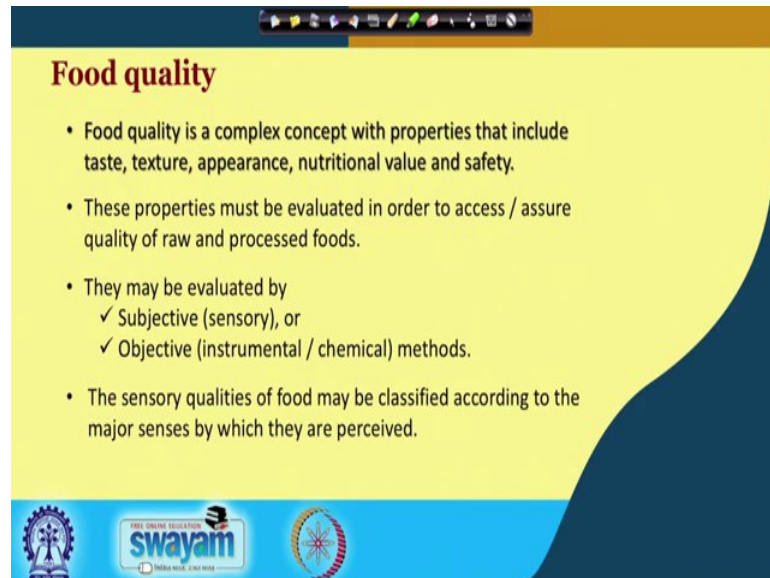


Novel Technologies for Food Processing and Shelf Life Extension
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Lecture - 02
Quality and Safety Aspects of Food

In this section, a brief overview of the Quality and Safety Aspects of Food is highlighted.



Food quality

- Food quality is a complex concept with properties that include taste, texture, appearance, nutritional value and safety.
- These properties must be evaluated in order to assess / assure quality of raw and processed foods.
- They may be evaluated by
 - ✓ Subjective (sensory), or
 - ✓ Objective (instrumental / chemical) methods.
- The sensory qualities of food may be classified according to the major senses by which they are perceived.

Logos at the bottom: IIT Kharagpur, swayam, and a circular logo.

Food quality is a complex concept; it includes the properties like taste, texture, appearance, nutritional value and safety. These properties must be evaluated in order to assess or assure the quality of raw and processed foods. These quality attributes may be evaluated by subjective or sensory methods or objective like instrumental or chemical methods.

Evaluation of food quality

- **Subjective or sensory evaluation** of food uses the human sense organs for taste, smell, mouthfeel, etc.
- Groups of consumers may be used in preference testing for marketing purposes and scoring using standard sensory testing procedures.
- Sensory evaluation of food is expensive and time consuming.
- **Objective evaluation** using instruments eases the process.
- Objective evaluation may use imitative or non imitative measurements of sensory properties.



The sensory quality of food may be classified according to the major senses by which they are perceived. Subjective or sensory evaluation of food generally uses the human sense organs for taste, smell, mouthfeel etc.

For this, a group of consumers or even trained panelists may be used in preference testing for marketing purposes and scoring using standard sensory test procedures or protocols. Sensory evaluation; however, is an expensive and time consuming process; although it is highly desirable particularly when a new food is to be introduced in the market. So, before that it is always desirable to be tested by human individuals or by consumers for its attributes. Objective evaluation of food normally involves instruments and this instrumental analysis or chemical analysis may generally ease the processes. Objective evaluation may use imitative or non imitative measurements of sensory properties.



Before the food material goes to the table for consumption, it has to pass through different stages. In this slide, the stages in the food value chain i.e. starting from the raw material to the consumption are given. Sometimes, the actual raw material that is taken may be little inferior than that required in the ideal raw material and this may be because of different agronomical, environmental, horticultural or other factors.

Except for the case where by appropriate selection of the proper material, its blending and formulation in proper proportion, in each and every stage there is reduction in the quality. Whether in processing, packaging further processing, storage in factory, distribution to depots etc., in each and every stage there is a great potential for the loss in quality of the food. Food has different chemicals, biochemical, bioactive, enzymes, microorganisms etc. These have constant and continuous interactions during all these stages and therefore, they bring about changes in different constituents of the food.

