%, poultry is estimated at 6% while marine products are estimated at 8%. But only about 1% of the total meat is converted into value added products like sausages, ham, bacon, kababs, meatballs, etc. Processing of meat is licensed under the Meat Food Products Order, 1973. Presently the country has 3,600 slaughterhouses, 9 modern abattoirs and 171 meat-processing units licensed under the meat products order.

Poultry industry is also among the faster growing sectors rising at a rate of 8% per year. It is observed that the vertical integration of poultry production and marketing has lowered costs of production, consumer prices of poultry meat and marketing margins. There are eight integrated poultry processing units in the country, which of course hold a significant share in the industry.

Meat export is largely driven by poultry, buffalo, sheep and goat meat, which is growing at close to 30% per annum in terms of quantity. It is considered that the growing number of fast food outlets in the country has and will have a notable impact on the meat processing industry.

Marine Products

India is the largest fish producing country in the world it is the third largest fish producer in the world while ranks second in inland fish production. Categorically India's potential for fishes, from both inland and marine resources, is supplemented by the 8,000 km coastline, 3 mn hectares of reservoirs, 50,600 sq km of continental shelf area, 1.4 mn hectares of brackish water and 2.2 mn sq km of exclusive economic zone.

Processing of marine produce into canned and frozen forms is carried out fully for the export market. With regards to infrastructure facilities for processing of marine products there are 372 freezing units with a daily processing capacity of 10,320 tonnes and 504 frozen storage facilities for safe storage with a capacity of 138,229.10 tonnes, besides there are 11 surimi units, 473 pre-processing centres and 236 other storages.

Processed fish products for export include conventional block frozen products, individual quick frozen products (IQF), minced fish products like fish sausage, cakes, cutlets, pastes, surimi, texturised products and dry fish etc.
Exports of marine products have been inconsistent and on a declining trend which can be owed to the adverse market conditions prevailing in the European and American markets. The anti-dumping procedure initiated by the US Government has affected India's shrimp exports to the US.

Grain Processing

Processing of grain includes milling of wheat, rice and pulses. In 1999-00, there were more than 91,000 rice hullers and 2,60,000 small flourmills which were engaged in primary milling. There are 43,000 modernized rice mills and huller-cum-shellers. Around 820 large flourmills in the country convert about 10.5 mn tonnes of wheat into wheat products. Also there are 10,000 pulse mills milling about 75% of pulse production of 14 mn tonnes in the country.

Primary milling of grains is the considered to be the important activity in the grain-processing segment of the industry. However, primary milling adds little to shelf life, wastage control and value addition. Around 65% of rice production is milled in modern rice mills. However, the sheller-cum-huller mills operating give low recovery. Wheat is processed for flour, refined wheat flour, semolina and grits. Apart from the 820 large flourmills, there are over 3 lakh small units operating in this segment in the unorganised sector. Dal milling is the third largest in the grain processing industry, and have about 11,000 mechanised mills in the organised segment. Oilseed processing is another major segment, an activity largely concentrated in the cottage industry. According to estimates, there are approximately 2.5 lakh ghanis and kolus which are animal operated oil expellers, 50,000 mechanical oil expellers, 15,500 oil mills, 725 solvent extraction plants, 300 oil refineries and over 175 hydrogenated vegetable oil plants.

Indian Basmati rice has gained international recognition, and is a premium export product. Branded grains as well as grain processing is now gaining popularity due to hygienic packaging.

Beer & Alcoholic Beverages

When discussed on alcoholic beverages, India is considered to be the third largest market for alcoholic beverages in the world. The domestic beer and alcoholic beverage market is largely dominated by United Breweries, Mohan Meakins and Radico Khaitan. The demand for beer and spirits is estimated to be around 373 million cases per year. There are 12 joint venture companies having a licensed capacity of 33,919 kilo-litres per annum for production of grain based alcoholic beverages. Around 56 units are manufacturing beer under license from the Government of India.

Country liquor and Indian Made Foreign Liquor are the two segments in liquor; both cater to different sections of society . The former is very much consumed in rural areas and by low-income groups, while the middle and high-income groups consume the latter.

Liquor license outlets in India figures approximately 23,000 with another 10,000 outlets in the form of bars and restaurants. Regulations in this sector differ state-wise in terms of excise and custom duty. In Tamil Nadu, Kerala and Andhra Pradesh, the distribution is controlled by the state government, and any change XVIII in the ruling party has a direct impact on the availability of alcohol.

The wine industry in India has come into prominence lately and has been receiving support from the Government as well, to promote the industry,. The market for this industry has been estimated to be growing at around 25% annually. Maharashtra has emerged as an important state for the manufacture of wines.

Consumer Foods

This segment comprises of packaged foods, aerated soft drinks, packaged drinking water and alcoholic beverages.

Packaged / Convenience Foods

Consumer food industry mainly consists of ready-to-eat and ready-to-cook products, salted snacks, chips, pasta products, cocoa based products, bakery products, biscuits, soft drinks, etc.

There are around 60,000 bakeries, several pasta food units and 20,000 traditional food units and in India. The bakery industry is among the few processed food segments whose production has been increasing consistently in the country in the last few years. Products of bakery include bread, biscuits, pastries, cakes, buns, rusk etc. This activity is mostly concentrated in the unorganized sector. Bread and biscuits constitute the largest segment of consumer foods with an annual production of around 4.00 million tonnes. Bread manufacturing is reserved for the small-scale sector. Out of the total production of bread, 40% is produced in the organized sector and remaining 60% in the unorganised sector, in the production of biscuits the share of unorganized sector is about 80%.

Cocoa Products

Cocoa products like chocolates, drinking chocolate, cocoa butter substitutes, cocoa based malted milk foods are highly in demand these days, 20 production units are engaged in their manufacture with an annual production of about 34,000 tonnes.

Soft drinks

After packed tea and packed biscuits the soft drink segment is considered to be the 3rd largest in the packaged foods industry. Over 100 plants are engaged in aerated soft drinks industry and provide huge employment. It has obviously attracted one of the highest FDI in the country. Strong forward and backward linkages with glass, plastic, refrigeration, sugar and the transportation industry further strengthen the position of the industry. Soft drink segment has a huge potential in the Indian market, as a vast portion of the market is still to cover.

Constraints & Drivers of Growth

Changing lifestyles, food habits, organized food retail and urbanization are the key factors for processed foods in India, these are post-liberalization trends and they give boost to the sector.

There has been a notable change in consumption pattern in India. Unlike earlier, now the share and growth rates for fruits, vegetables, meats and dairy have gone higher compared to cereals and pulses. Such a shift implies a need to diversify the food production base to match the changing consumption preferences.

Also in developed countries it has been observed that there has been a shift from carbohydrate staple to animal sources and sugar. Going by this pattern, in future, there will be demand for prepared meals, snack foods and convenience foods and further on the demand would shift towards functional, organic and diet foods.

Some of the key constraints identified by the food processing industry include:

- Poor infrastructure in terms of cold storage, warehousing, etc
- Inadequate quality control and testing infrastructure
- Inefficient supply chain and involvement of middlemen
- High transportation and inventory carrying cost
- Affordability, cultural and regional preference of fresh food
- High taxation
- High packaging cost

PROCESSING OF FOOD – AN OVER VIEW

I. Fruits and Vegetable Processing

Fruits and vegetables are different from cereals, pulses and oilseeds. Generally they cannot be stored for longer periods and should be used as soon as possible. If stored, they should be kept in a cool, dark place to prevent sprouting, mould growth and rotting. Since they are tender and high in moisture content they are highly perishable. If not handled properly, a high value nutritious product can deteriorate and rot in a matter of days or even hours. Some fruits such as coconut and citrus (with a protective rind) can be handled and shipped reasonably well. Post harvest losses can occur in the field, in packing areas, in storage, during transportation, and in wholesale or retail markets. Therefore, a series of sophisticated technologies have to be applied in post harvest handling of horticultural crops. Fruits and vegetables breathe like humans do, respiring day and night, continuously giving off water as they release energy for growth and metabolism. In respiration, plants use oxygen to break down carbohydrates, proteins, and fats into carbon-dioxide and water. Respiration leads to drying out, wilting and shriveling, less food value and less sweetness. This leads to loss of quality and freshness. Mechanical injuries such as abrasion, puncture and bruising lead to more water loss. Also wounded and punctured areas are more prone to be attacked by bacteria and fungi. Apart from these, there are other factors that lead to loss in quality. These include inefficient crop production, harvesting and handling methods, poor crop processing techniques, inadequate methods of storage and transportation and even poor preparation procedures. Traditional marketing systems often contribute to reduced returns to farmers, by involving several changes of hands. Modern post harvest technologies applied in grading, packaging, pre-cooling, storage, and transportation, minimize losses, and preserve quality.

Another useful approach to minimize post harvest loss of horticultural commodities is to add value to products. Value addition involves change of form of a product, converting raw material into ingredients or processed products to cater to demands of heterogenous consumers. Value addition offers numerous advantages to the growers and consumers. Value added products have extended shelf life, improved quality, and palatability. Farmers can derive high farm income from their produce by adding value to their products by way of cleaning, trimming, processing, and packaging.

Post-harvest value addition includes primary, secondary, and tertiary processing, operations performed on farm produce. Primary processing refers to on-farm handling, cleaning, trimming, sorting, grading, cooling and packaging whereas secondary processing includes processes which modify the form of the product i.e. convert raw product to a processed products. Processed products offer cent percent edible product, are convenient, and have improved eating quality. Jams, jellies, marmalades, sauces, ketchups, cordials, juices, nectars, pickles, candies, preserves, canned, frozen, dried, and fermented products are examples of secondary processed products.

Jams, jellies and marmalades

Jam is made using pulp from a single fruit or from a mixture of fruits. The combination of high acidity (pH around 3.0) and high sugar content (68-72%), prevents mould growth after opening the jar. Jellies are crystal-clear jams that are made using filtered juice instead of fruit pulp and marmalades are produced from clear citrus juices (lime, orange, grapefruit, lemon or orange) that have fine shreds of peel suspended in the gel. Ginger may also be used alone or mixed with the citrus fruits.

There are two important points to remember when making jams, jellies or marmalades:

1) There must be the correct proportions of juice, sugar, acid and pectin in order to form a good gel. In general, slightly under-ripe fruits contain more acid and pectin than do overripe fruits, but there are differences in the amounts of acid and pectin in different types of fruit.

2) Water must be boiled off quickly to concentrate the mixture before it darkens. If whole fruit is used, there are two heating stages: at the start, the fruit is heated slowly to soften it and to extract pectin; then the mixture is boiled rapidly until the sugar content reaches 68-

72%. This change in heat output requires a large and easily controllable burner. At a small scale, a stainless steel pan and a gas burner can be used2, but the mixture should be constantly stirred to prevent it burning onto the base of the pan, particularly towards the end of boiling when it thickens. At higher production rates, a double-jacketed pan is better because it gives more even and faster heating and does not risk burning the product.

The type of pectin used in jams and marmalades (above 55% solids) is known as high methoxyl (HM) pectin. It is used in a pH range of 2.0-3.5. A second type, known as low methoxyl (LM) pectin, is used mainly for spreads or for gelling agents in milk products. There are a large number of different types of HM pectin, such as 'rapid set' and 'slow set' and it is necessary to specify carefully the type required when ordering pectin from a supplier.

Jams should be hot filled (at around 85oC) into glass jars and sealed with a new lid. If the temperature is too high, steam condenses to water on the inside of the lid and dilutes sugar at the surface of the jam, which can cause mould growth. If the temperature is too low, the jam thickens and is difficult to pour into containers. Jars should be filled to approximately 9/10ths full, to help a vacuum to form in the space above the product as it cools. The jars are kept upright during cooling until the gel has formed.

II. <u>Milk Processing</u>

To ensure safe milk free from disease-producing bacteria, toxic substances and foreign flavors, fresh whole milk is to be processed before marketing. The processing helps produce milk that has an initial low bacterial count, good flavor and satisfactory keeping qualities. Milk processing operations consist of clarification, pasteurization and homogenization.

The **flow chart** for the manufacture, packaging and storage of pasteurized milk is as follows:

Raw milk
↓
Receiving milk (grading, sampling, weighing, testing)
↓
Preheating (35 -40°C)
↓
Pre-filtration/Clarification
↓
Cooling and storage (5°C or below)
↓
Standardization
↓
Homogenization I (2000 psi/60°C)
↓
Homogenization II (500 psi/60°C)
↓
Pasteurization (63°C/30min or 72°C/15 sec)
↓
Packaging
↓
Storage (5°C or below)

Clarification

Noticeable quantities of foreign materials such as particles of dust, dirt and many other undesirable substances find their way into milk due to careless handling. To remove these, milk is generally passed through a centrifugal clarifier. The speed of the clarifier will be such that there is little separation of cream. This operation removes all dirt, filth, cells from the udder and some bacteria. Clarification does not remove all pathogenic bacteria from milk.

Filtration removes suspended foreign particles by the straining process, while clarification is by centrifugal sedimentation.

Standardisation is the adjustment of fat and /or SNF by increasing or decreasing.

Homogenization

The process of making a stable emulsion of milk fat and milk serum by mechanical treatment and rendering the mixture homogenous is homogenization. This is achieved by passing warm milk or cream through a small aperture under high pressure and velocity. High-pressure homogenizers, low-pressure rotary type homogenizers and sonic vibrators are used for the purpose.

The fat globules have a tendency to gather into clumps and rise due to their lower density than skim milk. When milk is homogenized the average size of the globule will be about 2 µm. homogenized milk has a creamier structure, bland flavor and a whiter appearance.

Pasteurisation

The aim of pasteurization of milk is to get rid of any disease-producing bacteria it may contain and to reduce substantially the total bacterial count for improved keeping qualities.

Current recommendations for pasteurization are based on low temperature-long-time **(LTLT)** method of holding at 63°C for 30 min to eliminate pathogenic bacteria that may be present such as Mycobacterium tuberculosis and Coxiella burnett. The index organism for pasteurization is taken as Mycobacterium tuberculosis.

In high temperature short time pasteurization **(HTST)**, milk is heated to 72°C for 15 sec. In ultrahigh temperature **(UHT)** pasteurization milk and milk product they are heated to at least 138°C for 2 sec and packaged aseptically. As pasteurized milk is not sterile it must be quickly cooled after pasteurization to prevent multiplication of surviving bacteria.

The effectiveness of pasteurisation is evaluated by phosphatase test (alkaline phosphatase activity in milk).

III. <u>Meat processing</u>

Muscles of a slaughtered animal undergo a lot of postmortem biochemical and biophysical changes **(rigor mortis)** on storage at chilling temperature of 0 - 4°C without spoilage. These changes convert muscle to meat with increase in tenderness, juiciness and colour besides other sensory characteristics. This is known as **ageing or conditioning**.

Processing of meat refers to processing techniques applied to fresh meat. Meat processing may include protein extraction, chemical and enzymatic treatments, massaging or tumbling, salting, curing, stuffing, thermal processing, smoking, grinding, mincing, chopping, flaking, dicing, cubing, restructuring and mixing of meat with various additives. Meat, non-meat ingredients, processing equipment, contact surfaces, food handlers, packaging materials, water and air are sources of contamination of meat products.

Meat products

Numerous processed meat products in the form of 'convenience foods', ready-to-cook or ready-to-eat items are available in retail stores. Meat products can be divided into several groups based on their product characteristics and processing procedures, viz., canned meats, frozen meats, dry preserved meats, cured meats, sausages, frozen dinner meats, fermented meats and luncheon meats:

i) Canned meats: Canning is a thermal process employing steam to sterilize the food material in a sealed container. Pasteurized canned products have to be kept refrigerated while sterilized products can be kept at room temperature. Processing procedure involves commercial sterilization in retorts at 121°C. Product may be fully cooked, cured or noncured. Cured products are usually pasteurized at 65 - 75°C. Metal cans are coated with sulphur resistant resins and nylon cans are used for packing. Examples of canned meats are canned ham, corned beef, beef stew, beef in chili sauce, etc.

ii) Frozen meats: Frozen meat products may be prepared from cooked or raw meat. Products are quick frozen at -20 to -40°C by blast freezing and vacuum packaged to prevent development of rancidity. Some of the products include e.g., home meal replacement items and breakfast items like meat loaf, breaded boneless pork/beef cutlet, pork sausage, meat ball, etc.

iii) Dry preserved meat: Drying of meat is an old process to keep meat at ambient temperature for longer time. Sun drying and hot air drying is prevalent commercially. Ethnic dried meat is available in some states especially buffalo meat, ostrich, etc. Dried beef item, biltong, is a popular product from South Africa. It is dried after marination with salt, seasoning and spices or after cooking. The reduced water activity increases shelf life. The dried meat is smoked to impart flavour and to increase shelf life. But texture will be hard.

iv) Cured meats: Meat cured with salt, sodium nitrite/nitrate, other adjuncts like ascorbate, erythorbate, alpha tocopherol, sugar/corn syrup and polyphosphates by injection or dry rub or as immersion pickle for preservation and getting desirable colour and flavour. They include pork products such as ham and bacon and beef product such as corned beef. Corned beef is being exported in bulk from India. The domestic consumption of the traditional products ham and bacon is comparatively higher although innumerable cured sliced restructured ready-to-eat products are in the retail stores and restaurants.

Ham is from pork thighs while conventional **bacon** is from pork bellies. Bone-in hams and boneless hams or bacon are cured by injection followed by immersion in pickle in stainless steel vats at 4°C. Hardwood or liquid smoke is used for smoking and cooking of cured products. Ham slices and bacon rashers must be cooked to ensure destruction of possible microorganisms.
Corned beef is prepared using thin strips of precooked beef cured and cooked in cans and is the major value added meat product that is exported.

v) Sausages: Sausage is a comminuted/ minced meat product with seasonings and stuffed in natural (submucosal layer of intestine) or synthetic casings (cellulose or regenerated/co-extruded collagen, fibrous and plastic). They may be marketed fresh, cooked, cooked and smoked, semidry/ summer, dry/ fermented or emulsified. Based on the processing method and characteristics, sausages are classified. For example, Frankfurter, salami, fresh beef/ pork sausages, Pepperoni, Bologna, cocktail sausages (combinations of different types of meat), etc. Several compounds are added to sausages as spices, preservatives, curing ingredients, flavour enhancers, extenders or additives.

Sausage making consists of several steps- comminution to reduce meat and fat particle size (grinding, mincing, chopping or flaking), mixing with ingredients, emulsifying, stuffing into casings, linking and tying to obtain specific length and finally packaging. Sausages other than fresh are cooked or cooked and smoked. Smoked and cooked products are showered with cold water and chilled by refrigeration. The time, temperature and humidity controls have to be checked for their precision. The microbiological quality of meat and fat trimmings used for the manufacture of sausages, temperature of thermal processing, hygienic quality of natural casing and storage temperature must be scrupulously monitored to ensure food safety. India exports about 1,200 MT of animal casings a year, mainly to EU countries.

vi) Prepared dinner meats: Most of the consumers prefer to avoid extended cooking and meal preparation time as far as possible. The options include eating out at restaurants, having takeout foods, or purchasing ready prepared meals to be reheated at home for the family meal. Taking advantage of this shift in consumer attitude and lifestyle, many processors have developed new products as home meal replacements. For example, battered/ breaded meat, coated meat products like tikka, croquettes, nuggets, frozen or refrigerated sandwiches, frozen dinner, 'pulao'/ 'biriyani', etc. Such prepared meals including meat, vegetables and other items in one package are available in railway restaurants and with other caterers.

Coated products (breaded/battered) products are prepared in three steps:
1) predusting - applying a finely ground flour and seasoning mixture to raw meat, cut-up-parts of chicken, rabbit, fish or seafoods;
2) battering - applying a flour/ seasoning batter of specific consistency to the predusted meat; and
3) breading - apply a flour mixture with a coarser bread crumbs/rusk.

Not all three steps are required depending on the specific products. Sodium tripolyphosphates may be added to increase palatability and product yield. Breaded meat can be fried and the final product frozen or refrigerated. Many of these are considered 'finger foods' or appetizer.

vii) Fermented meat products: Fermented meat products, very popular with European consumers, are prepared by microbial fermentation and dehydration to develop specific flavour and texture. Selected bacterial starter cultures like Lactobacillus, Pediococcus, Lactococcus and Micrococcus are added to the minced meat in the preparation of such products. Meats which are most commonly used for fermented products are pork and beef. The minced meat-bacterial mixture is kept at specific temperature and humidity for specified period. This allows the maximum growth of the added bacteria. During the fermentation, the bacteria utilizes the sugar and produce lactic acid, which causes decrease in pH. After completion of fermentation, the product is dried to specific moisture level. After drying, products are cooked and/or smoked as per requirement. Lower moisture content, lower water activity and low pH do not allow spoilage bacteria to grow. Based on the pH level, the fermented meat items can be divided into two groups: low acid and high acid products.

Fermented dry sausages do not require refrigeration for storage. However, semi-dry sausages require refrigeration temperature to prevent microbial spoilage during storage. Fermented sausages are very popular in Goa.

viii) Luncheon meats: These are deli (delicatessen) meat fully cooked and ready to consume 'restructured meat', manufactured in the form of loaves or slices. They are available in the retail and convenience store or deli markets as consumer demand for ready-to heat (RTH) products has increased. Luncheon meats are fully cooked/ pasteurized and are to be stored under refrigeration. Loaves are pre-sliced and packaged other than wholesale loaves. As the name indicates, these types of products are utilized for sandwich preparation. The fully cooked product is re-pasteurised after slicing to ensure inactivation of any pathogen accidentally contaminated during slicing. Since reheating tend to cause water loss, inclusion of water binding agents is essential. Many low fat formulations started appearing in retail shops, e.g., cooked beef patties.

ix) Restructured meat products: Any meat product that is partly or completely disassembled and then formed into the same or a different form is restructured. Sausages and luncheon meat are also manufactured by restructuring.

There are three basic procedures in the production of restructured meats: 1) chunking and forming, 2) flaking and forming and 3) sectioning and forming.

Chunking is by passing meat through a coarse grinder plate (kidney plate) or a dicer or chopper. Meat temperature should be 4 to 10°C. Use of antioxidants in any restructured meat product requires prior approval. Flaking is the process of reducing meat cuts and trimmings using a centrifugal cutter. Sectioning is now replaced by chunking. Examples are restructured steaks, chicken rolls, nugget sticks, cutlets, turkey ham, patties, etc.

x) Poultry meat products: Further processing of dressed poultry includes portioning (making cut up parts), seasoned cut, batter-breaded patties and nuggets, sliced meat for delis in fast food outlets and restaurants, luncheon meats for sandwiches, varieties of cooked, cured items like turkey ham and turkey bacon, frankfurters, bologna, etc. Processed whole chicken will be either halved or quartered. The various cut- up- parts of poultry are wings, breast, leg (thigh and drumstick), back and neck. Normally only the breast and thighs are hand deboned from chilled carcass. Chicken and turkey are deboned mechanically, as well.

Restructured poultry products: Restructured poultry products are sectioned and formed meat, as discussed above, e.g. poultry/ turkey rolls, fillets, poultry roasts, patties, nuggets, loaf items, turkey bacon and turkey ham. Some items are coated with batter-breading, precooked and packaged for reheating. These products are from well chilled whole muscle pieces defatted, salted and cured.

Emulsified (comminuted) poultry products: Frankfurters, bologna and loaf items are emulsified poultry products from chilled or frozen deboned poultry/ turkey. Processing is same as that of sausages discussed above.

Coated poultry products: Nuggets and patties are made from whole muscle trimmings, salt, polyphosphate, water, starches and soy proteins as binders, extenders and fillers and a variety of spices and seasonings.

Marinated poultry products: New poultry products have been evolved on marination, curing and cooking. Marination is by soaking/rubbing salt, vinegar/lemon juice/wine, oil in combination with spices to improve flavour and yield and to increase tenderness and other eating quality. All types of poultry - whole birds, cut up parts, boneless meat, chopped and formed items can be marinated. Some pieces of the product may pickup more ingredients and produce detectable variations in flavour and juiciness and may exceed the permissible levels. Good manufacturing practices have to be adopted to maintain consistency in the product. Vacuum tumbling enables commercial marination.

Ethnic Indian meat products: The demand for comminuted or minced meat products such as kabab, gushtaba, akhani, korma, kofta, meat pickle, quail egg pickle, tandoori preparations, etc. is increasing.

Rendered edible fat: Tallow is rendered beef or mutton fat, while lard is from pork. Diced or minced beef/mutton/pork fat is cooked in steam jacketed kettle to extract fat from the tissues.

Functional meat products: Functional foods are those which contain health giving qualities or provide protection against certain diseases. Functional meat products are with potential health benefits by increasing or introducing bioactive properties. Meat based bioactive peptides such as carnosine, anserine, L-carnitine (antihepertensive action), taurine, glutathione, creatine and conjugated linoleic acid are found to have nutraceutical effect. Traditionally some schools of Ayurveda prepare and market buffalo meat and chevon (goat meat) extracts/soup/broth in combination with herbal plant extracts. They are popular as functional meat food/ nutraceuticals. They are commercially manufactured according to ayurvedic pharmacopoeia. Such functional meat products are found very effective in debilitating diseases, for convalescents and women after child birth.

xi) Meat analogues: They are not meat products but are made from non-meat proteins such as soya and cultivated mould mycelia (mycoprotein). The dried chunks on rehydration will have a texture similar to lean meat. So they may be used in cheaper kinds of meat products to increase bulk or texture with proper labeling on the product.

IV. Oil Processing

Processing of oilseeds may vary with raw material however some general steps are common to all.

The first step involves, preparation of the raw material; removal of fine impurities, husks or seed coats from the seeds and separating the seeds from the chaff. The seeds are then cracked to expose the "meats" of the raw material.

Oil is then extracted mechanically with an oil press, an expeller. Presses range from small, hand-driven models that an individual can build to power-driven commercial presses.

Expellers have a rotating screw inside a horizontal cylinder that is capped at one end. The screw forces the seeds or nuts through the cylinder, gradually increasing the pressure. The material is heated by friction and/or electric heaters. The oil escapes from the cylinder through small holes or slots, and the press cake emerges from the end of the cylinder.

Oils can also be extracted with solvents, but solvent extraction is a complex operation and not suitable for small scale processor. With materials containing a low percentage of oil, solvent extraction is the only practical method of removing oil. The most commonly employed solvent is hexane. After extraction of the oil the solvent is removed from the oil.

Refining: Oils extracted by the above methods are crude and contain many other constituents like free fatty acids, unsaponifiable matter, gums, waxes, variety of coloring matter, undesirable odoriferous constituents etc. In refining the suspended particles are removed by filtration or centrifugation. The free fatty acids are removed by alkali treatment. When the free fatty acid content is high as in palm oil (5%), it is removed by blowing steam through hot oil under vacuum. This results in both deacidification and deodorization. Any remaining free fatty acids are removed by neutralization. Pigments are removed by bleaching using adsorbents like activated earth or carbon or, in special cases, chemical bleaching agents. Finally, the oil is deodorized by injecting steam through the heated fat kept under reduced pressure.

Sealed glass or plastic bottles are adequate. Colored containers in a dark box help to increase shelf life. Seed cake is a valuable by-product of pressing and makes a good chicken, pig, or cattle feed. Oil finds wide uses as food, skin care products, aromatherapies, biodiesel fuels, and industrial lubricants.

Hydrogenated oils

Unsaturated vegetable fats and oils can be transformed through partial or complete **hydrogenation** into fats and oils of higher melting point. The hydrogenation process involves *"sparging"* the oil at high temperature and pressure with hydrogen in the presence of a catalyst, typically a powdered nickel compound. As each double-bond is broken, two hydrogen atoms each form single bonds with the two carbon atoms. The elimination of double-bonds by adding hydrogen atoms is called *saturation*; as the degree of saturation increases, the oil progresses towards being fully hydrogenated. An oil may be hydrogenated to increase resistance to rancidity (oxidation) or to change its physical characteristics. As the degree of saturation increases, the oil's viscosity and melting point increase.

The use of hydrogenated oils in foods has never been completely satisfactory. Because the center arm of the triglyceride is shielded somewhat by the end fatty acids, most of the hydrogenation occurs on the end fatty acids. This makes the resulting fat more brittle. A margarine made from naturally more saturated oils will be more plastic (more "spreadable") than a margarine made from, say, hydrogenated soy oil. In addition, partial hydrogenation results in the formation of large amounts of trans fats in the oil mixture, which, since the 1970s, have increasingly been viewed as unhealthy.

(In the U.S., the USDA Standard of Identity *for a product labeled as* vegetable oil margarine *specifies that only canola, safflower, sunflower, corn, soybean, or peanut oil may be used. Products not labeled* vegetable oil margarine *do not have that restriction.)*

Particular oils

The following triglyceride vegetable oils account for almost all worldwide production, by volume. All are used as both cooking oils and as SVO or to make biodiesel.

Oil source	**USES**
Palm	The most widely produced tropical oil. Also used to make biofuel.
Soybean	Accounts for about half of worldwide edible oil production.
Rapeseed	One of the most widely used cooking oils, Canola is a (trademarked) variety

	(cultivar) of rapeseed.
Sunflower seed	A common cooking oil, also used to make biodiesel.
Peanut	Mild-flavored cooking oil.
Cottonseed	A major food oil, often used in industrial food processing.
Palm kernel	From the seed of the African palm tree
Coconut	Widely used oil for consumption and for cosmetics
Olive	Used in cooking, cosmetics, soaps and as a fuel for traditional oil lamps

*Note that these figures include industrial and animal feed use.

Other significant triglyceride oils include:

- Corn oil, one of the most common, and inexpensive cooking oils.
- Grape seed oil, used in cooking and cosmetics
- Hazelnut and other nut oils
- Linseed oil, from flax seeds
- Rice bran oil, from rice grains
- Safflower oil, a flavorless and colorless cooking oil.
- Sesame oil, used as a cooking oil, and as a massage oil, particularly in India.

V. <u>Grain Milling</u>

Milling of Wheat

The traditional procedure for milling wheat in India has been stone grinding (chakki) to obtain whole meal flour (atta). This method results in 90-95% extraction rate flour which retains almost all the nutrients of the grain while simultaneously eliminating that part of the grain which is most indigestible like cellulose, and phytic acid which binds and carries away minerals.

In modern milling, wheat is first subjected to cleaning to remove various types of impurities together with damaged, shrunken and broken kernels which are collectively known as screenings. Impurities that adhere to the grain are removed by dry scouring which loosens the impurities which are then blown away by an air current. Other impurities in the form of particles unattached to the grain are separated by making use of characteristics in which the impurities differ from wheat. These include separation based on differences in size, shape, terminal velocity in air currents, specific gravity, magnetic and electrostatic properties, colour, surface roughness etc. The total quantity of screenings removed generally amounts to 1-1.5% of the grain fed to the machine.

Next, the cleaned wheat is subjected to conditioning. This improves the physical state of the grain for milling, and sometimes improves the baking quality of the milled flour. The process involves adjustment of the average moisture content of the wheat. When the moisture content is optimum (i.e. 15-17%), the bran is toughened and separation of endosperm from the bran becomes easy.

Finally the cleaned and conditioned wheat is subjected to milling to separate the endosperm from the bran and germ, and to reduce the endosperm to flour fineness to obtain the maximum extraction of white flour from the wheat. The reduced endosperm is known as flour (white flour) and the germ, bran and residual endosperm obtained as by-products are used primarily in animal feeding.

Flour milling is achieved by grinding in roller mills. Grinding is carried out in four or five stages, i.e., in a gradual reduction process. Each grinding stage gives a “grind” consisting of a mixture of coarse, medium and fine particles, including a proportion of flour. The

different-sized particles are sorted by sifting and the coarse particles are conveyed to a subsequent grinding stage.
In each grinding stage, endosperm is separated from the bran coats. The coarse fraction from the last grind can yield no more endosperm and forms the by-product “bran”. The percentage of wheat converted into flour from the first grind to the fourth grind will be approximately 30, 66, 78 and 81.

Milling of Rice

Milling of rice (paddy) consists of cleaning to remove small and large heavy impurities, dehulling and ‘milling’ - a process which removes the coarse outer layers of bran and germ. Paddy, on milling, yields approximately 20% hulls, 8% bran, 2% polishing and 70% rice.

Paddy is milled in India either by home pounding or in mechanized rice mills. Home pounding is most commonly done using a pestle-and-mortar made of wood and worked by hand or foot. Pounding is continued till the charge has been sufficiently husked, after which it is winnowed and polished by light hand pounding. The average recovery of rice, including broken rice, in home pounding is higher than in rice milling. Home pounded rice has a short storage life owing to the high content of fat in the bran which develops rancidity.

In modern milling, rice is cleaned by using various types of machinery. The cleaned rice is then dehulled in a huller. This is actually a shelling device and there are different devices to carry it out. Rice is passed through two stone or rubber discs rotating at different speeds and, by the shearing action on the grain, the hull is pulled away. The whole kernel from which the hulls have been removed is known as “brown rice”. This is then milled in a machine called a pearler to remove coarse outer layers of bran and germ by a process of rubbing, resulting in unpolished milled rice. There is always a certain amount of breakage of rice in this milling. Unpolished rice is liable to develop rancidity and so it is next polished in a brush machine, which removes the aleurone layer and yields ‘polished rice’. Sometimes the polished rice is further treated in a device known as trumbol, to give a coating of sugar and talc to produce a brighter shine on the grains.

The milled rice consists of unbroken kernels (the heads) and broken kernels. The latter are then separated, based on their size, into large fragments (second heads), medium ones (screenings) and the smallest ones (brewers rice).

Polishing of brown rice is also carried out by solvent extraction milling (SEM). In this case, the brown rice is soaked in an oil so that the bran layer is softened and then wet milled in the presence of rice oil and hexane. The debrowned rice is rinsed with hexane and the solvent removed by suitable methods. From the bran-and-oil mixture the solvent and bran are recovered. This method has any advantages over the conventional method. The yield of heads is up by 10%; the decrease fat content of rice increases its storage life. The bran contains 17-20% protein but less than 1.5% fat and is thus good for use in dietetic food, snacks, etc. the rice oil (about 2% yield on rice weight) has edible and industrial applications.

Milling of Maize

Maize is milled by a dry or wet process. In both processes, the germ is separated from the grain in order to extract and recover germ oil. The germ oil is a valuable product, but if allowed to remain a constituent of maize meal would lead to the development of rancidity. After degermination, the dry milling employs roller mills and the process is somewhat similar to wheat milling. Wet milling involves a steeping stage and complete disintegration of the endosperm in order to recover starch and protein.

In dry milling, the object is to recover the maximum amount of grits with the minimum amount of flour, with the least possible contamination of the germ. The grains are cleaned and conditioned by addition of cold or hot water or steam, which results in the loosening and toughening of the germ and bran. The endosperm is moistened to an ideal moisture content such that the yield of grits is maximum. The conditioned grain is passed through a suitable machine to separate the bran and germ. The stock after degermination is dried to 15-15.5% moisture content and then sifted, to produce a number of fractions. The large, medium and fine fractions (hominy) are then milled in roller mills. This consists of a number of stages. All the finished grits, meal (corn meal is a product somewhat smaller than grits, but still much coarser than corn flour) and flour are sifted. The yield of products in dry maize milling is as follows: grits, 40; coarse meal, 20; fine meal, 10; flour, 5; germ, 14 and hominy feed, 11%.

Maize is wet milled to obtain starch, oil, cattle feed and the products of starch hydrolysis, viz., liquid and solid glucose and syrup. The first step in wet milling is steeping. The cleaned maize is steeped for 48 hours in warm water (50°C) containing some sulphur dioxide. Steeping in water softens the kernel and assists separation of the hull, germ and fibre from each other. After steeping, the steep water is drained off, and the maize is coarsely ground in degerminating mills to free the germ from the grain. Then the ground material flows down separating troughs in which hulls and grits settle, while the germ overflows. The germ is then separated, dried and oil extracted by hydraulic pressing or by using a solvent. The degerminated material in the separating troughs is then finely ground in a bhur or attrition mill. The hulls and fibre, which are not reduced so much in size, can then be separated from the protein and starch by sieving. The suspension of starch and protein from wet screening is adjusted to a specific gravity of 1.04 by dewatering over string filters and the starch is separated from the protein by continuous centrifugation. Finally, the starch is filtered and dried. The protein in the steep water is recovered by vacuum evaporation and dried as “gluten feed” for animal feeding.

Milling of Sorghum

Sorghum grains are processed by dry milling, wet milling and by fermentation. The products of milling are chiefly starch and feed products. Dry milling is used to obtain products low in fibre, fat and ash, and wet milling to make starch and its derivatives.

The dry milling process starts with the cleaning of grains. The cleaned grain is conditioned, by addition of water, to soften the endosperm, and milled by the conventional roller mills to soften the endosperm, and milled by the conventional roller mills to separate the endosperm, germ and bran from each other. The endosperm is recovered in the form of grits, with the minimum production of flour. Yields of various fractions from the dry milling process are: grit, 76.7; bran, 1.2; germ, 11; and fibre, 10%.

Another milling process for sorghum is “pearling” or decortication. In this case cleaned grains are wetted by spraying water for 2-3 mins and immediately milled in a rice huller, to remove a major part of the coarse fibre, pigment and phytin, with minimum degree of the cracking of the grain. A maximum of 12% polishing can be carried out. This type of milling can give products rich in protein (upto 27%), and which are also high in fat and give a high yield of ash, but are low in fibre. These products are used in the preparation of food products of high protein content.

Wet milling of sorghum is carried out by methods similar to that of maize wet milling. However, the milling of sorghum is more difficult than that of maize because of the small size and spherical shape of the sorghum kernel and the dense high-protein peripheral endosperm layer. Manufacture of starch is the main purpose of wet milling.

Milling of Barley

Barley is milled to make blocked barley, pearl barley, barley groats (grits), barley flakes and barley flour. The sequence of operations is as follows:

Barley is cleaned and conditioned, i.e., its moisture content is adjusted by drying or damping. In some countries, blocked barley or occasionally the whole grain is subjected to bleaching by sulphur dioxide. The conditioned barley is next subjected to blocking (shelling) and pearling (rounding). Both blocking and pearling are abrasive processes differing in degree of removal of the superficial layers of the grain. Blocking removes part of the husk, and pearling the remainder of the husk and part of the endosperm. Aspiration of the blocked or pearled grain removes the abraded portions. The grain is then cut into portions known as grits. The grits are graded by size and then rounded in a pearling machine and polished. Barley flakes are made from pearl barley by steaming and flaking on a smooth large-diameter roller.

Pearl or blocked barley is converted into barley flour in roller mills. Barley flour can also be milled from whole barley. The flour is also a byproduct of the cutting, pearling and polishing processes. The average yield of barley flour from pearl barley is 82% representing 58% of the grain, i.e., an overall extraction rate of 48% based on the original grain, while 59% can be obtained by using blocked barley.

VI. <u>Tea and Coffee processing:</u>

TEA

The Tea Plant: There are two major strains of the tea bush, which are:

• *Camellia Sinensis* - Pertaining to China, Tibet and Japan. 9 - 15 feet tall, 2 inch leaves. Resistant to very cold temperatures.

• *Camellia Assamica* - Pertaining to North East India. 45 - 60 feet tall (More of a tree than a bush.) 6 inch leaves. Prefers warmer climates. There are numerous hybrids that originate from the above two species, which have been developed to suit different conditions.

Plants are placed in rows some approximately one metre apart. The bushes must be pruned every four to five years in order to rejuvenate the bush and keeping it at a convenient height for the pluckers to pick the tea from. This is known as the **"Plucking Table".**

A tea bush may happily produce good tea for 50 – 70 years, but after 50 years the plant yield will reduce. At this time the older bushes will be considered for replacement by younger plants grown on the estates nursery.

Plucking: Plucking rounds depend on climate; new growth can be plucked at 7 - 12 day intervals during the growing season. Tea harvesting is exhaustive and labour intensive (between two and three thousand tea leaves are needed to produce just a kilo of unprocessed tea) and is a procedure of considerable skill.

During quality periods i.e. first flush or second flush, two leaves and a bud are picked - this is called **fine plucking**, resulting in high quality teas. At other times, even three or four leaves and a bud are plucked - this is called **coarse plucking**. The plucked leaves are collected in bamboo baskets, taking care that they are not crushed by overloading the baskets.

Tea pluckers, learn to recognise the exact moment at which the flush should be removed. This is important, to ensure the tenderest leaves are plucked to produce the finest teas.

After plucking, leaves are transported to factories for processing. The fields are normally adjacent to the factory.

Manufacture

Black Tea manufacture:

Withering: The objective of withering is to reduce the moisture in the tealeaf by up to 70% (varies from region to region).

The leaves are thinly spread to wither either naturally (where the climate is suitable) or by means of heated air forced over the withering racks. Tea is laid out on a wire mesh in troughs. Air is then passed through the tea removing the moisture in a uniform way.

This process takes around 12 to 17 hours. At the end of this time the leaf is limp and pliable and so will roll well.

Rolling: Tea is placed into a rolling machine, which rotates horizontally on the rolling table. This action creates the twisted wiry looking tealeaves.

It breaks up the leaf cells and releases the juices which give the tea its flavor. The first important chemical change starts here when the juices which remain on the leaf are exposed to the air and development of the essential oil begins. This starts the third process - oxidization.

Roll-breaking: From the roller the tea emerges as twisted lumps which are broken up by coarse mesh sieves or roll-breakers. The fine leaves which fall through are taken to the fermenting rooms, while the coarse leaf is returned for further rolling.

Oxidization/Fermentation: Once rolling is complete, the tea is either put into troughs or laid out on tables whereby the enzymes inside the tea leaf come in to contact with the air and start to oxidize. This creates the flavour, colour and strength of the tea.

It is during this process that the tealeaf changes from green, through light brown, to a deep brown, and happens at about 26 degrees centigrade.

This stage is critical to the final flavour of the tea, if left too long the flavour will be spoilt. Oxidization takes from between half an hour to 2 hours.

This process is monitored constantly with the use of a thermometer along with years of experience. The tea then passes to the final stage of drying.

Drying/Firing: To stop the oxidizing process the tea is passed through hot air dryers.

The automatic tea drier consists of a large iron box inside which the leaves, spread on trays, travel slowly from top to bottom while a continuous blast of hot dry air is forced into the box.

Careful regulation of the temperature and of the speed at which the trays move is the main factor in successful firing.

This reduces the total moisture content down to about 3%. The oxidization will be stopped by this process, and now the dried tea is ready to be sorted into grades before packing.

Green Tea manufacture:

The main difference when making green tea is that the oxidization process is omitted, which allows the tea to remain green in colour, and very delicate in flavour.

In order to ensure that the freshly picked leaf does not oxidize, before the tea is rolled, the leaf is either pan fried, or steamed. This will prevent the interaction of the enzymes in the leaf, and so no oxidization can take place.

Rolling, drying, and sorting follow.

Oolong Tea

This tea is a compromise between black and green tea. The leaves are only partly oxidized. They turn a greenish brown.

Sorting and Packaging Sorting, or grading, is the final stage in the tea process and one of the most crucial. Here leaves are sifted into different sizes, then classified according to appearance and type.

When sufficient amount of each grade has been sorted, it is then packed. This is either packed into foil lined paper sacks, which provide a moisture barrier, keeping the tea dry.

Tea chests, however, are used for larger leaf teas as they provide an extra degree of protection against the leaves being damaged in transit.

COFFEE

Coffee planting: A coffee bean is actually a seed. When dried, roasted and ground, it is used to brew coffee. But if the seed is not processed, it can be planted and will grow into a coffee tree.

Coffee seeds are generally planted in large beds in shaded nurseries. After sprouting, the seedlings are removed from the seed bed to be planted in individual pots in carefully formulated soils. They will be watered frequently and shaded from bright sunlight until they are hearty enough to be permanently planted.

Planting often takes place during the wet season, so that the soil around the young trees remains moist while the roots become firmly established.

Harvesting the Cherries: Depending on the variety, it will take approximately 3 or 4 years for the newly planted coffee trees to begin to bear fruit. The fruit, called the coffee cherry, turns a bright, deep red when it is ripe and ready to be harvested. In most countries, the coffee crop is picked by hand, a labor-intensive and difficult process, though in places like Brazil, where the landscape is relatively flat and the coffee fields immense, the process has been mechanized. Whether picked by hand or by machine, all coffee is harvested in one of two ways:

1. **Strip Picked -** the entire crop is harvested at one time. This can either be done by machine or by hand. In either case, all of the cherries are stripped off of the branch at one time.

2. **Selectively Picked -** only the ripe cherries are harvested and they are picked individually by hand. Pickers rotate among the trees every 8 - 10 days, choosing only the cherries which are at the peak of ripeness. Because this kind of harvest is labor intensive, and thus more costly, it is used primarily to harvest the finer arabica beans.

In most coffee-growing countries, there is one major harvest a year; though in countries like Colombia, where there are two flowerings a year, there is a main and secondary crop.

A good picker averages approximately 100 to 200 pounds of coffee cherry a day, which will produce 20 to 40 pounds of coffee beans. At the end of a day of picking, each worker's harvest is carefully weighed and each picker is paid on the merit of his or her work. The day's harvest is then combined and transported to the processing plant.

Processing the Cherries

Once the coffee has been picked, processing must begin as quickly as possible to prevent spoilage. Depending on location and local resources, coffee is processed in one of two ways.

1. The dry method

This is the age-old method of processing coffee and is still used in many countries where water resources are limited.

The freshly picked cherries are simply spread out on huge surfaces to dry in the sun. In order to prevent the cherries from spoiling, they are raked and turned throughout the day, then covered at night, or if it rains, to prevent them from getting wet.

Depending on the weather, this process might continue for several weeks for each batch of coffee. When the moisture content of the cherries drops to 11 percent, the dried cherries are moved to warehouses where they are stored.

2. **The wet method**

In wet method processing, the pulp is removed from the coffee cherry after harvesting and the bean is dried with only the parchment skin left on. There are several actual steps involved.

First, the freshly harvested cherries are passed through a pulping machine where the skin and pulp is separated from the bean. The pulp is washed away with water, usually to be dried and used as mulch. The beans are separated by weight as they are conveyed through water channels, the lighter beans floating to the top, while the heavier, ripe beans sink to the bottom.

Next they are passed through a series of rotating drums which separate them by size.

After separation, the beans are transported to large, water-filled fermentation tanks. Depending on a combination of factors -- such as the condition of the beans, the climate and the altitude -- they will remain in these tanks for anywhere from 12 to 48 hours. The purpose of this process is to remove the slick layer of mucilage (called the parenchyma) that is still attached to the parchment; while resting in the tanks, naturally occurring enzymes will cause this layer to dissolve. When fermentation is complete the beans will feel rough, rather than slick, to the touch. At that precise moment, the beans are rinsed by being sent through additional water channels. They are then ready for drying.

Drying the beans

If the beans have been processed by the wet method, the pulped and fermented beans must now be dried to approximately 11 percent moisture to properly prepare them for storage.

These beans, still encased inside the parchment envelope (the endocarp), can be sun dried by spreading them on drying tables or floors, where they are turned regularly, or they can be machine dried in large tumblers. Once dried, these beans, referred to as 'parchment coffee,' are warehoused in sisal or jute bags until they are readied for export.

Milling the beans

Before it is exported, parchment coffee is processed in the following manner:

a. **Hulling -** Machines are used to remove the parchment layer (endocarp) from wet processed coffee. Hulling dry processed coffee refers to removing the entire dried husk -- the exocarp, mesocarp & endocarp -- of the dried cherries.

b. **Polishing -** This is an optional process in which any silver skin that remains on the beans after hulling is removed in a polishing machine. While polished beans are considered superior to unpolished ones, in reality there is little difference between the two.

c. **Grading & Sorting -** Before being exported, the coffee beans will be even more precisely sorted by size and weight. They will also be closely evaluated for color flaws or other imperfections.

Typically, the bean size is represented on a scale of 10 to 20. The number represents the size of a round hole's diameter in terms of 1/64's of an inch. A number 10 bean would be the approximate size of a hole in a diameter of 10/64 of an inch and a number 15 bean, 15/64 of an inch. Beans are sized by being passed through a series of different sized screens. They are also sorted pneumatically by using an air jet to separate heavy from light beans.
Next defective beans are removed. Though this process can be accomplished by sophisticated machines, in many countries, it is done by hand while the beans move along an electronic conveyor belt. Beans of unsatisfactory size, color, or that are otherwise unacceptable, are removed. This might include over-fermented beans, those with insect damage or that are unhulled. In many countries, this process is done both by machine and hand, insuring that only the finest quality coffee beans are exported.

Exporting the beans

The milled beans, now referred to as **'green coffee',** are ready to be loaded onto ships for transport to the importing country. Green coffee is shipped in either jute or sisal bags which are loaded into shipping containers, or it is bulk shipped inside plastic-lined containers. Approximately seven million tons of green coffee is produced worldwide each year.

Tasting the coffee

At every stage of its production, coffee is repeatedly tested for quality and taste. This process is referred to as '**cupping**' and usually takes place in a room specifically designed to facilitate the process.

First, the taster -- usually called the **cupper** -- carefully evaluates the beans for their overall visual quality. The beans are then roasted in a small laboratory roaster, immediately ground and infused in boiling water, the temperature of which is carefully controlled. The cupper "noses" the brew to experience its aroma, an integral step in the evaluation of the coffee's quality. After letting the coffee rest for several minutes, the cupper "breaks the crust" by pushing aside the grounds at the top of the cup. Again the coffee is nosed before the tasting begins.

To taste the coffee, the cupper "slurps" a spoonful with a quick inhalation. The objective is to spray the coffee evenly over the cupper's taste buds, and then "weigh" it before spitting it out. Samples from a variety of batches and different beans are tasted daily. Coffees are not only analyzed this way for their inherent characteristics and flaws, but also for the purpose of blending different beans or determining the proper roast. An expert cupper can taste hundreds of samples of coffee a day and still taste the subtle differences between them.

Roasting the coffee

Roasting transforms green coffee into the aromatic brown beans that we purchase, either whole or already ground, in our favorite stores. Most roasting machines maintain a temperature of about 550 degrees Fahrenheit. The beans are kept moving throughout the entire process to keep them from burning and when they reach an internal temperature of about 400 degrees, they begin to turn brown and the caffeol, or oil, locked inside the beans begins to emerge.

This process, called **pyrolysis** is at the heart of roasting. It is what produces the flavor and aroma of the coffee we drink. When the beans are removed from the roaster, they are immediately cooled either by air or water. Roasting is generally performed in the importing countries because freshly roasted beans must reach the consumer as quickly as possible.

Grinding coffee

The objective of a proper grind is to get the most flavor in a cup of coffee. How coarse or fine the coffee is ground depends on the method by which the coffee is to be brewed. Generally, the finer the grind the more quickly the coffee should be prepared. That is why coffee ground for use in an espresso machine is much finer than coffee which will be brewed in a drip system.

VII. Spices and Condiments processing

There are about 35 spices and condiments which can be broadly classified into 6 groups, based upon the parts of the plants which they are obtained, namely (i) rhizomes and root spices, (ii) bark spices, (iii) leaf spices, (iv) flower spices, (v) fruit spices, and (vi) seed spices.

The important spices and condiments under commercial or large-scale cultivation are cardamom, pepper, chillies, turmeric and ginger. The total area under these spices and condiments in India is over one million hectares, and they account for an annual export earning of over 40 crores of rupees.

CARDAMOM

Cardamom (*Elettaria cardamomum* L.) is considered to be the 'Queen of Spices'. India is the largest producer and exporter of this spice, accounting for nearly 70 per cent of the total world production and 60 per cent of the total world trade.

The preparation of cardamom for the market consists in harvesting, drying, sorting, bleaching, etc. These processing activities have an important bearing on the quality of the finished product.

After harvesting, the produce is dried either in the sun or in the specially built drying houses by using radiated heat. For the latter, the devices vary from sheltered mud platforms heated by a slow fire from beneath to large drying-houses to kilns heated by fuel pipes, as is mostly done in large plantations. The fruits kept for drying are spread out thinly and stirred frequently to ensure uniform drying. Sun-drying takes 3-5 days, whereas in the case of artificial heating, it takes only about 48 hours for proper drying. The latter process also helps to retain the green colour of the capsule which is much valued, especially in the Middle-East. The dried capsules are rubbed by hand or with rough coir matting or with a piece of wire-mesh and winnowed to remove other plant residues and foreign matter. They are then sorted according to their size and colour. Since green capsules fetch a premium price in foreign markets, it is essential to retain this colour as far as possible. For this purpose, various methods have been tried. Soaking the capsules of freshly harvested green cardamom in two per cent washing-soda solution for 10 minutes before drying to less than ten per cent moisture level and storing in gunny bags lined with two layers of polythene helps to preserve green colour effectively for 6-9 months. Similarly, bleached cardamom constitutes a distinct trade quality. Bleaching is done by exposing the dried capsules to the action of sulphur dioxide produced by burning sulphur.

PEPPER

Pepper (*Piper nigrum* L.) is one of the most important and the earliest known spice crops of India. Pepper is used as a flavouring agent for food-stuff and also carminative. The alkaloid piperine forms 5 to 8 per cent by weight of the seed and the volatile pepper oil forms 1 to 3 per cent of the unripe berries.

Harvesting is generally done by plucking the spikes, when one or two berries become bright orange or red. The spikes are spread on the floor or on the mats and the berries are separated by trampling and they are dried in the sun for 4 to 7 days until the outer skins become black and shrink. This is the black pepper of commercial use.

White pepper is prepared from fully ripened berries by removing the outer rind and the pulp before drying. The recovery of the white pepper is 25 per cent of the ripe berries whereas that of black pepper is 33 per cent.

CHILLIES

Chilli (*Capsicum annuum* L.; *Capsicum frutescens* L.), also called 'red pepper', is an important cash crop in India and is grown for its pungent fruits, which are used both green and ripe (the latter in the dried form) to impart pungency to the food. The pungency is due to the active principle 'capsicin' contained in the skin and the septa of the fruit.

The crop becomes ready for harvesting in about 3½ months after planting. The picking of ripe fruit continues for about 2 months and about 6-10 pickings are taken for this purpose. The summer crop is wholly disposed of as green chillies. Ripe fruits are picked along with stalks and are heaped indoors for 3 or 4 days for the partially ripe fruit to develop the proper red colour. They are then dried in the sun for 4-5 days depending upon weather conditions and are graded for size and colour before marketing. Unripe chillies are sometimes oiled and dried for domestic consumption.

GINGER

Ginger (*Zingiber officinale Rose.*L) is an important commercial crop grown for its aromatic rhizomes which are used both as a spice and a medicine. India still is the largest producer of dry ginger.

The crop is ready for harvesting in about 8 months. The leaves at this time turn yellow and the pseudostems begin to dry. The green ginger is soaked in water to facilitate the removal of the skin. The skin is scraped off with pieces of sharpened bamboo or bits of sea-shells. The scraped produce is washed and dried in the sun for 3 or 4 days and hand-rubbed. It is again steeped in water for two hours, dried and then rubbed to remove all the remaining bits of the skin. Sun-drying also bleaches the produce. Peeling should be done with great care and skill. The essential oil which gives ginger the aromatic character is present in the epidermal cells and excessive or careless scraping will result in damaging these cells leading the loss of essential oils. Steel knives are not used as they are found to stain the produce.

TURMERIC

Turmeric (*Curcuma longa L.)* is an important and a useful dye, with varied uses in drug and cosmetic industries. It is used medicinally for external application and taken internally as a stimulant.

The crop is ready for harvesting in about 7 to 9 months after sowing depending upon the variety. The curing quality and the proportion of the cured and dried produce to the green produce depend mainly on the variety. Mother-rhizomes give a higher curing percentage than the fingers are separated. If need be, the former is kept for seed and the latter is cured for selling. The green rhizomes are boiled in water till a froth comes out and white fumes appear giving out a characteristic odour. After cooking, the rhizomes would be soft and would yield when pressed between the fingers. The quality of the final product, including its colour and aroma depends largely on the right amount of curing. The boiled rhizomes are spread out on a clean floor and allowed to dry in the sun for about 10 to 15 days. They are stirred 3 or 4 times to ensure uniform drying. The rounds and fingers are dried separately. The former takes more time to dry, when fully dried the turmeric becomes hard and stiff. The dried turmeric is rubbed against the hard surface of the drying floor or trampled under feet covered with pieces of gunny cloth. The scales and the root bases are separated by winnowing. Clean & big pieces are separated out since they fetch a premium price. The broken bits are taken separately.

SPICE OLEORESINS

Spice oleoresins represent the complete flavour profile of the spice. It contains the volatile as well as non volatile constituents of spices. Oleoresins can be defined as the true essence of the spices and can replace whole/ground spices without impairing any flavour and aroma characteristic. Spice Oleoresins are the concentrated liquid form of the spice and reproduce the character of the respective spice and spice oil fully. They are obtained by the solvent extraction of the powdered dried spices with subsequent removal of solvent.

Use

The oleoresins are used mainly as a flavouring agent in the food processing industry. They are more economical to use, easier to control for quality and cleaner than the equivalent ground spices. Oleoresins are more stable when heated. The main products in a spice oleoresin plant is oleoresins of chilli, pepper, ginger and turmeric. The co-products are the corresponding spice oils, which are widely used in food and pharmaceutical industries.

Process

The volatile oil is distilled out from the ground spices. The wet powdered spice free from volatiles are dried and then extracted with suitable solvent systems to remove the fixed oil and resineous / gummy materials. The solvent is removed from the miscella, dried and the extract is mixed with the dry spice oil to the required level and the product is suitably packed in containers.

SPICE OILS

Spice oils are the volatile components present in most spices and provide the characteristic aroma of the spices. Spice oil is normally extracted by steam distillation. Spice oils have the major advantages such as standardisation, consistency and hygiene. The standard of quality expected in a spice oil will differ depending on its end uses. Therefore, these oils are custom-made to meet the exact requirement of the user. Spice oils are mostly used in food, cosmetics, perfumes and personal hygiene products like toothpastes, mouthwashes and aerosols, besides in a variety of pharmaceutical formulation. India is a leading exporter of spice oils to West Europe, USA and Far East.

FOOD PROCESSING TECHNIQUES

HISTORY

Food processing techniques dates back to the prehistoric ages when crude processing techniques incorporated slaughtering, fermenting, sun drying, preserving with salt, and various types of cooking (such as roasting, smoking, steaming, and oven baking). Salt-preservation was especially common for foods that constituted warrior and sailors' diets, up until the introduction of canning methods.

Modern food processing technology in the 19th and 20th century was largely developed to serve military needs. In 1809 Nicolas Appert invented a vacuum bottling technique that would supply food for French troops, and this contributed to the development of tinning and then canning by Peter Durand in 1810. Although initially expensive and somewhat hazardous due to the lead used in cans, canned goods would later become a staple around the world. Pasteurization, discovered by Louis Pasteur in 1862, was a significant advance in ensuring the micro-biological safety of food.

In the 20th century, World War II, the space race and the rising consumer society in developed countries (including the United States) contributed to the growth of food processing with such advances as spray drying, juice concentrates, freeze drying and the introduction of artificial sweeteners, colouring agents, and preservatives such as sodium benzoate. In the late 20th century products such as dried instant soups, reconstituted fruits and juices, and self cooking meals such as MRE food ration were developed.

Benefits

- Mass production of food is much cheaper overall than individual production of meals from raw ingredients. Therefore, a large profit potential exists for the manufacturers and suppliers of processed food products.
- Individuals may see a benefit in convenience.
- The food industry offers products that fulfil many different needs: From peeled potatoes that only have to be boiled at home to fully prepared ready meals that can be heated up in the microwave oven within a few minutes.
- Benefits of food processing include toxin removal, preservation, easing marketing and distribution tasks, and increasing food consistency.
- It increases seasonal availability of many foods.
- Enables transportation of delicate perishable foods across long distances.
- Makes many kinds of foods safe to eat by de-activating spoilage and pathogenic micro-organisms.
- Modern food processing also improves the quality of life for people with allergies, diabetics, and other people who cannot consume some common food elements. Food processing can also add extra nutrients such as vitamins.
- Processed foods are often less susceptible to early spoilage than fresh foods and are better suited for long distance transportation from the source to the consumer.

Drawbacks

- In general, fresh food that has not been processed other than by washing and simple kitchen preparation, may be expected to contain a higher proportion of naturally-occurring vitamins, fiber and minerals than an equivalent product processed by the food industry. Vitamin C, for example, is destroyed by heat and therefore canned fruits have a lower content of vitamin C than fresh ones.
- Food processing can lower the nutritional value of foods, and introduce hazards not encountered with naturally-occurring products.
- Processed foods often include food additives, such as flavourings and texture-enhancing agents, which may have little or no nutritive value, or be unhealthy.

- Preservatives added or created during processing to extend the 'shelf-life' of commercially-available products, such as nitrites or sulphites, may cause adverse health effects. Use of low-cost ingredients that mimic the properties of natural ingredients (e.g. cheap chemically-hardened vegetable oils in place of more-expensive natural saturated fats or cold-pressed oils) have been shown to cause severe health problems.
- Processed foods often have a higher ratio of calories to other essential nutrients than unprocessed foods, a phenomenon referred to as "empty calories". So-called junk food, produced to satisfy consumer demand for convenience and low cost, are most often mass-produced processed food products.
- Because processed food ingredients are often produced in high quantities and distributed widely amongst value-added food manufacturers, failures in hygiene standards in 'low-level' manufacturing facilities that produce a widely-distributed basic ingredient can have serious consequences for many final products.
- The addition of these many chemicals for preservation and flavor have been known to cause human and animal cells to grow rapidly, without going into Apoptosis.

Performance parameters for food processing

When designing processes for the food industry the following performance parameters may be taken into account:

- Hygiene, e.g. measured by number of micro-organisms per ml of finished product
- Energy consumption, measured e.g. by "ton of steam per ton of sugar produced"
- Minimization of waste, measured e.g. by "percentage of peeling loss during the peeling of potatoes'
- Labour used, measured e.g. by "number of working hours per ton of finished product"
- Minimization of cleaning stops measured e.g. by "number of hours between cleaning stops"

Trends in modern food processing technologies.

Cost reduction

- Profit Incentive drives most of the factors behind any industry; the food industry not least of all. Health concerns are generally subservient to profit potential, leading the food processing industry to often ignore major health concerns raised by the use of industrially-produced ingredients (partially-hydrogenated vegetable oils, for example, a well-known and well-researched cause of heart disease, that is still commonly used in processed food to increase profit margin.)

Health

- Reduction of fat content in final product e.g. by using baking instead of deep-frying in the production of potato chips, another processed food
- Maintaining the natural taste of the product e.g. by using less artificial sweetener than they used before.

Hygiene

The rigorous application of industry and government endorsed standards to minimise possible risk and hazards. In the USA the standard adopted is HACCP. Lims solutions help industry to manage those quality standards.

Efficiency

- Rising energy costs lead to increasing usage of energy-saving technologies[2], e.g. frequency converters on electrical drives, heat insulation of factory buildings and

heated vessels, energy recovery systems, keeping a single fish frozen all the way from China to Switzerland.
- Factory automation systems (often Distributed control systems) reduce personnel costs and may lead to more stable production results.
- Excellent efficiency and quality is the world of food processing

Industries

Food processing industries and practices include the following:

- Cannery
- Industrial rendering
- Meat packing plant
- Slaughterhouse
- Sugar industry
- Vegetable packing plant

Minimal processing technologies

Consumers increasingly demand foods which retain their natural flavour, colour and texture and contain fewer additives such as preservatives. In response to these needs, one of the most important recent developments in the food industry has been the development of minimal processing technologies designed to limit the impact of processing on nutritional and sensory quality and to preserve food without the use of synthetic additives.

'Minimal processing' describes nonthermal technologies to process food in a manner to guarantee the food safety and preservation as well as to maintain as much as possible the fresh-like characteristics of fruits and vegetables.

Traditional thermal processing techniques can be both beneficial to foods in such areas as preservation and flavour formation but detrimental in damaging other sensory and nutritional properties. Minimising undesirable changes can be achieved in a number of ways, whether through more effective process control, the use of High Temperature Short Time (HTST) techniques such as aseptic processing, or newer thermal technologies such as volume heating methods.

However, it is well-known that processing of vegetables promotes a faster physiological deterioration, biochemical changes and microbial degradation of the product even when only slight processing operations can be used, which may result in degradation of the color, texture and flavor. Storage temperature is the single most important factor affecting spoilage of minimally processed fruit and vegetables. However, there are many other preservation techniques that are currently being used by the fresh-cut industry such as antioxidants, chlorines and modified atmosphere packaging (MAP).The safety and effectiveness of minimal processing depends on the use of novel preservation technologies, most notably in packaging.

Photochemical processes

Recently, many studies have demonstrated the effectiveness of surface decontamination techniques to reduce the microbial risk involved with the consumption of fresh fruits and vegetables. Nonionizing, artificial **ultraviolet-C (UV-C) radiation** is extensively used in a broad range of antimicrobial applications including disinfection of water, air, food preparation surfaces, food containers and surface disinfection of vegetable commodities. The ultraviolet light acts as an antimicrobial agent directly due to DNA damage and indirectly due to the induction of resistance mechanisms in different fruit and vegetables against pathogens. Exposure to UV-C also induces the synthesis of health-promoting compounds such as anthocyanins and stilbenoids. However, high UV doses, can cause damage to the treated tissue. Therefore, the possibility of decreasing the treatment intensity by combining two or more treatments to preserve the fruit and vegetable quality without decreasing the inactivation properties appears very promising. Additionally, UV-C light has already been recommended as best used in combination with other preservation techniques, since the accumulative damage due to microbial DNA appears effective in decreasing the overall number of bacteria cells, but does not result in complete sterilization.

UV-C light can also be used in **advanced oxidation processes (AOP)** (e.g. UV/ozone), which use UV oxidation as a destruction process that oxidizes organic constituents in water by the addition of strong oxidizers and UV light. In this case, oxidation of organic material or microorganisms is caused by direct reaction with the oxidizers, UV photolysis, and through the synergistic action of UV light, in combination with O3. The AOP as an oxidation step before biodegradation represent an alternative that may be more effective and less costly than O3 alone. This technology combines the potent oxidizing action of O3, which is able to convert many non-biodegradable organic materials into biodegradable forms, minimizing the accumulation of inorganic waste in the environment.

Light pulses have been used successfully as a new technique for the inactivation of bacteria and fungi on the surface of food products when the major composition of the emitted spectrum is UV light. Some studies have focused on the microbial and sensory quality of fresh-cut vegetables using intense light pulses combined with MAP.

Low-dose gamma irradiation is very effective reducing bacterial, parasitic, and protozoan pathogens in raw foods. Irradiation was approved by the FDA for use on fruits and vegetables at a maximum level of 1.0 kGy. It has already been tested in minimally processed fruit and vegetables observing that dose of 2.0 kGy strongly inhibited the growth of aerobic mesophilic and lactic microflora in shredded carrots.

Non photochemical processes

Many combinations of physical and chemical treatments have been tested in recent years to enhance the antimicrobial action of different disinfectant agents. Among them, the use of **acidic electrolyzed water (AcEW)** produced by the electrolysis of an aqueous sodium chlorite solution as a disinfectant for minimally processed vegetable products has been successfully applied.

Chlorine dioxide (ClO2) has been recognized as a strong oxidizing agent with a broad biocidal effectiveness due to the high oxidation capacity of about 2.5 times greater than chlorine.

Power ultrasound, as used for cleaning in the electronics industry, has a potential application to fresh produce decontamination. Ultrasonic fields consist of waves at high amplitude, which form cavitation bubbles, which generate the mechanical energy which has a 'cleaning action on surfaces'. Cavitation enhances the mechanical removal of attached or entrapped bacteria on the surfaces of fresh produce by displacing or loosening particles through a shearing or scrubbing action, achieving an additional log reduction when applying to a chlorinated water wash.

Pediocin and **nisin** applications in combination with organic acids caused a significant reduction of native microflora and inoculated populations on fresh produce.

Pulsed electric field

Pulsed electric field (PEF) processing is a non-thermal method of food preservation that uses short bursts of electricity for microbial inactivation and causes minimal or no detrimental effect on food quality attributes. PEF can be used for processing liquid and semi-liquid food products. PEF processing offers high quality fresh-like liquid foods with excellent flavor, nutritional value, and shelf-life. Since it preserves foods without using heat, foods treated this way retain their fresh aroma, taste, and appearance.

PEF processing involves treating foods placed between electrodes by high voltage pulses in the order of 20–80 kV (usually for a couple of microseconds). The applied high voltage results in an electric field that causes microbial inactivation. After the treatment, the food is packaged aseptically and stored under refrigeration.

PEF treatment has lethal effects on various vegetative bacteria, mold, and yeast. Efficacy of spore inactivation by PEF in combination with heat or other hurdles is a subject of current research. A series of short, high-voltage pulses breaks the cell membranes of vegetative microorganisms in liquid media by expanding existing pores (electroporation) or creating new ones. The membranes of PEF-treated cells become permeable to small molecules; permeation causes swelling and eventual rupture of the cell membrane.

Application of PEF technology has been successfully demonstrated for the pasteurization of foods such as juices, milk, yogurt, soups, and liquid eggs. Application of PEF processing is restricted to food products with no air bubbles and with low electrical conductivity. PEF is a continuous processing method, which is not suitable for solid food products that are not pumpable.

While the shelf-life of the orange juice processed with PEF was extended to 14 days, the non-treated juice was not acceptable after 4 days of storage. However, to prevent spoilage of orange-carrot juice, it would be necessary to combine an efficient PEF treatment with chilling temperatures during the distribution and storage periods and to guarantee low initial concentrations of contaminating bacteria in fresh-squeezed juice.

High hydrostatic pressure

The application of high hydrostatic pressure for processing food products consists of a pressure treatment in the range of 4000-9000 atmospheres. Hydrostatic pressure may be generated by the addition of free energy, e.g., heating at constant volume or mechanical volume reduction. It is now technically feasible to reach pressures up to several gigapascals and to keep it constant for a comparably long time in specially designed vessels made from highly alloyed steel.

The high hydrostatic pressure is used to inactivate microbial growth as well as certain enzymes to prolong the shelf-life of the food products, although the microbial inactivation will depend on the pH, food composition, osmotic pressure and the temperature of the environment. The extension of shelf-life or the elimination of microbial pathogens can be achieved since the viability of vegetative microorganisms is affected by inducing structural changes at the cell membrane or by the inactivation of enzyme systems which are responsible for the control of the metabolic actions. Thermodynamic properties and phase equilibrium of any system as well as transport properties such as viscosity, thermal conductivity, or diffusivity have to be considered in their functional relationship with temperature and pressure.

It is known that Gram negative bacteria are inhibited at lower pressure than Gram positive bacteria. The inhibition of microbial spores can be managed by combining the high pressure treatment with chilling temperatures.

Hurdle Technology

The combined use of several preservation methods, possibly physical and chemical, or a combination of different preservatives is an age-old practice. It has been commonly applied by the food industry to ensure food safety and stability. In smoked products, for example, combination treatment includes heat, reduced moisture content and antimicrobial chemicals deposited from the smoke onto the surface of the food. Some smoked foods may also be dipped or soaked in brine or rubbed with salt before smoking, to impregnate the flesh with salt and thus add a further preservative mechanism. In jam and other fruit preserves, the combined factors are heat, a high solids content (reduced water activity) and high acidity. In vegetable fermentation, the desired product quality and microbial stability are achieved by a combination of factors such as salt, acidification, and so forth.

In recent years, the concept of combining several factors has been developed by Leistner and others into the 'hurdle effect'. From an understanding of the hurdle effect, hurdle technology has been derived, which has the goal not just to understand why a certain food is safe and stable, but to improve the microbial quality of the food by an optimization and intelligent modification of the hurdles present. It employs the intelligent combination of different hurdles or preservation techniques to achieve multi-target, mild but reliable preservation effects. Hurdle technology has arisen in response to a number of developments; (i) Consumer demands for healthier foods that retain their original nutritional properties, (ii) The shift to ready-to-eat and convenience foods which require little further processing by consumers, (iii) Consumer preference for more 'natural' food which require less processing and fewer chemical preservatives. Hurdle technology provides a framework for combining a number of milder preservation techniques to achieve an enhanced level of product safety and stability.

Examples of hurdles used to preserve foods

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

Mechanism

Microorganisms react homeostatically to stress factors. When their environment is disturbed by a stress factor, they usually react in ways that maintain some key element of their physiology constant. Microorganisms undergo many important homeostatic reactions. Preservative factors functioning as hurdles can disturb one or more of the homeostasis mechanisms, thereby preventing microorganisms from multiplying and causing them to remain inactive or even die. Therefore, food preservation is achieved by disturbing the homeostasis of microorganisms. The best way to do this is to deliberately disturb several homeostasis mechanisms simultaneously thus a combination of multiple hurdles (hurdle technology) could increase the effectiveness of food preservation.

The use of different stresses at the same time (combination treatment) may also prevent the synthesis of those protective proteins because simultaneous exposure to different stresses will require energy-consuming synthesis of several or at least much more protective stress shock proteins which in turn may cause the microorganisms to become metabolically exhausted. This antimicrobial action of combining hurdles is known as 'multitarget preservation' introduced by Leistner (1995). The concept of multitarget preservation increases the effectiveness of food preservation by using a combination of different hurdles which have different spectra of antimicrobial actions. It has been suspected for some time that combining different hurdles for good preservation might not have just an additive effect (explained below) on microbial stability, but they could act synergistically. A synergistic effect (explained below) could be achieved if the hurdles in a food hit, at the same time, different targets (e.g. cell membrane, DNA, enzyme systems, pH, aw, Eh) within the microbial cells and thus disturb the homeostasis of the microorganisms present in several respects. Therefore, simultaneously employing different hurdles in the preservation of a particular food should lead to optimal microbial stability. In addition, no one preservative factor is active against all the spoilage microorganisms present in foods. An attempt is therefore made to compensate for this deficiency by combining various preservative factors having different spectra of action. Since from this multitargeted approach, hurdle technology could more effective than single targeting, it allows the use of individual hurdles of lower intensity for improving product quality as well as for food preservation.

Limitation

As described above, hurdles used in food preservation could provide varying results depending on bacterial stress reactions such as the synthesis of protective proteins. These stress reactions or cross-tolerance may not exist when combined hurdles are used. However, although hurdles are applied simultaneously in combined form, there are three possible results whereby the action may be changed by combining two or more preservative factors: (i) addition or additive effect, (ii) synergism or synergistic effect, (iii) antagonism or antagonistic effect. The term additive effect denotes that the effects of the individual substances are simply added together. Synergistic effect is the expression used when the inhibitory action of the combination is reached at a concentration lower than that of the constituent substances separately. An antagonistic effect is the opposite of this latter, i.e. one where the mixture concentration required is higher than that of the individual constituents. Among these results, first two are desirable results and the main reason the hurdle technology is employed for food preservation rather than one hurdle.

Generally, it is accepted that the combination of hurdles has a higher inhibitory effect than any single hurdle. However, recently, some studies showed that combination treatments were less effective at reducing levels of microorganism than were single treatments. These effects of combining hurdles were antagonistic. In some cases, application of the hurdle concept for food preservation may inhibit outgrowth but induce prolonged survival of microorganisms in foods. The various responses of microorganisms under mild stress conditions of hurdle technology might hamper food preservation and could turn out to be problematic for the application of hurdle technology.

FOOD PRESERVATION TECHNIQUES

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by micro-organisms. Some methods, however, use benign bacteria, yeasts or fungi to add specific qualities and to preserve food (e.g., cheese, wine). Maintaining or creating nutritional value, texture and flavour is important in preserving its value as food.

Preservation usually involves preventing the growth of bacteria, fungi, and other micro-organisms, as well as retarding the oxidation of fats which cause rancidity. It also includes processes to inhibit natural ageing and discolouration that can occur during food preparation such as the enzymatic browning reaction in apples which causes browning when apples are cut. Some preservation methods require the food to be sealed after treatment to prevent recontamination with microbes; others, such as drying, allow food to be stored without any special containment for long periods.

Common methods of applying these processes include drying, spray drying, freeze drying, freezing, vacuum-packing, canning, preserving in syrup, sugar crystallisation, food irradiation, and adding preservatives or inert gases such as carbon dioxide. Other methods that not only help to preserve food, but also add flavour, include pickling, salting, smoking, preserving in syrup or alcohol, sugar crystallisation and curing.

Preservation processes

Preservation processes include:

- Heating to kill or denature micro-organisms (e.g. boiling)
- Oxidation (e.g. use of sulphur dioxide)
- Toxic inhibition (e.g. smoking, use of carbon dioxide, vinegar, alcohol etc)
- Dehydration (drying)
- Osmotic inhibition (e.g. use of syrups)
- Low temperature inactivation (e.g. freezing)
- Ultra high water pressure (e.g. fresherized, a kind of "cold" pasteurization, the pressure kills naturally occurring pathogens, which cause food deterioration and affect food safety.)
- Many combinations of these methods
- Chelation

Various food preservation techniques to increase shelf-life of the products

Method	Effect on microbial growth or survival
Refrigeration	Low temperature to retard growth
Freezing	Low temperature and reduction of water activity to prevent microbial growth, slowing of oxidation reactions
Drying, curing and conserving	Reduction in water activity sufficient to delay or prevent microbial growth
Vacuum and oxygen free modified atmosphere packaging	Low oxygen tension inhibits strict aerobes and delays growth of facultative anaerobes
Carbon dioxide enriched and or modified atmosphere packaging	Specific inhibition of some micro-organisms
Addition of weak acids; e.g.	Reduction of the intracellular pH of micro-organisms

sodium lactate	
Lactic fermentation	Reduction of pH value *in situ* by microbial action and sometimes additional inhibition by the lactic and acetic acids formed and by other microbial products. (e.g. ethanol, bacteriocins)
Sugar preservation	Cooking in high sucrose concentration creating too high osmotic pressure for most microbial survival.
Ethanol preservation	Steeping or cooking in Ethanol produces toxic inhibition of microbes. Can be combined with sugar preservation
Emulsification	Compartmentalisation and nutrient limitation within the aqueous droplets in water-in-oil emulsion foods
Addition of preservatives such as nitrite or sulphite ions	Inhibition of specific groups of micro-organisms
Pasteurization and appertization	Delivery of heat sufficient to inactivate target micro-organisms to the desired extent
Food irradiation (Radurization, radicidation and radappertization)	Delivery of ionising radiation to disrupt cellular RNA
Application of high hydrostatic pressure (Pascalization)	Pressure-inactivation of vegetative bacteria, yeasts and moulds
Pulsed electric field processing (PEF treatment)	Short bursts of electricity for microbial inactivation

Drying

One of the oldest methods of food preservation is by drying, which reduces water activity sufficiently to prevent or delay bacterial growth. Drying also reduces weight, making food more portable. **Drying** is a method of food preservation that works by removing water from the food, which inhibits the growth of microorganisms and hinders quality decay. Drying food using sun and wind to prevent spoilage has been practised since ancient times. Water is usually removed by evaporation (air drying, sun drying, smoking or wind drying) but, in the case of freeze-drying, food is first frozen and then the water is removed by sublimation.

Bacteria yeasts and moulds need the water in the food to grow. Drying effectively prevents them from surviving

There are many different methods for drying, each with their own advantages for particular applications; these include:

- Bed dryers
- Fluidized bed dryers
- Freeze Drying
- Shelf dryers
- Spray drying
- Sunlight
- Commercial food dehydrators
- Household oven

Examples:

Most types of meat can be dried; a good example is beef biltong.

Many fruits can also be dried; for example, the process is often applied to apples, pears, bananas, mangoes, papaya, apricot, and coconut. Zante currants, sultanas and raisins are all forms of dried grapes.

Drying is also the normal means of preservation for cereal grains such as wheat, maize, oats, barley, rice, millet and rye.

Freezing

Freezing is also one of the most commonly used processes commercially and domestically for preserving a very wide range of food including prepared food stuffs which would not have required freezing in their unprepared state. Cold stores provide large volume, long-term storage for strategic food stocks held in case of national emergency in many countries.

Examples:

Potato waffles are stored in the freezer, but potatoes themselves require only a cool dark place to ensure many months' storage.

Smoking

Smoking is the process of flavoring, cooking, or preserving food by exposing it to the smoke from burning or smoldering plant materials, most often wood. Meats and fish are the most common smoked foods, though cheeses, vegetables, and ingredients used to make beverages such as whisky,[1] Rauchbier, and lapsang souchong tea are also smoked. Smoke is an antimicrobial and antioxidant, but smoke alone is insufficient for preserving food in practice.

"**Hot smoking**" exposes the foods to smoke and heat in a controlled environment. Although foods that have been hot smoked are often reheated or cooked, they are typically safe to eat without further cooking. "**Smoke-roasting**" or "**Smoke-baking**" refers to any process that has the attributes of smoking with either roasting or baking. "**Cold smoking**" can be used as a flavor enhancer for items such as pork chops, beef steaks, chicken breasts, salmon and scallops.

Eating a diet high in smoked, cured, or salted meats has been shown to be a risk factor in stomach cancer.In addition to sugar and salt exposure, smoking can directly create compounds known to have long-term health consequences, namely polycyclic aromatic hydrocarbons, or PAHs, many of which are known or suspected carcinogens.

Vacuum packing

Vacuum-packing stores food in a vacuum environment, usually in an air-tight bag or bottle. The vacuum environment strips bacteria of oxygen needed for survival, slowing spoiling.

Example:

Vacuum-packing is commonly used for storing nuts to reduce loss of flavor from oxidation.

Salting / Pickling

Salting or curing draws moisture from the meat through a process of osmosis. **Pickling**, also known as **brining** or **corning**, is the process of preserving food by anaerobic fermentation in brine (a solution of salt in water) to produce lactic acid, or marinating and storing it in an acid solution, usually vinegar (acetic acid). The resulting food is called a *pickle.* This procedure gives the food a salty or sour taste. In South Asia edible oils are used as the pickling medium instead of vinegar.

Table salt, which consists primarily of sodium chloride, is the most important ingredient for curing food and is used in relatively large quantities. Salt kills and inhibits the growth of microorganisms by drawing water out of the cells of both microbe and food alike through osmosis. Concentrations of salt up to 20% are required to kill most species of unwanted bacteria.

Pickling is a method of preserving food in an edible anti-microbial liquid. Pickling can be broadly categorized as chemical pickling (for example, brining) and fermentation pickling (for example, making sauerkraut).

In **chemical pickling**, the food is placed in an edible liquid that inhibits or kills bacteria and other micro-organisms. Typical pickling agents include brine (high in salt), vinegar, alcohol, and vegetable oil, especially olive oil but also many other oils. Many chemical pickling processes also involve heating or boiling so that the food being preserved becomes saturated with the pickling agent. Common chemically pickled foods include cucumbers, peppers, corned beef, herring, and eggs, as well mixed vegetables such as piccalilli, chow-chow, giardiniera, and achar.

In **fermentation pickling**, the food itself produces the preservation agent, typically by a process that produces lactic acid. Fermented pickles include sauerkraut, nukazuke, kimchi, surströmming, and curtido. Some chemically pickled cucumbers are also fermented.

In **commercial pickles**, a preservative like sodium benzoate or EDTA may also be added to enhance shelf life.

Example:

Meat is cured with salt or sugar, or a combination of the two. Nitrates and nitrites are also often used to cure meat and contribute the characteristic pink color, as well as inhibition of Clostridium botulinum.

Sauerkraut and Korean kimchi are produced by salting the vegetables to draw out excess water.

Sugar

Sugar is used to preserve fruits, either in syrup with fruit such as apples, pears, peaches, apricots, plums or in crystallized form where the preserved material is cooked in sugar to the point of crystallisation and the resultant product is then stored dry. This method is used for the skins of citrus fruit (candied peel), angelica and ginger. A modification of this process produces glacé fruit such as glacé cherries where the fruit is preserved in sugar but is then extracted from the syrup and sold, the preservation being maintained by the sugar content of the fruit and the superficial coating of syrup. The use of sugar is often combined with alcohol for preservation of luxury products such as fruit in brandy or other spirits. These should not be confused with fruit flavored spirits such as cherry brandy or Sloe gin.

Lye

Sodium hydroxide (lye) makes food too alkaline for bacterial growth. Lye will saponify fats in the food, which will change its flavor and texture. Lutefisk uses lye in its preparation, as do some olive recipes. Modern recipes for century eggs also call for lye. Masa harina and hominy use lye in their preparation, but not for preservation.

Pasteurization

Pasteurization is a process which slows microbial growth in food. Pasteurization is not intended to destroy all pathogenic micro-organisms in the food or liquid. Instead, pasteurization aims to reduce the number of viable pathogens so they are unlikely to cause disease (assuming pasteurization product is stored as indicated and consumed before its expiration date). Commercial-scale sterilisation of food is not common because it adversely affects the taste and quality of the product. Certain food products are processed to achieve the state of commercial sterility. A newer method called flash pasteurization involves shorter exposure to higher temperatures, and is claimed to be better for preserving fashion and taste in some eggs.

Canning and bottling

Canning involves cooking food, sealing it in sterile cans or jars, and boiling the containers to kill or weaken any remaining bacteria as a form of sterilization, inventor Nicolas Appert. Various foods have varying degrees of natural protection against spoilage and may require that the final step occur in a pressure cooker.

High-acid fruits like strawberries require no preservatives to can and only a short boiling cycle, whereas marginal fruits such as tomatoes require longer boiling and addition of other acidic elements. Low acid foods, such as vegetables and meats require pressure canning. Food preserved by canning or bottling is at immediate risk of spoilage once the can or bottle has been opened.

Jellying

Food may be preserved by cooking in a material that solidifies to form a gel. Such materials include gelatine, agar, maize flour and arrowroot flour. Some foods naturally form a protein gel when cooked such as eels and elvers, and sipunculid worms which are a delicacy in the town of Xiamen in Fujian province of the People's Republic of China. Jellied eels are a delicacy in the East End of London where they are eaten with mashed potatoes. Potted meats in aspic, (a gel made from gelatine and clarified meat broth) were a common way of serving meat off-cuts in the UK until the 1950s. Many jugged meats are also jellied.

Fruit preserved by jellying is known as jelly, marmalade, or fruit preserves. In this case, the jellying agent is usually pectin, either added during cooking or arising naturally from the fruit. Most preserved fruit is also sugared in jars. Heating, packaging and acid and sugar provide the preservation.

Potting

A traditional British way of preserving meat (particularly shrimp) is by setting it in a pot and sealing it with a layer of fat. Also common is potted chicken liver; compare pâté.

Jugging

Meat can be preserved by jugging, the process of stewing the meat (commonly game or fish) in a covered earthenware jug or casserole. The animal to be jugged is usually cut into pieces, placed into a tightly-sealed jug with brine or gravy, and stewed. Red wine and/or the animal's own blood is sometimes added to the cooking liquid. Jugging was a popular method of preserving meat up until the middle of the 20th century.

Irradiation

Irradiation of food is the exposure of food to ionizing radiation; either high-energy electrons or X-rays from accelerators, or by gamma rays (emitted from radioactive sources as Cobalt-60 or Caesium-137). The treatment has a range of effects, including killing bacteria, molds and insect pests, reducing the ripening and spoiling of fruits, and at higher doses inducing sterility. The technology may be compared to pasteurization; it is sometimes called 'cold pasteurization', as the product is not heated. Irradiation is not effective against viruses or prions, it cannot eliminate toxins already formed by microorganisms, and is only useful for food of high initial quality.

It is estimated that about 500,000 tons of food items are irradiated per year worldwide in over 40 countries. These are mainly spices and condiments with an increasing segment of fresh fruit irradiated for fruit fly quarantine.

Pulsed Electric Field Processing

Pulsed electric field (PEF) processing is a method for processing cells by means of brief pulses of a strong electric field. PEF holds potential as a type of low temperature alternative pasteurization process for sterilizing food products. In PEF processing, a substance is placed between two electrodes, then the pulsed electric field is applied. The electric field enlarges the pores of the cell membranes which kills the cells and releases their contents. PEF for food processing is a developing technology still being researched. There have been limited industrial applications of PEF processing for the pasteurization of fruit juices.

Modified atmosphere

is a way to preserve food by operating on the atmosphere around it. Salad crops which are notoriously difficult to preserve are now being packaged in sealed bags with an atmosphere modified to reduce the oxygen (O_2) concentration and increase the carbon dioxide (CO_2) concentration.

Grains may be preserved using carbon dioxide. A block of dry ice is placed in the bottom and the can is filled with grain. The can is then "burped" of excess gas. The carbon dioxide from the sublimation of the dry ice prevents insects, mold, and oxidation from damaging the grain. Grain stored in this way can remain edible for five years. - Nitrogen gas (N_2) at concentrations of 98% or higher is also used effectively to kill insects in grain through hypoxia. However, carbon dioxide has an advantage in this respect as it kills organisms through both hypoxia and hypercarbia, requiring concentrations of only 80%, or so. This makes carbon dioxide preferable for fumigation in situations where an hermetic seal cannot be maintained.

Burial in the ground

Burial of food can preserve it due to a variety of factors: lack of light, lack of oxygen, cool temperatures, pH level, or desiccants in the soil. Burial may be combined with other methods such as salting or fermentation.

Many root vegetables are very resistant to spoilage and require no other preservation other than storage in cool dark conditions, for example by burial in the ground, such as in a storage clamp.

Century eggs are created by placing eggs in alkaline mud (or other alkaline substance) resulting in their "inorganic" fermentation through raised pH instead of spoiling. The fermentation preserves them and breaks down some of the complex, less flavorful proteins and fats into simpler more flavorful ones.

Most foods can be preserved in soil that is very dry and salty (thus a desiccant), or soil that is frozen.

Cabbage was traditionally buried in the fall in northern farms in the USA for preservation. Some methods keep it crispy while other methods produce sauerkraut. A similar process is used in the traditional production of kimchi.

Sometimes meat is buried under conditions which cause preservation. If buried on hot coals or ashes, the heat can kill pathogens, the dry ash can desiccate, and the earth can block oxygen and further contamination. If buried where the earth is very cold, the earth acts like a refrigerator.

Controlled use of micro-organism

Some foods, such as many cheeses, wines, and beers will keep for a long time because their production uses specific micro-organisms that combat spoilage from other less benign organisms. These micro-organisms keep pathogens in check by creating an environment toxic for themselves and other micro-organisms by producing acid or alcohol. Starter micro-organisms, salt, hops, controlled (usually cool) temperatures, controlled (usually low) levels of oxygen and/or other methods are used to create the specific controlled conditions that will support the desirable organisms that produce food fit for human consumption.

High pressure food preservation

High pressure food preservation refers to high pressure used for food preservation. "Pressed inside a vessel exerting 70,000 pounds per square inch or more, food can be processed so that it retains its fresh appearance, flavour, texture and nutrients while disabling harmful microorganisms and slowing spoilage."

Modified Atmosphere Packaging

Modified Atmosphere Packaging is a way of extending the shelf life of fresh food products. The technology substitutes the atmospheric air inside a package with a protective gas mix. The gas in the package helps ensure that the product will stay fresh for as long as possible.

The modification process often tries to lower the amount of oxygen (O_2), moving it from 20% to 0%, In order to slow down the growth of aerobic organisms and the speed of oxidation reactions. The removed oxygen can be replaced with nitrogen (N_2), commonly acknowledged as an inert gas, or carbon dioxide (CO_2), which can lower the pH or inhibit the growth of bacteria. Carbon monoxide can be used for keeping the red color of meat.

There are two techniques used in the industry to pack vegetables namely **gas-flushing** and **compensated vacuum**. For its cheapness the gas-flushing is more widely used. In gas-flushing the package is flushed with a desired gas mixture, as in compensated vacuum the air is removed totally and the desired gas mixture then inserted. The label "packaged in a protective atmosphere" can refer to either of these; an example of a gas mixture used for non-vegetable packaged food (such as crisps) is 99.9% nitrogen gas, which is inert at the temperatures and pressures the packaging is subjected to.
A wide variety of products are gas flushed, typical products are:

- Fresh meat, Processed meat, Cheese, Milk powder, Snacks, Fresh pasta, Vegetables, Bread, Convenience products, Case ready meat, Fresh poultry, Seafood etc.

Introduction
Adequate, safe and wholesome food is a vital element for the achievement of acceptable standards of living. There is increasingly worldwide concern about food safety and animal and plant health. The WTO Agreement on Sanitary and Phytosanitary Measures sets out the basic rules for food safety and animal and plant health regulations. It applies to all such measures which may, directly or indirectly, affect international trade. All countries have the right to adopt or enforce necessary measures to protect human, animal or plant life or health, subject to the requirement that these measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between Members where the same conditions prevail.

The major objectives of the work of Codex Alimentarius Commission [CAC] are to protect the health of the consumers and ensure fair practices in the food trade as well as to facilitate international trade in food. The National Codex Contact Point (NCCP) in the Ministry of Health and Family Welfare acts as the liaison office to coordinate with the other concerned government departments (at central and state level), food industry, consumers, traders, research and development institutions to ensure fulfill this objective. Article 7 of the Agreement requires the members to provide information on Sanitary or Phytosanitary requirements in the country. For this purpose each Member is required to ensure that one Enquiry Point exists which is responsible for answering all reasonable questions from interested Members as well as to provide relevant documents relating to SPS Regulations adopted or proposed, etc.

Codex Alimentarius Commission [CAC]
The Codex Alimentarius Commission was created in 1963 by Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) to develop food standards, guidelines and related texts such as codes of practice under the Joint FAO/WHO Food Standards Programme. The main purpose of this Programme is to protect the health of consumers, ensure fair practices in the food trade, and promote coordination of all food standards work undertaken by international governmental and non-governmental organizations. These standards are accepted by World Trade Organization (WTO) in settling disputes in international trade.

Codex Alimentarius is a collection of standards, codes of practice, guidelines and other recommendations. The Codex General Principles of Food Hygiene introduces the use of the Hazard Analysis and Critical Control Point (HACCP), being the prime food safety management system. Several significant issues, vital to fulfilling the objectives of the Codex Alimentarius Commission, namely, protecting the health of consumers, ensuring food safety and promoting fair global trade practices are under discussion across several Codex Committees that focus on Food Safety Objectives.

Standards, codes of practice, guidelines and other recommendations
Codex standards usually relate to product characteristics and may deal with all government-regulated characteristics appropriate to the commodity, or only one characteristic. Maximum
residue limits (MRLs) for residues of pesticides or veterinary drugs in foods are examples of standards dealing with only one characteristic. There are ***Codex general standards*** for food additives and contaminants and toxins in foods that contain both general and commodity- specific provisions. The Codex General Standard for the Labelling of Prepackaged Foods covers all foods in this category. Because standards relate to product characteristics, they can be applied wherever the products are traded.

Codex methods of analysis and sampling, including those for contaminants and residues of pesticides and veterinary drugs in foods, are also considered Codex standards.

Codex codes of practice – including codes of hygienic practice – define the production, processing, manufacturing, transport and storage practices for individual foods or groups of foods that are considered essential to ensure the safety and suitability of food for consumption. For food hygiene, the basic text is the Codex General Principles of Food Hygiene, which introduces the use of the Hazard Analysis and Critical Control Point (HACCP) food safety management system.

Codex guidelines fall into two categories:

• principles that set out policy in certain key areas; and

• guidelines for the interpretation of these principles or for the interpretation of the provisions of the Codex general standards.

Interpretative Codex guidelines include those for food labelling, especially the regulation of claims made on the label. This group includes guidelines for nutrition and health claims; conditions for production, marketing and labelling of organic foods; and foods claimed to be “halal”.

Commodity standards
By far the largest number of specific standards in the Codex Alimentarius is the group called “commodity standards”.

The major commodities included in the Codex are:
• cereals, pulses (legumes) and derived products including vegetable proteins
• fats and oils and related products
• fish and fishery products
• fresh fruits and vegetables
• processed and quick-frozen fruits and vegetables
• fruit juices
• meat and meat products; soups and broths
• milk and milk products
• sugars, cocoa products and chocolate and other miscellaneous products

The Commission’s operations

Compiling the Codex Alimentarius
As stated in Article 1 of the Commission’s Statutes, one of the principal purposes of the Commission is the preparation of food standards and their publication in the Codex Alimentarius.

The legal base for the Commission’s operations and the procedures it is required to follow are published in the ***Procedural Manual of the Codex Alimentarius Commission.*** Like all other aspects of the Commission’s work, the procedures for preparing standards are well defined, open and transparent.

In essence they involve:

• The ***submission of a proposal*** for a standard to be developed by a national government or a subsidiary committee of the Commission. This is usually followed by a discussion paper that outlines what the proposed standard is expected to achieve, and then a project proposal that indicates the time frame for the work and its relative priority.

• A ***decision by the Commission or the Executive Committee that a standard be developed*** as proposed. “Criteria for the Establishment of Work Priorities” exist to assist the Commission or Executive Committee in their decision-making and in selecting the subsidiary body to be responsible for steering the standard through its development. If necessary, a new subsidiary body – usually a specialized task force – may be created.

• The preparation of a ***proposed draft standard*** is arranged by the Commission Secretariat and ***circulated to member governments*** for comment.

• Comments are considered by the subsidiary body that has been allocated responsibility for the development of the proposed draft standard, and this subsidiary body may present the text to the Commission as a ***draft standard.*** The draft may also be referred to the Codex Committees responsible for labelling, hygiene, additives, contaminants or methods of analysis for endorsement of any special advice in these areas.

• Most standards take a number of years to develop. Once adopted by the Commission, a ***Codex standard*** is added to the Codex Alimentarius.

Revising and adapting: keeping the Codex Alimentarius up to date
The Commission and its subsidiary bodies are committed to keeping the Codex standards and related texts up to date to ensure that they are consistent with current scientific knowledge and with the needs of the member countries.

The procedure for revision or consolidation follows that used for the initial preparation of standards.

General Subject Committees
These Committees are so called because their work has relevance for all Commodity Committees and, because this work applies across the board to all commodity standards, General Subject Committees are sometimes referred to as "horizontal committees".

General Subject Committees develop all-embracing concepts and principles applying to foods in general, specific foods or groups of foods; endorse or review relevant provisions in Codex commodity standards; and, based on the advice of expert scientific bodies, develop major recommendations pertaining to consumers' health and safety.

Six of the General Subject Committees have the responsibility of ensuring that specific provisions in Codex commodity standards are in conformity with the Commission's main general standards and guidelines in their particular areas of competence. They are:

• Committee on Food Additives
• Committee on Contaminants in Foods
• Committee on Food Hygiene
• Committee on Food Labelling
• Committee on Methods of Analysis and Sampling
• Committee on Nutrition and Foods for Special Dietary Uses

These Committees may also develop standards, maximum limits for additives and contaminants, codes of practice or other guidelines for either general application or in specific cases where the development of a complete commodity standard is not required. For example, the Committee on Food Hygiene has developed a Code of Hygienic Practice for Spices and Dried Aromatic Plants, and the Committee on Food Additives and Contaminants (divided into two committees in 2006) has developed a Standard for Maximum Levels of Lead in Foods. The Committees on Food Labelling and on Nutrition and Foods for Special Dietary Uses have worked together to prepare the Codex Guidelines on Nutrition Claims.

The Committee on Pesticide Residues and the Committee on Residues of Veterinary Drugs in Foods prepare MRLs for these two categories of chemicals used in agricultural production.

The Committee on Food Import and Export Inspection and Certification Systems deals with the application of standards to foods moving in international trade, in particular to the regulatory measures applied by governments to assure their trading partners that foods and their production systems are correctly regulated to protect consumers against foodborne hazards and deceptive marketing practices.

Commodity Committees
The responsibility for developing standards for specific foods or classes of food lies with the Commodity Committees. In order to distinguish them from the "horizontal committees" and recognize their exclusive responsibilities, they are often referred to as "vertical committees".

Commodity Committees convene as necessary and go into recess or are abolished when the Commission decides their work has been completed. New Committees may be established on an ad hoc basis to cover specific needs for the development of new standards. There are currently five Commodity Committees that meet regularly:

• Committee on Fats and Oils
• Committee on Fish and Fishery Products
• Committee on Fresh Fruits and Vegetables
• Committee on Milk and Milk Products
• Committee on Processed Fruits and Vegetables

The following Commodity Committees work through correspondence or are in recess:
• Committee on Cereals, Pulses and Legumes
• Committee on Cocoa Products and Chocolate
• Committee on Meat Hygiene
• Committee on Natural Mineral Waters
• Committee on Sugars
• Committee on Vegetable Proteins

Applying Codex standards
The harmonization of food standards is generally viewed as contributing to the protection of consumer health and to the fullest possible facilitation of international trade. For this reason, the Uruguay Round Agreements on the Application of Sanitary and Phytosanitary Measures and on Technical Barriers to Trade (SPS and TBT Agreements) both encourage the international harmonization of food standards.

Differing legal formats and administrative systems, varying political systems and sometimes the influence of national attitudes and concepts of sovereign rights impede the progress of harmonization and deter the acceptance of Codex standards.

Despite these difficulties, however, the process of harmonization is gaining impetus by virtue of the strong international desire to facilitate trade and the desire of consumers around the world to have access to safe and nutritious foods. An increasing number of countries are aligning their national food standards, or parts of them (especially those relating to safety), with those of the Codex Alimentarius. This is particularly so in the case of additives, contaminants and residues, i.e. the invisibles.

Codex Maximum Limits for Pesticides Residues in Food & TBT Agreement
A country which accepts a codex maximum limit for pesticides residues in foods according to the provision of General Principles of the Codex Alimentarius should be prepared to offer advice and guidance to exporters and processors of food for export to promote understanding of and compliance with the requirements of importing countries. Technical barriers to trade (TBT) generally result from the preparation, adoption and application of different technical regulations and conformity assessment procedures. If a producer in an exporting country 'A' wants to export to an importing country 'B'; he will be obliged to satisfy the technical requirements that apply in country 'B', with all the financial consequences this entails. The importing country agreeing Codex MRLs have a right to reject consignment on different technical regulations.

Codex India

"Codex India" the National Codex Contact Point (NCCP) for India, is located at the Directorate General of Health Services, Ministry of Health and Family Welfare (MOH&FW), Government of India. It coordinates and promotes Codex activities in India in association with the National Codex Committee and facilitates India's input to the work of Codex through an established consultation process.

Role of Ministry of Health & Family Welfare/Directorate General of Health Services (Codex Contact Point) now FSSAI

Food Legislation and food control infrastructure should be sufficiently developed in the country to enable provide adequate health protection and in the well being of its citizens. It should be ensured that all types of food are free from any hazards responsible for adverse health effects. The Food is also a vital and critical item of international trade. We know that the observance of food hygiene principles is a condition of utmost importance. 'Food hygiene' comprises conditions and measures necessary for the production, processing, storage and distribution of food, designed to ensure a safe, sound, wholesome product fit for human consumption. This can be achieved by evolving a 'Food System' regulated by competent Food Laws. In India, Prevention of Food Adulteration Act, 1954 (PFA Act) is the relevant Act. It is governed by the Ministry of Health & Family Welfare, Government. of India. This Ministry is responsible for framing or amending the laws and providing guidelines to the State Governments/Local Bodies for implementation of Rules/provisions contained under this Act. PFA Act is the statutory Act under which the quality and safety of food at the national level is regulated.

As per the provisions of the Act, Central Government has constituted a Committee called the Central Committee for Food Standards (CCFS). The CCFS is assisted by various Sub Committees. This Committee reviews the standards of food articles to regulate their manufacture, processing, storage, distribution, sale and import on regular basis. This Committee also undertakes to promote co-ordination of work on food standards being carried out by international governmental and non-governmental organizations. It has been well realized that the prime duty of this Committee is to help and guide the Central Government to promote consistency between international technical standards and domestic food standards, so as to keep the country in pace with international activities. This exercise greatly helps the country, in playing a constructive and beneficial role in international trade. The National Codex Contact Point (NCCP) for India is located at the Directorate General of Health Services, Ministry of Health and Family Welfare (MOH&FW), Government of India, Nirman Bhavan, New Delhi. It coordinates and promotes Codex activities in India in association with the National Codex Committee and various Shadow Committees and facilitates India's input to the work of Codex through an established consultation process.

The Directorate General of Health Services, Ministry of Health and Family Welfare (MOH&FW) has been designated as the nodal Ministry for liaison with the Codex Alimentarius Commission [CAC].

National Codex Contact Point [NCCP]

The National Codex Contact Point (NCCP) acts as the liaison office to coordinate with the other concerned government departments (at central and state level), food industry, consumers, traders, research and development Institutions and academia. National Codex Committee and its Shadow Committees are to ensure that the government is backed with an appropriate balance of policy and technical advice upon which to base decisions relating to issues raised in the context of the Codex Alimentarius Commission and its subsidiary bodies.

Core Functions of NCCP-INDIA

The NCCP has to perform the following core functions, established by the Codex Alimentarius Commission for National Codex Contact Points :

- Act as a link between the Codex Secretariat and India Member Body;
- Coordinate all relevant Codex activities within India ;
- Receive all Codex final texts (standards, codes of practice, guidelines and other advisory texts) and working documents of Codex Sessions and ensure that these are circulated to all those concerned;
- Send comments on Codex documents or proposals to the CAC or its subsidiary bodies and /or the Codex Secretariat within the time frame;
- Work in close cooperation with the National Codex Committee and its Shadow Committees;
- Act as a channel for the exchange of information and coordination of activities with other Codex Members;
- Receive invitations to Codex Sessions and inform the relevant chairpersons and the Codex Secretariat of the names of participants representing India;

- Maintain a library of Codex final texts ; and
- Promote Codex Activities throughout India.

National Codex Committee of India
The Department of Health in Ministry of Health and Family Welfare has constituted the National Codex (Food Products Standards) Committee (NCC) for liaison with the Codex Alimentarius Commission.

According to the Government of India Resolution GSR 762 issued by the Ministry of Health and Family Welfare, the National Codex (Food Products Standards) Committee shall meet as and when necessary to consider the various issues that may be discussed at the annual meetings of the Codex Alimentarius Commission and prepare necessary material thereof. The work of the Committee includes- standards for all the principal foods whether processed, semi-processed or raw for the distribution to the consumer. It also includes provisions in respect of food hygiene, food additives, pesticide residues, contaminants, labeling and preservation, methods of analysis and sampling, etc.

Terms of Reference of NCC-INDIA:
- To advise government on the implications of various food standardization, food quality and safety issues which have arisen and related to the work undertaken by the CAC so that national economic interest is taken into account, or at least considered, when international standards are discussed;
- To provide important inputs to the government so as to assist in ensuring quality and safety of food to the consumers, while at the same time maximizing the opportunities for development of industry and expansion of international trade;
- To appoint sub-committees (shadow committees) on subject matters related to the corresponding Codex Committees to assist in the study or consideration of technical matters; and
- To meet as and when necessary to formulate national position.

Functions of NCC- INDIA
- To cooperate with the Joint FAO/WHO Food Standards Programme and to nominate delegates to attend Codex meetings;
- To formulate national position in consultation with the members of NCC in the matters of Codex;
- To study Codex documents, collect and revise all relevant information relating to technology, economics, health and control system, so as to give supporting reasons to the government in the acceptance of Codex Standards or otherwise;
- To identify organizations to take action for generation of data base or preparation of base paper projecting the country's interest for interacting with the CAC; and
- To cooperate with other local/regional or foreign organizations dealing with activities relating to food standardization.

Shadow Committees of NCC-India
The NCC has been authorized to appoint Shadow Committees (sub-committees) on subject matters corresponding to the Codex subcommittees to assist the NCC in the study or consideration of technical matters.

Officers in the rank of Joint Secretary in the concerned Department/Ministry who handle the subject at the policy level and also serve as the members of the NCC are nominated as the Chairpersons of these Shadow Committees. Specialized experts in the relevant field are nominated as members of these Shadow committees. These list of experts are reviewed from time to time to ensure that they meet the ongoing requirements of India.

Currently, the Shadow Committees assist the National Codex Committee in the following areas:
- Codex Commission
- Regional Coordinating Committee for Asia
- General Principles

- Food labelling
- Methods of Analysis and Sampling
- Pesticides Residues
- Food Hygiene
- Food Additives and Contaminants
- Food Export and Import and Certification Systems
- Special Dietary Uses
- Fish and Fishery Products
- Oils and Fats
- Fresh Fruits and Vegetables
- Processed Fruits and Vegetables
- Milk and Milk Products
- Cocoa Products and Chocolate
- Mineral Water
- Genetically Modified Food

Terms of Reference of Shadow Committees

The terms of reference of the Shadow Committees under NCC are:

- To advise the NCC on the implications of various food standardization, food quality and safety issues which have arisen and related to the work undertaken by the relevant Subsidiary Body/Task Force so that national economic interest is taken into account or at least considered when international standards are deliberated by the CAC; and
- To follow the Codex agenda of the relevant Subsidiary Body and provide important inputs to the government so as to assist in ensuring quality and safety of food to the consumers while at the same time safeguard national interests and maximize the opportunities for development of industry and expansion of international trade.

Functions of Shadow Committees

- To study Codex documents, collect and revise all relevant information relating to technology, economics, health and control system so as to give supporting reasons to the government in the acceptance of Codex Standards or otherwise;
- To formulate national position in consultation with the members of the Shadow Committee with respect to the agenda for the forthcoming meeting of the Subsidiary Body and transmit them same through the NCCP;
- To formalize the delegation for the meeting in consultation with the NCCP and transmit the names to the host secretariat through the NCCP; and
- To recommend to the NCC regarding the position to be taken during the Sessions of the Commission with respect to agenda items relevant to the terms of reference of the Shadow Committees.

ORGANIC FOOD

INTRODUCTION

Organic foods are made according to certain production standards. For the vast majority of human history, agriculture can be described as organic; only during the 20th century got large supply of new synthetic chemicals introduced to the food supply. Under organic production, the use of conventional non-organic pesticides, insecticides and herbicides is greatly restricted and saved as a last resort.

However, since the early 1990s organic food production has had growth rates of around 20% a year, far ahead of the rest of the food industry, in both developed and developing nations. As of April 2008, organic food accounts for 1–2% of food sales worldwide.

MEANING AND ORIGIN OF TERM

In 1939, Lord Northbourne coined the term organic farming in his book Look to the Land (1940), out of his conception of "the farm as organism," to describe a holistic, ecologically-balanced approach to farming—in contrast to what he called chemical farming, which relied on "imported fertility" and "cannot be self-sufficient nor an organic whole."

Organic food refers to crops or livestock that are grown on the farm without the application of synthetic fertilizers or pesticides, and without using genetically modified organisms. In contrast, the type of agriculture followed by most farmers, which does include the use of synthetic pesticides and fertilizers, is termed "conventional" agriculture.

Organic food, food raised without chemicals and processed without additives. Food whose ingredients are at least 95% organic by weight may carry the "USDA ORGANIC" label; products containing only organic ingredients are labelled 100% organic. Organic gardening uses organic seeds, organic fertilizers, compost, organic root stimulators, and organic pest control.

LEGAL DEFINITION

The National Organic Program (run by the USDA) is in charge of the legal definition of organic in the United States and does organic certification.

To be certified organic, products must be grown and manufactured in a manner that adheres to standards set by the country they are sold in.

Many people prefer to grow organic food in their home gardens, because it costs about 20% more than the conventional food.

IDENTIFYING ORGANIC FOODS

Processed organic food usually contains only organic ingredients. If non-organic ingredients are present, at least a certain percentage of the food's total plant and animal ingredients must be organic (95% in the United States and Australia) and any non-organically produced ingredients are subject to various agricultural requirements.

Foods claiming to be organic must be free of artificial food additives, and are often processed with fewer artificial methods, materials and conditions, such as chemical ripening, food irradiation, and genetically modified ingredients. Pesticides are allowed so long as they are not synthetic.

Popular organic food items include organic tea, organic coffee, organic wine, organic meat, organic beef, eggs, organic milk, organic honey, organic vegetables, organic fruits, organic rice, organic corn, organic herbs, organic essential oils, organic coconut oil and organic olive oil.

ADVANTAGES OF ORGANIC FOODS

- Organic food is natural without any sprayed chemical and fresh, and thus, it is tasty.
- Organically grown foods are nutritious and full of taste although they may not look as colorful and well presented as shop produce.
- Organic foods put less burden on environment. Growing foods organically can protect the topsoil from erosion and is a great way of getting closer to nature.
- Organically grown foods are safer than foods raised with non-organic methods such as pesticides, non-organic fertilizers, antibiotics and hormones.
- Organic food ensures high food quality, which other conventional foods cannot give.

Environmental impact

The general consensus across these surveys is that organic farming is less damaging for the following reasons:

- Organic farms do not consume or release synthetic pesticides into the environment—some of which have the potential to harm soil, water and local terrestrial and aquatic wildlife.
- Organic farms are better than conventional farms at sustaining diverse ecosystems, *i.e.*, populations of plants and insects, as well as animals.
- When calculated either per unit area or per unit of yield, organic farms use less energy and produce less waste, *e.g.*, waste such as packaging materials for chemicals.

Yield

One study found a 20% smaller yield from organic farms using 50% less fertilizer and 97% less pesticide. Supporters claim that organically managed soil has a higher quality and higher water retention. This may help increase yields for organic farms in drought years.

The researchers also found that while in developed countries, organic systems on average produce 92% of the yield produced by conventional agriculture, organic systems produce 80% more than conventional farms in developing countries, because the materials needed for organic farming are more accessible than synthetic farming materials to farmers in some poor countries.

Energy efficiency

The general analysis is that organic production methods are usually more energy efficient because they do not use chemically synthesized nitrogen. But they generally consume more petroleum because of the lack of other options for weed control and more intensive soil management practices. Also increased fuel use from incorporating less nutrient dense fertilizers results in higher fuel consumption rates.

Pesticide residue

Organic farming standards do not allow the use of synthetic pesticides, but they do allow the use of specific pesticides derived from plants. The most common organic pesticides, accepted for *restricted* use by most organic standards, include Bt, pyrethrum, and rotenone.

Nutritional value and taste

In April 2009, results from Quality Low Food Input (QLIF), project studying the effects of organic and low-input farming on crop and livestock nutritional quality "showed that organic food production methods resulted in:

(a) higher levels of nutritionally desirable compounds (e.g., vitamins/antioxidants and poly-unsaturated fatty acids such as omega-3 and CLA)

(b) lower levels of nutritionally undesirable compounds such as heavy metals, mycotoxins, pesticide residues and glyco-alkaloids in a range of crops and/or milk

Regarding taste, a 2001 study concluded that organic apples were sweeter by blind taste test.

The Organic Certification Process

The process to certify a farm as organic is a rather rigorous task that involves a lot of planning, good management, and record-keeping. Farmers rely on published organic certification guidelines to find out what practices are acceptable and what products are allowed for use on the farm.

For land to be certified as organic, no synthetic fertilizers or pesticides can be applied to it for three years prior to certification. Part of the application process involves a detailed plan provided by the farmer that describes the entire operation, with a focus on what organic techniques will be used to produce and market crops in the farm.

If the original fertility of the soil is deficient, the detail plan what will be done to rectify this problem. The certification process also includes taking soil samples to evaluate soil fertility and to detect the possible presence of any unacceptable pesticides in the soil.

To ensure that the farm remains in compliance, organic inspectors will visit the farm annually. The record-keeping maintained by the farm helps the inspector to double-check that the farm operations are being conducted as indicated in the original farm plans.

Organic Labelling

Foods that are organically grown can state that fact on the label. This makes shopping easier for those of us who want to buy organic foods.

- **"100% Organic"**
  Foods that are labelled as ***100% Organic*** must contain all organically grown ingredients except for added water and salt.
- **"Organic"**
  Foods that are labelled as ***Organic*** need to contain at least 95% organic ingredients, except for added water and salt, plus they must not contain sulfites added as a preservative. Sulfites have been known to provoke allergies and asthma in some people. Up to 5% of the ingredients may non-organically produced.
- **"Made with Organic Ingredients"**
  Product labels that claim ***Made with Organic Ingredients*** need to contain at least 70% organic ingredients, except for added water and salt. They must not contain added sulfites, and up to 30% of the ingredients may be non-organically produced.
- Food products made with less than 70% organic ingredients may state which ingredients are organic, but they cannot claim to be organic food products.

INTRODUCTION

During World War II, the freeze-dried process was developed commercially when it was used to preserve blood plasma and penicillin. Freeze-drying requires the use of a special machine called a freeze-dryer, which has a large chamber for freezing and a vacuum pump for removing moisture. Over 400 different types of freeze-dried food products have been commercially developed since the 1960s. Two bad candidates for freeze-drying are lettuce and watermelon because they have too high a water content and freeze-dry poorly. Freeze-dried coffee is the best-known freeze-dried product.

Freeze-dried coffee was first produced in 1938, and lead to the development of powdered food products. Nestle company invented freeze-dried coffee, after being asked by Brazil to help find a solution to their coffee surpluses. Nestle's own freeze-dried coffee product was called Nescafe, and was first introduced in Switzerland.

Definition

Freeze drying is the process of dehydrating frozen foods under a vacuum so the moisture content changes directly from a solid to a gaseous form without having to undergo the intermediate liquid state through sublimation. In this process, the product maintains its original size and shape with a minimum of cell rupture.

Principle of Freeze-drying

The principle behind freeze-drying is that under certain conditions of low vapor pressure, water can evaporate from ice without the ice melting. When a material can exist as a solid, a liquid, and a gas but goes directly from a solid to a gas without passing through the liquid phase, the material is said to sublime. Dry ice sublimes at atmospheric pressure and room temperature. Frozen water will sublime if the temperature is 0°C or below and the frozen water is placed in a vacuum chamber at a pressure of 4.7 mm or less. Under such conditions the water will remain frozen, and water molecules will leave the ice block at a faster rate than water molecules from the surrounding atmosphere re-enter the frozen block.

Process

Freeze-drying, or lyophilization, is the sublimation/removal of water content from frozen food. The dehydration occurs under a vacuum, with the plant/animal product solidly frozen during the process. Shrinkage is eliminated or minimized, and a near-perfect preservation results. Freeze-dried food lasts longer than other preserved food and is very light weighted, which makes it perfect for space travel.

The fundamental process steps are:

1. Freezing: The product is frozen. This provides a necessary condition for low temperature drying.
2. Vacuum: After freezing, the product is placed under vacuum. This enables the frozen solvent in the product to vaporize without passing through the liquid phase, a process known as sublimation.
3. Heat: Heat is applied to the frozen product to accelerate sublimation.
4. Condensation: Low-temperature condenser plates remove the vaporized solvent from the vacuum chamber by converting it back to a solid. This completes the seperation process.

Within the vacuum chamber, heat is applied to the frozen food to speed sublimation. If the vacuum is maintained sufficiently high, usually within a range of about 0.1-2 mm Hg, and the heat is controlled just short of melting the ice, moisture vapor will sublime at a near maximum rate. Sublimation takes place from the surface of the ice, and so as it continues, the ice front recedes toward the center of the food piece; that is, the food dries from the surface inward. Finally, the last of the ice sublimes and the food is below 5% moisture. Since the frozen food remains rigid during sublimation, escaping water molecules leave voids behind them, resulting in a porous sponge like dried structure. Thus, freeze-dried foods reconstitute rapidly but also must be protected from ready absorption of atmospheric moisture and oxygen by proper packaging.

A heating plate is positioned above and below the food to increase the heat transfer rate, but an open space is left with expanded metal so as not to seal off escape of sublimed water molecules. Nevertheless, as drying progresses and the ice front recedes, the drying rate drops off for several reasons. The porous dried layer ahead of the receding ice layer acts as an effective insulator against further heat transfer and slows the rate of escape of water molecules subliming from the ice surface. But, in well-engineered freeze-drying systems, the growing porous dried layer generally interferes more with heat transfer than with water mass transfer. Some of the more practical means of increasing overall drying rates have therefore made use of energy sources with penetrating power, such as infrared and microwave radiations to pass through dried food layers into the receding ice core.

Foods Freeze-dried

Freeze drying can be used to dehydrate sensitive, high-value liquid foods such as coffee and juices, but it is especially suited to drying solid foods of high value such as strawberries, whole shrimp, chicken dice, mushroom slices, and sometimes food pieces as large as steaks and chops. These types of food, in addition to having delicate flavors and colors, have textural and appearance attributes that cannot be well preserved by any current drying method except freeze-drying. A whole strawberry, for example, is soft, fragile, and almost water. Any conventional drying method that employs heat would cause considerable shrinkage, distortion, and loss of natural strawberry texture. Upon reconstitution, such a dried strawberry would not have the natural color, flavor, or turgor and would be more like a strawberry preserve or jam.

Shelf-life

Depending on the product and the packaging environment, freeze dried foods are shelf-stable at room temperature for up to twenty-five years or more, if canned, and between 6 months to 3 years if stored in a poly-bag container.

The main determinant of degradation is the amount and type of fat content and the degree to which oxygen is kept away from the product.

The Benefits of Freeze-Drying

- Retains original characteristics of the product, including:
  - color
  - form
  - size
  - taste
  - texture
  - nutrients
- Reconstitutes to original state when placed in water
- Shelf stable at room temperature - cold storage not required
- The weight of the freeze-dried products is reduced by 70 to 90 percent, with no change in volume
- The product is light weight and easy to handle
- Shipping costs are reduced because of the light weight and lack of refrigeration
- Low water activity virtually eliminates microbiological concerns
- Offers highest quality in a dry product compared to other drying methods
- Virtually any type of food or ingredient, whether solid or liquid, can be freeze-dried

IRRADIATED FOOD

Irradiation is a more general term of deliberate exposure of materials to radiation to achieve a technical goal (in this context "ionizing radiation" is implied).

Food irradiation is the process of exposing food to ionizing radiation to destroy and check the multiplication microorganisms, bacteria, viruses, or insects that might be present in the food. Further applications include sprout inhibition, delay of ripening, and improvement of re-hydration.

The genuine effect of processing food by ionizing radiation involves damage to DNA, the basic genetic information for life. Microorganisms can no longer proliferate and continue their malignant or pathogenic activities. Spoilage-causing micro-organisms cannot continue their activities. Insects do not survive, or become incapable of proliferation. Plant ripening or ageing process is delayed by irradiation.

How is food irradiated?

Bulk or packaged food passes through a radiation chamber on a conveyor belt. The food does not come into contact with radioactive materials, but instead passes through a radiation beam, like a large flashlight. The type of food and the specific purpose of the irradiation determine the amount of radiation, or dose, necessary to process a particular product. The speed of the belt helps control the radiation dose delivered to the food by controlling the exposure time. The actual dose is measured by dosimeters within the food containers.
Cobalt-60 is the most commonly used radionuclide for food irradiation. However, there are also large cesium-137 irradiators and the Army has also used spent fuel rods for irradiation.

Effect of Ionizing Radiation

- Causes disruption of internal metabolism of cells
- DNA cleavage
- Formation of free radicals
- Disrupts chemical bonds

Sources of radiation used:

Electron irradiation beam
Electron irradiation uses electrons accelerated in an electric field to a velocity close to the speed of light. Electrons are particulate radiation and, hence, have cross section many times larger than photons, so that they do not penetrate the product beyond a few inches, depending on product density.

Gamma irradiation
Gamma radiation is radiation of photons in the gamma part of the electromagnetic spectrum. The radiation is obtained through the use of radioisotopes, generally cobalt-60 or, in theory, caesium-137. Cobalt-60 is intentionally bred from cobalt-59 using specifically designed nuclear reactors. Caesium-137 is recovered during the refinement of "spent nuclear fuel", formerly referred to as "nuclear waste".
Food irradiation using Cobalt-60 is the preferred method by most processors, because the deeper penetration enables administering treatment to entire industrial pallets or totes, reducing the need for material handling.

Levels of Gamma irradiation

- Radappertization
  - Commercially sterile
  - 25s kGy
- Radicidation
  - Reduction of non-spore forming pathogens
  - 2.5 – 10 kGy
- Radurization
  - Target specific spoilage MO
  - 0.75 – 2.5 kGy

Radiation absorbed dose

"Dose" is the physical quantity governing the radiation processing of food, relating to the beneficial effects to be achieved.

Unit of measure for irradiation dose
The dose of radiation is measured in the SI unit known as Gray (Gy). One Gray (Gy) dose of radiation is equal to 1 joule of energy absorbed per kg of food material. In radiation processing of foods, the doses are generally measured in kGy (1,000 Gy).

Dosimetry
The measurement of radiation dose is referred to as dosimetry, and involves exposing dosimeters jointly with the treated food item.

Applications
Because the irradiation process works with both large and small quantities, it has a wide range of potential uses. For example, a single serving of poultry can be irradiated for use on a space flight. Or, a large quantity of potatoes can be treated to reduce sprouting during warehouse storage.

Irradiation is most useful in four areas:

Preservation
Irradiation can be used to destroy or inactivate organisms that cause spoilage and decomposition, thereby extending the shelf life of foods. It is an energy-efficient food preservation method that has several advantages over traditional canning. The resulting products are closer to the fresh state in texture, flavor, and color. Using irradiation to preserve foods requires no additional liquid, nor does it cause the loss of natural juices. Both large and small containers can be used and food can be irradiated after being packaged or frozen.

Sterilization
Foods that are sterilized by irradiation can be stored for years without refrigeration just like canned (heat sterilized) foods. With irradiation it will be possible to develop new shelf-stable products. It is cold sterilization.

Control sprouting, ripening, and insect damage
In this role, irradiation offers an alternative to chemicals for use with potatoes, tropical and citrus fruits, grains, spices, and seasonings. However, since no residue is left in the food, irradiation does not protect against reinfestation like insect sprays and fumigants do.

Control of food pathogens
Irradiation can be used to effectively eliminate those pathogens that cause foodborne illness, such as Salmonella.

On the basis of the dose of radiation the application is generally divided into three main categories as detailed under:

Low Dose Applications (up to 1 kGy)

- Sprout inhibition in bulbs and tubers 0.03-0.15 kGy
- Delay in fruit ripening 0.25-0.75 kGy
- Insect disinfestation including quarantine treatment and elimination of food borne parasites 0.07-1.00 kGy

Medium Dose Applications (1 kGy to 10 kGy)

- Reduction of spoilage microbes to prolong shelf-life of meat, poultry and seafoods under refrigeration 1.50–3.00 kGy
- Reduction of pathogenic microbes in fresh and frozen meat, poultry and seafoods 3.00–7.00 kGy
- Reducing the number of microorganisms in spices to improve hygienic quality 10.00 kGy

High Dose Applications (above 10 kGy)

- Sterilisation of packaged meat, poultry and their products which are shelf stable without refrigeration. 25.00-70.00 kGy
- Sterilisation of Hospital diets 25.00-70.00 kGy
- Product improvement as increased juice yield or improved re-hydration

Advantages of Food Irradiation

- Little or no heating of food
- Can treat packaged or frozen foods
- No chemicals used for preservation of fresh foods
- Low energy requirements
- Comparable change in nutritional value
- High automation

Disadvantages of Food Irradiation

- High capital costs
- Possible development of resistant MO
- Inadequate analytical procedures to detect irradiation in food
- Public resistance

Legal Status

- In the U.S. for packaging material, spices, vegetable seasoning, poultry and ground beef
- ≥ 35 other countries have approved some form of food irradiation
- Biggest hurdle consumer acceptance

Potential uses of Food Irradiation

Type of food	**Effect of Irradiation**
Meat, poultry	Destroys pathogenic organisms, such as Salmonella, Campylobacter and Trichinae
Perishable foods	Delays spoilage; retards mold growth; reduces number of microorganisms
Grain, fruit	Controls insect vegetables, infestation dehydrated fruit, spices and seasonings , Reduces rehydration time
Onions, carrots, potatoes, garlic, ginger	Inhibits sprouting
Bananas, mangos, papayas, guavas, other non-citrus fruits	Delays ripening avocados, natural juices.

How does irradiation affect the food itself?

Ionizing radiation also breaks some of the chemical bonds within the food itself. The effects of chemical changes in foods are varied. Some are desirable, others are not. Examples of some food changes are:

- changes in structure of certain foods too fragile to withstand the irradiation, for example, lettuce and other leafy vegetables turn mushy
- slowed ripening and maturation in certain fruits and vegetables lengthens shelf-life
- reduction or destruction of some nutrients, such as vitamins, reduces the nutritional value (the effect is comparable to losses in heat pasteurization)
- alteration of some flavour compounds
- formation of compounds that were not originally present requires the strict control of radiation levels
- generation of free radicals, some of which recombine with other ions.

These effects are the result of radiolysis. Whether the products of radiolysis in food are all innocent from a human health perspective is still debated. However, years of experience in food irradiation has not demonstrated any identifiable health problems.

Labelling

As per FSS Act (2006) regulation 4.1.8 describes the labelling of irradiated food. The labelling of prepacked irradiated food shall be in accordance with the provisions of Regulation 4.1.1, 4.1.2 and Regulation 4.1.14 of these rules and the provisions of the atomic energy (control of Irradiation of Food) Rules, 1991, under the Atomic Energy Act, 1962 (Act 33 of 1962).

All packages of irradiated food shall bear the following declaration and logo, namely:-

PROCESSED BY IRRADIATION METHOD............................

DATE OF IRRADIATION...

LICENSE NO. ....

PURPOSE OF IRRADIATION..

PFA LIST OF APPROVED FOOD ITEMS FOR IRRADIATION

Sl. No.	*Name of Foods*	*Dose of Irradiation (kGy)*		
		Minimum	*Maximum*	*Overall average*
1.	Onions	0.030	0.09	0.06
2.	Spices	6	14	10
3.	Potatoes	0.06	0.15	0.10
4.	Rice	0.25	1.0	0.62
5.	Semolina (Sooji or Rawa), Wheat	0.25	1.0	0.62
6.	Mango	0.25	0.75	0.50

7.	Raisins, Figs and Dried Dates	0.25	0.75	0.50
8.	Ginger, Garlic and Shallots (Small Onion)	0.03	0.15	0.09
9.	Meat and Meat Products including Chicken	2.5	4.0	3.25
10.	Fresh Sea Foods	1.0	3.0	2.00
11.	Frozen Sea Foods	4.0	6.0	5.00
12.	Dried Sea Foods	0.25	1.0	0.62
13.	Pulses	0.25	1.0	0.62

GENETICALLY MODIFIED (GM) FOOD

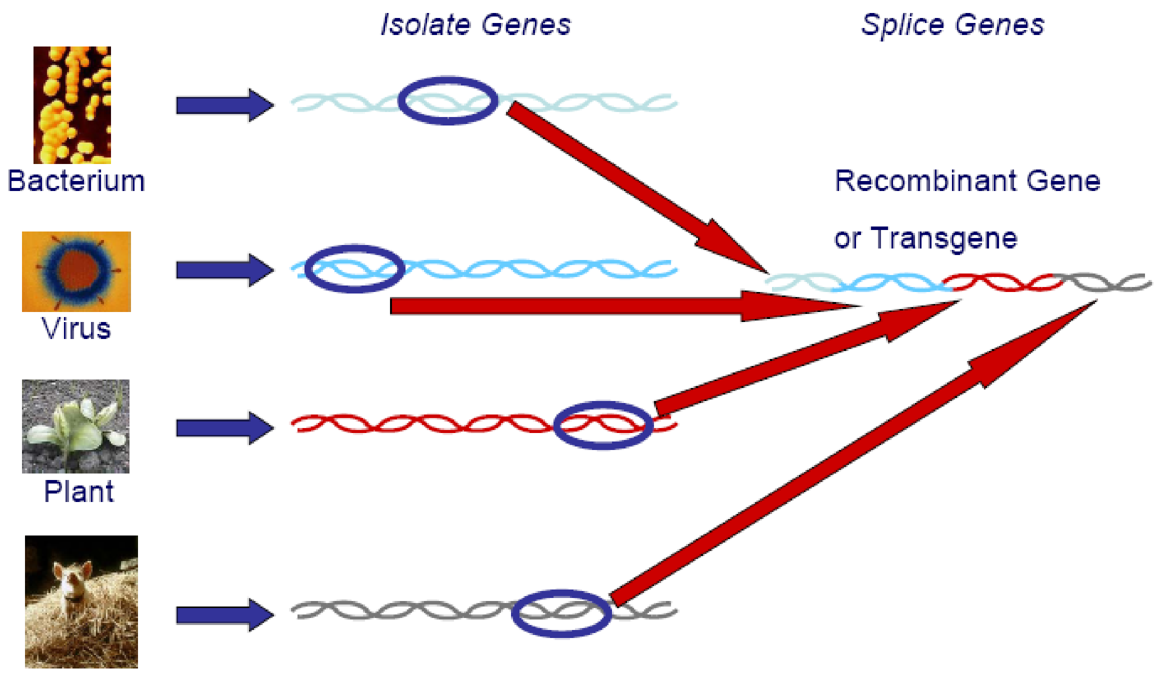
Genetically Modified (GM) Organisms and GM Foods

Genetically modified organisms (GMOs) can be defined as organisms in which the genetic material (DNA) has been altered in a way that does not occur naturally. The technology is often called "modern biotechnology" or "gene technology", sometimes also "recombinant DNA technology" or "genetic engineering". It allows selected individual genes to be transferred from one organism into another, also between non-related species.

Although "biotechnology" and "genetic modification" commonly are used interchangeably, GM is a special set of technologies that alter the genetic makeup of organisms such as animals, plants, or bacteria. Biotechnology, a more general term, refers to using organisms or their components, such as enzymes, to make products that include wine, cheese, beer, and yogurt.

Combining genes from different organisms is known as recombinant DNA technology, and the resulting organism is said to be "genetically modified," "genetically engineered," or "transgenic." GM products (current or those in development) include medicines and vaccines, foods and food ingredients, feeds, and fibers.

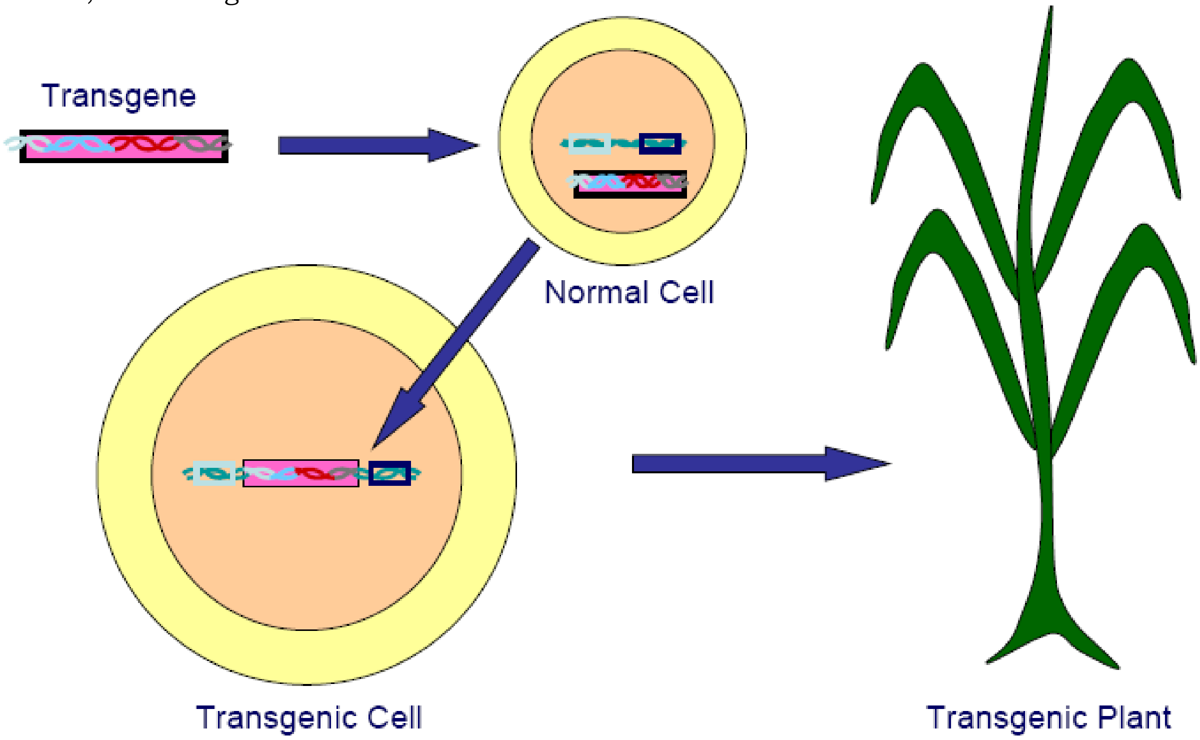
Such methods are used to create GM plants – which are then used to grow GM food crops.



Why are GM foods produced

GM foods are developed – and marketed – because there is some perceived advantage either to the producer or consumer of these foods. This is meant to translate into a product with a lower price, greater benefit (in terms of durability or nutritional value) or both. Initially GM seed developers wanted their products to be accepted by producers so have concentrated on innovations that farmers (and the food industry more generally) would appreciate.

The initial objective for developing plants based on GM organisms was to improve crop protection. The GM crops currently on the market are mainly aimed at an increased level of crop protection through the introduction of resistance against insects, pests, diseases and viruses;s or through increased tolerance towards herbicides.



Insect resistance is achieved by incorporating into the food plant the gene for toxin production from the bacterium Bacillus thuringiensis (BT). This toxin is currently used as a conventional insecticide in agriculture and is safe for human consumption. GM crops that permanently produce this toxin have been shown to require lower quantities of insecticides in specific situations, e.g. where pest pressure is high.

Virus resistance is achieved through the introduction of a gene from certain viruses which cause disease in plants. Virus resistance makes plants less susceptible to diseases caused by such viruses, resulting in higher crop yields.

Herbicide tolerance is achieved through the introduction of a gene from a bacterium conveying resistance to some herbicides. In situations where weed pressure is high, the use of such crops has resulted in a reduction in the quantity of the herbicides used.

Are GM foods assessed differently from traditional foods

Generally consumers consider that traditional foods (that have often been eaten for thousands of years) are safe. When new foods are developed by natural methods, some of the existing characteristics of foods can be altered, either in a positive or a negative way National food authorities may be called upon to examine traditional foods, but this is not always the case. Indeed, new plants developed through traditional breeding techniques may not be evaluated rigorously using risk assessment techniques.

With GM foods most national authorities consider that specific assessments are necessary. Specific systems have been set up for the rigorous evaluation of GM organisms and GM foods relative to both human/animal health and the environment. Similar evaluations are generally not performed for traditional foods. Hence there is a significant difference in the evaluation process prior to marketing for these two groups of food.

One of the objectives of the WHO Food Safety Programme is to assist national authorities in the identification of foods that should be subject to risk assessment, including GM foods, and to recommend the correct assessments.

How are the potential risks to human health determined

The safety assessment of GM foods generally investigates:

(a) direct health effects (toxicity),
(b) tendencies to provoke allergic reaction (allergenicity);
(c) specific components thought to have nutritional or toxic properties;
(d) the stability of the inserted gene;
(e) nutritional effects associated with genetic modification; and
(f) any unintended effects which could result from the gene insertion.

Main issues of concern for human health

While theoretical discussions have covered a broad range of aspects, the three main issues debated are
-tendencies to provoke allergic reaction (allergenicity),
-gene transfer and
-outcrossing.

1. **Allergenicity.** As a matter of principle, the transfer of genes from commonly allergenic foods is discouraged unless it can be demonstrated that the protein product of the transferred gene is not allergenic. While traditionally developed foods are not generally tested for allergenicity, protocols for tests for GM foods have been evaluated by the Food and Agriculture Organization of the United Nations (FAO) and WHO. No allergic effects have been found relative to GM foods currently on the market.

2. **Gene transfer.** Gene transfer from GM foods to cells of the body or to bacteria in the gastrointestinal tract would cause concern if the transferred genetic material adversely affects human health. This would be particularly relevant if antibiotic resistance genes, used in creating GMOs, were to be transferred. Although the probability of transfer is low, the use of technology without antibiotic resistance genes has been encouraged by a recent FAO/WHO expert panel.

3. **Outcrossing.** The movement of genes from GM plants into conventional crops or related species in the wild (referred to as “outcrossing”), as well as the mixing of crops derived from conventional seeds with those grown using GM crops, may have an indirect effect on food safety and food security. This risk is real, as was shown when traces of a maize type which was only approved for feed use appeared in maize products for human consumption in the United States of America. Several countries have adopted strategies to reduce mixing, including a clear separation of the fields within which GM crops and conventional crops are grown.

Feasibility and methods for post-marketing monitoring of GM food products, for the continued surveillance of the safety of GM food products, are under discussion.

How is a risk assessment for the environment performed

Environmental risk assessments cover both the GMO concerned and the potential receiving environment. The assessment process includes evaluation of the characteristics of the GMO and its effect and stability in the environment, combined with ecological characteristics of the environment in which the introduction will take place. The assessment also includes unintended effects which could result from the insertion of the new gene.

Issues of concern for the environment

Issues of concern include: the capability of the GMO to escape and potentially introduce the engineered genes into wild populations; the persistence of the gene after the GMO has been harvested; the susceptibility of non-target organisms (e.g. insects which are not pests) to the gene product; the stability of the gene; the reduction in the spectrum of other plants including loss of biodiversity; and increased use of chemicals in agriculture. The environmental safety aspects of GM crops vary considerably according to local conditions.

Current investigations focus on: the potentially detrimental effect on beneficial insects or a faster induction of resistant insects; the potential generation of new plant pathogens; the potential detrimental consequences for plant biodiversity and wildlife, and a decreased use of the important practice of crop rotation in certain local situations; and the movement of herbicide resistance genes to other plants.

Are GM foods safe

Different GM organisms include different genes inserted in different ways. This means that individual GM foods and their safety should be assessed on a event by event basis and that it is not possible to make general statements on the safety of all GM foods.

GM foods currently available on the international market have passed risk assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved. Continuous use of risk assessments based on the Codex principles and, where appropriate, including post market monitoring, should form the basis for evaluating the safety of GM foods.

How are GM foods regulated internationally

The way governments have regulated GM foods varies. In some countries GM foods are not yet regulated. Countries which have legislation in place focus primarily on assessment of risks for consumer health. Countries which have provisions for GM foods usually also regulate GMOs in general, taking into account health and environmental risks, as well as control- and trade-related issues (such as potential testing and labelling regimes).

In Japan, the Ministry of Health and Welfare has announced that health testing of GM foods will be mandatory as of April 2001. Currently, testing of GM foods is voluntary. Japanese supermarkets are offering both GM foods and unmodified foods, and customers are beginning to show a strong preference for unmodified fruits and vegetables.

Some states in Brazil have banned GM crops entirely, and the Brazilian Institute for the Defence of Consumers, in collaboration with Greenpeace, has filed suit to prevent the importation of GM crops.

In Europe, anti-GM food protestors have been especially active. In response to the public outcry, Europe now requires mandatory food labelling of GM foods in stores, and the European Commission (EC) has established a 0.9% threshold for contamination of unmodified foods with GM food products.

Regulations in India

In India GM crops are regulated under the Environment Protection Act [1986]'s 1989 Rules. These Rules are called the Rules for the Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms, Genetically Engineered Organisms or Cells.

The Genetic Engineering Approval Committee [GEAC] has been authorized as the inter-ministerial body under the Ministry of Environment and Forests to be the authority to permit any manufacture, use, import, export and storage of hazardous micro-organisms and genetically modified organisms or cells. In practice, it is the Review Committee on Genetic Manipulation [RCGM] under the Department of Biotechnology that is currently authorizing research up to limited field trials and also imports of GM material for research purposes.
In addition to these rules, guidelines have been prepared by the regulators for the actual experimentation and release. There are specific formats prescribed for various applications for GM imports and use to be received by the regulators.

Under the Ministry of Health and Family Welfare, the Indian Council of Medical Research (ICMR) stated its own views on the Regulatory Regime and the Way Ahead for Genetically Modified Foods in the country. The ICMR opines that the safety assessment of GM foods should be as per Codex alimentarius [India follows OECD guidelines for most tests under safety assessment as of now].

For GM Foods, there is now a proposed legislation to make labeling mandatory under the Prevention of Food Adulteration Act, under the Ministry of Health & Family Welfare. Food Safety & Standards Authority of India has constituted the expert group to formulate the regulatory framework for GM food.
The country also witnessed in 2005, the move by the Department of Biotechnology to make a biotechnology policy in the form of the Draft Biotechnology Development Strategy. Civil society groups responded to this draft policy and gave their feedback strongly, questioning the very premise on which transgenic agriculture is being promoted as a necessity for Indian agriculture through this draft policy.

India's regulatory regime has recently been questioned by the United States of America, through the Committee on Technical Barriers on Trade. This notification in the Committee has received a strong response from civil society groups. Regulation of GM crops in India, what constitutes the biosafety regime, the institutional mechanisms and issues beyond biosafety in a larger impact assessment framework have been an issue of good debate in the recent past. This is accentuated by the fact that there are many GM crops in the pipeline, waiting for approvals for various stages of trials. Amongst these are GM Potato, GM Mustard, GM Brinjal (briefing paper and civil society feedback to GEAC) and GM Rice.

Kind of GM foods on the market internationally

All GM crops available on the international market today have been designed using one of three basic traits:
-resistance to insect damage;
-resistance to viral infections; and
-tolerance towards certain herbicides.

All the genes used to modify crops are derived from microorganisms.

What happens when GM foods are traded internationally

No specific international regulatory systems are currently in place. However, several international organizations are involved in developing protocols for GMOs.

The Codex Alimentarius Commission (Codex) is the joint FAO/WHO body responsible for compiling the standards, codes of practice, guidelines and recommendations that constitute the Codex Alimentarius: the international food code. Codex is developing principles for the human health risk analysis of GM foods. The premise of these principles dictates a premarket assessment, performed on a case-by-case basis and including an evaluation of both direct effects (from the inserted gene) and unintended effects (that may arise as a consequence of insertion of the new gene). Codex principles do not have a binding effect on national legislation, but are referred to specifically in the Sanitary and Phytosanitary Agreement of the World Trade Organization (SPS Agreement), and can be used as a reference in case of trade disputes.

The Cartagena Protocol on Biosafety (CPB), an environmental treaty legally binding for its Parties, regulates transboundary movements of living modified organisms (LMOs). GM foods are within the scope of the Protocol only if they contain LMOs that are capable of transferring or replicating genetic material. The cornerstone of the CPB is a requirement that exporters seek consent from importers before the first shipment of LMOs intended for release into the environment.

Have GM products on the international market passed a risk assessment

The GM products that are currently on the international market have all passed risk assessments conducted by national authorities. These different assessments in general follow the same basic principles, including an assessment of environmental and human health risk. These assessments are thorough, they have not indicated any risk to human health.

Further developments expected in the area of GMOs

Future GM organisms are likely to include plants with improved disease or drought resistance, crops with increased nutrient levels, fish species with enhanced growth characteristics and plants or animals producing pharmaceutically important proteins such as vaccines.

Role of WHO to improve the evaluation of GM foods

WHO will take an active role in relation to GM foods, primarily for two reasons:

(1) on the grounds that public health could benefit enormously from the potential of biotechnology, for example, from an increase in the nutrient content of foods, decreased allergenicity and more efficient food production; and

(2) based on the need to examine the potential negative effects on human health of the consumption of food produced through genetic modification, also at the global level. It is clear that modern technologies must be thoroughly evaluated if they are to constitute a true improvement in the way food is produced. Such evaluations must be holistic and all-inclusive, and cannot stop at the previously separated, non-coherent systems of evaluation focusing solely on human health or environmental effects in isolation.

Work is therefore under way in WHO to present a broader view of the evaluation of GM foods in order to enable the consideration of other important factors. This more holistic evaluation of GM organisms and GM products will consider not only safety but also food security, social and ethical aspects, access and capacity building. International work in this new direction presupposes the involvement of other key international organizations in this area.

GM Products: Benefits and Controversies

Benefits

As the population is growing fast, ensuring an adequate food supply is going to be a major challenge in the years to come. GM foods promise to meet this need in a number of ways, with properties like pest resistance, herbicide tolerance, disease resistance, cold tolerance, and drought tolerance/ salinity tolerance, and tailored for better nutrition and therapeutic purposes.

- **Crops**
  - Enhanced taste and quality
  - Reduced maturation time
  - Increased nutrients, yields, and stress tolerance
  - Improved resistance to disease, pests, and herbicides
  - New products and growing techniques

- **Animals**
  - Increased resistance, productivity, hardiness, and feed efficiency
  - Better yields of meat, eggs, and milk
  - Improved animal health and diagnostic methods

- **Environment**
  - "Friendly" bioherbicides and bioinsecticides
  - Conservation of soil, water, and energy
  - Bioprocessing for forestry products
  - Better natural waste management
  - More efficient processing

- **Society**
  - Increased food security for growing populations

Controversies

- **Safety**
  - Potential human health impacts, including allergens, transfer of antibiotic resistance markers, unknown effects
  - Potential environmental impacts, including: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes), and loss of flora and fauna biodiversity

- **Access and Intellectual Property**
  - Domination of world food production by a few companies
  - Increasing dependence on industrialized nations by developing countries
  - Biopiracy, or foreign exploitation of natural resources

- **Ethics**
  - Violation of natural organisms' intrinsic values
  - Tampering with nature by mixing genes among species
  - Objections to consuming animal genes in plants and vice versa
  - Stress for animal

- **Labeling**
  - Not mandatory in some countries (e.g., United States)
  - Mixing GM crops with non-GM products confounds labeling attempts

- **Society**
  - New advances may be skewed to interests of rich countries

Functional Foods

Clearly, all foods are functional, as they provide taste, aroma, or nutritive value. Within the last decade, however, the term functional as it applies to food has adopted a different connotation -- that of providing an additional physiological benefit beyond that of meeting basic nutritional needs.

The term functional foods was first introduced in Japan in the mid-1980s and refers to processed foods containing ingredients that aid specific bodily functions in addition to being nutritious. To date, Japan is the only country that has formulated a specific regulatory approval process for functional foods. Known as Foods for Specified Health Use (FOSHU), these foods are eligible to bear a seal of approval from the Japanese Ministry of Health and Welfare. Currently, 100 products are licensed as FOSHU foods in Japan.

In the United States, the functional foods category is not recognized legally. The Institute of Medicine's Food and Nutrition Board (IOM/FNB, 1994) defined functional foods as "any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains."

Functional foods from plant sources

A plant-based diet can reduce the risk of chronic disease, particularly cancer. It is now clear that there are components in a plant-based diet other than traditional nutrients that can reduce cancer risk. Steinmetz and Potter (1991a) identified more than a dozen classes of these biologically active plant chemicals, now known as "phytochemicals."

Oats. Oat products are a widely studied dietary source of the cholesterol-lowering soluble fiber b-glucan. There is now significant scientific agreement that consumption of this particular plant food can reduce total and low density lipoprotein (LDL) cholesterol, thereby reducing the risk of coronary heart disease (CHD).

Soy. Soy has been in the spotlight during the 1990s. Not only is soy a high quality protein, as assessed by the FDA's "Protein Digestibility Corrected Amino Acid Score" method, it is now thought to play preventive and therapeutic roles in cardiovascular disease (CVD), cancer, osteoporosis, and the alleviation of menopausal symptoms.

Flaxseed. Among the major seed oils, flaxseed oil contains the most (57%) of the omega-3 fatty acid, a-linolenic acid. Recent research, however, has focused more specifically on fiber-associated compounds known as lignans. Consumption of flaxseed has also been shown to reduce total and LDL cholesterol.

Tomatoes. Selected by Eating Well magazine as the 1997 Vegetable of the Year, tomatoes have received significant attention within the last three years because of interest in lycopene, the primary carotenoid found in this fruit, and its role in cancer risk reduction.

Garlic. Garlic (Allium sativum) is likely the herb most widely quoted in the literature for medicinal properties. The purported health benefits of garlic are numerous, including cancer chemopreventive, antibiotic, anti-hypertensive, and cholesterol-lowering properties.

Broccoli and other Cruciferous Vegetables. Epidemiological evidence has associated the frequent consumption of cruciferous vegetables with decreased cancer risk.

Others sources are citrus fruits, cranberry, tea, wines and grapes.

Functional foods from animal sources

Fish. Omega-3 (n-3) fatty acids are an essential class of polyunsaturated fatty acids (PUFAs) derived primarily from fish oil.

Dairy Products. There is no doubt that dairy products are functional foods. They are one of the best sources of calcium, an essential nutrient which can prevent osteoporosis and possibly colon cancer. In addition to calcium, however, recent research has focused specifically on other components in dairy products, particularly fermented dairy products known as probiotics. Probiotics are defined as "live microbial feed supplements which beneficially affect the host animal by improving its intestinal microbial balance".

Beef. An anticarcinogenic fatty acid known as conjugated linoleic acid (CLA) was first isolated from grilled beef in 1987.

Nutraceuticals

Nutraceutical, a term combining the words "nutrition" and "pharmaceutical," is a food or food product that provides health and medical benefits, including the prevention and treatment of disease. Such products may range from isolated nutrients, dietary supplements and specific diets to genetically engineered foods, herbal products, and processed foods such as cereals, soups, and beverages. The definition of nutraceutical that appears in the latest edition of the ***Merriam-Webster Dictionary*** is as follows: A food stuff (as a fortified food or a dietary supplement) that provides health benefits. Nutraceutical foods are not subject to the same testing and regulations as pharmaceutical drugs. The American Nutraceutical Association works with the Food & Drug Administration in consumer education, developing industry and scientific standards for products and manufacturers, and other related consumer protection roles.

Nutraceuticals is a broad umbrella term used to describe any product derived from food sources that provides extra health benefits in addition to the basic nutritional value found in foods. Products typically claim to prevent chronic diseases, improve health, delay the aging process, and increase life expectancy.

There are multiple different types of products that fall under the category of nutraceuticals.

A **dietary supplement** is a product that contains nutrients derived from food products that are concentrated in liquid or capsule form. The Dietary Supplement Health and Education Act (DSHEA) of 1994 defined generally what constitutes a dietary supplement. "A dietary supplement is a product taken by mouth that contains a "dietary ingredient" intended to supplement the diet. The "dietary ingredients" in these products may include: vitamins, minerals, herbs or other botanicals, amino acids, and substances such as enzymes, organ tissues, glandulars, and metabolites. Dietary supplements can also be extracts or concentrates, and may be found in many forms such as tablets, capsules, softgels, gelcaps, liquids, or powders."

Dietary supplements do not have to be approved by the U.S. Food and Drug Administration (FDA) before marketing. Although supplements claim to provide health benefits, products usually include a label that says: "These statements have not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease."

Regulation

Unlike pharmaceutical drugs, within the United States, nutraceutical products are widely available and monitored with the same level of scrutiny as "dietary supplements". Within the oversight of the Federal Food & Drug Administration, unlike many other countries such as Canada, the use of broad-based definitions creates inconsistent credibility distinguishing the standards, function, and effectiveness between "nutraceuticals" and "dietary supplements". Within this loose regulatory oversight, legitimate companies producing nutraceuticals provide credible scientific research to substantiate their manufacturing standards, products, and consumer benefits and differentiate their products from "dietary supplements".

Despite the international movement within the industry, professional organizations, academia, and health regulatory agencies to add specific legal and scientific criterion to the definition and standards for nutraceuticals, within the United States the term is not regulated by FDA. The FDA still uses a blanket term of "dietary supplement" for all substances without distinguishing their efficacy, manufacturing process, supporting scientific research, and increased health benefits.

Clause 22 of the **FSS Act, 2006** explains the definition of functional food as -

(1) “foods for special dietary uses or functional foods or nutraceuticals or health supplements” means:

(a) foods which are specially processed or formulated to satisfy particular dietary requirements which exist because of a particular physical or physiological condition or specific diseases and disorders and which are presented as such, wherein the composition of these foodstuffs must differ significantly from the composition of ordinary foods of comparable nature, if such ordinary foods exist, and may contain one or more of the following ingredients, namely:-
(i) plants or botanicals or their parts in the form of powder, concentrate or extract in water, ethyl alcohol or hydro alcoholic extract, single or in combination;
(ii) minerals or vitamins or proteins or metals or their compounds or amino acids (in amounts not exceeding the Recommended Daily Allowance for Indians) or enzymes (within permissible limits);
(iii) substances from animal origin;
(iv) a dietary substance for use by human beings to supplement the diet by increasing the total dietary intake;

(b) (i) a product that is labelled as a “Food for special dietary uses or functional foods or nutraceuticals or health supplements or similar such foods” which is not represented for use as a conventional food and whereby such products may be formulated in the form of powders, granules, tablets, capsules, liquids, jelly and other dosage forms but not parenterals, and are meant for oral administration;
(ii) such product does not include a drug as defined in clause (b) and ayurvedic, sidha and unani drugs as defined in clauses (a) and (h) of section 3 of the Drugs and Cosmetics Act, 1940 (23 of 1940) and rules made thereunder;
(iii) does not claim to cure or mitigate any specific disease, disorder or condition (except for certain health benefit or such promotion claims) as may be permitted by the regulations made under this Act;
(iv) does not include a narcotic drug or a psychotropic substance as defined in the Schedule of the Narcotic Drugs and Psychotropic Substances Act, 1985 (61 of 1985) and rules made thereunder and substances listed in Schedules E and EI of the Drugs and Cosmetics Rules, 1945;

What is Nanotechnology?

Nanotechnology is a powerful new technology for taking apart and reconstructing nature at the atomic and molecular level. It involves atomic level manipulation to transform and construct a wide range of new materials, devices, and technological systems.

Why is it different?

Nanotechnology and nanoscience involve the study of phenomena and materials, and the manipulation of structures, devices and systems that exist at the nanoscale, <100 nanometres (nm) in size.

Use in food production and processing

Industry analysts and proponents predict that nanotechnology will be used to transform food from the atom up. Tomorrow's food will be designed by shaping molecules and atoms.

Food will be wrapped in "smart" safety packaging that can detect spoilage or harmful contaminants.

Future products will enhance and adjust their color, flavor, or nutrient content to accommodate each consumer's taste or health needs.

In agriculture, nanotechnology promises to reduce pesticide use, improve plant and animal breeding, and create new nano-bioindustrial products".

Four key focus areas for nanotechnology food research:

- Nano-modification of seed and fertilisers/ pesticides
- Food 'fortification' and modification
- Interactive 'smart' food
- 'Smart' packaging and food tracking

Nano-modification of seed and fertilisers/ pesticides

Nanotechnology will be used to further automate the modern agribusiness unit. All farm inputs – seeds, fertilisers, pesticides and labour – will become increasingly technologically modified.

Nanotechnology will take the genetic engineering of agriculture to the next level down – atomic engineering. Atomic engineering could enable the DNA of seeds to be rearranged in order to obtain different plant properties including colour, growth season, yield etc.

Highly potent atomically engineered fertilisers and pesticides will be used to maintain plant growth.

Nano-sensors will enable plant growth, pH levels, the presence of nutrients, moisture, pests or disease to be monitored from far away, significantly reducing the need for on-farm labour inputs.

Food 'fortification' and modification

Nanotech companies are working to fortify processed food with nano-encapsulated nutrients, its appearance and taste boosted by nano-developed colours, its fat and sugar content removed or disabled by nano-modification, and 'mouth feel' improved.

Food 'fortification' will be used to increase the nutritional claims that can be made about a given processed food – for example the inclusion of 'medically beneficial' nano-capsules will soon enable chocolate chip cookies or hot chips to be marketed as health promoting or artery cleansing.

Nanotechnology will also enable junk foods like ice cream and chocolate to be modified to reduce the amount of fats and sugars that the body can absorb. This could happen either by replacing some of the fats and sugars with other substances, or by using nanoparticles to prevent the body from digesting or absorbing these components of the food. In this way, the nano industry could market vitamin and fibre-fortified, fat and sugar-blocked junk food as health promoting and weight reducing.

Interactive 'smart' food

Companies such as Kraft and Nestlé are designing 'smart' foods that will interact with consumers to 'personalise' food, changing colour, flavour or nutrients on demand. Kraft is developing a clear tasteless drink that contains hundreds of flavours in latent nanocapsules. A domestic microwave could be used to trigger release of the colour, flavour, concentration and texture of the individual's choice.

'Smart' foods could also sense when an individual was allergic to a food's ingredients, and block the offending ingredient.

'Smart' packaging could release a dose of additional nutrients to those which it identifies as having special dietary needs, for example calcium molecules to people suffering from osteoporosis.

'Smart' packaging and food tracking

Nanotechnology will dramatically extend food shelf life. Mars Inc. already has a patent on an invisible, edible, nano wrapper which will envelope foods, preventing gas and moisture exchange.

'Smart' packaging (containing nano-sensors and anti-microbial activators) is being developed that will be capable of detecting food spoilage and releasing nano-anti-microbes to extend food shelf life, enabling supermarkets to keep food for even greater periods before its sale.

Nano-sensors, embedded into food products as tiny chips that were invisible to the human eye, would also act as electronic barcodes. They would emit a signal that would allow food, including fresh food, to be tracked from paddock to factory to supermarket and beyond.

Key concerns about nanotechnology in food and agriculture

Concerns about the use of nanotechnology in agriculture and food production relate to the further automation and alienation of food production, serious new toxicity risks for humans and the environment, and the further loss of privacy as nano surveillance tracks each step in the food chain. The failure of governments to introduce laws to protect the public and the environment from nanotechnology's risks is a most serious concern.