So, in the actual quality of the product is less than what was to be perceived in the potential quality of the ideal raw material. All these changes in the quality i.e. whether it is a microbiological, enzymatic, physical, or chemical; can be minimized or accelerated. This is done in processing by appropriate selection of process or other parameters during storage and handling. Aim is to keep the undesirable changes to as minimum as possible; so that the food quality is retained to the maximum extent.

Undesirable changes in quality attributes

Attribute	Undesirable changes
Texture	<ul style="list-style-type: none"> • Loss of solubility • Loss of water holding capacity • Toughening • Softening
Flavour	<ul style="list-style-type: none"> • Development of <ul style="list-style-type: none"> ✓ Rancidity (hydrolytic or oxidative) ✓ Cooked or caramel flavours ✓ Other off flavours
Colour	<ul style="list-style-type: none"> • Darkening • Bleaching • Development of other off colors




Undesirable changes in food quality attributes may be numerous. In texture, there may be loss of solubility, water holding capacity; the food may become tough it may become soft. Depending upon the components present in the food, the factors which are there during processing and handling; there may be development of rancidity, both either hydrolytic or oxidative. There may be development of cooked or caramel flavour or other off flavours. Regarding undesirable changes in the colour of the food during processing, handling and storage etc., there may be darkening, bleaching or development of a new colour.

Undesirable changes in nutritive value

Attribute	Undesirable changes
Nutritive value	<ul style="list-style-type: none"> • Loss or / degradation of <ul style="list-style-type: none"> ✓ Vitamin ✓ Mineral ✓ Protein ✓ Lipid

- The changes that can occur, with the exception of nutritive value are readily evident to the consumer.
- Macroscopic changes arising from microscopic or chemical changes in the product during processing & storage.



All these changes are macroscopic changes arising from the microscopic or chemical changes in the product during processing and storage. There might be certain undesirable

microscopic changes in the nutritional value of the food because of the loss or degradation of vitamins, minerals, proteins, lipid, etc.

Chemical & biochemical reactions affecting quality of a food

- Many reactions can lead to the deterioration of food quality
 - ✓ Non enzymatic browning
 - ✓ Enzymatic browning
 - ✓ Lipid hydrolysis
 - ✓ Lipid oxidation
 - ✓ Protein denaturation
 - ✓ Protein cross linking
 - ✓ Protein hydrolysis
 - ✓ Oligo & polysaccharide hydrolysis
 - ✓ Polysaccharide synthesis
 - ✓ Degradation of specific natural pigments
 - ✓ Glycolytic changes
 - ✓ Several others

The slide features a yellow background with a dark blue wave on the right side. At the bottom, there are logos for 'swayam' and 'All India Institute of Food Technology' along with a small video inset of a man in a suit.

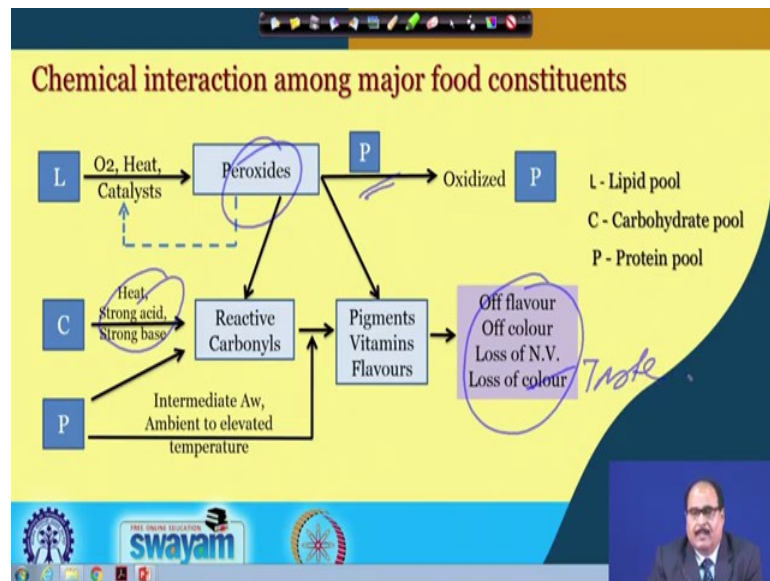
When the food is transported, handled, or exposed to various conditions during processing, it comes across various reactions which influence its quality. Major reactions may be non-enzymatic browning, enzymatic browning, lipid hydrolysis, oxidation, protein denaturation, crosslinking, protein hydrolysis, oligo and polysaccharide hydrolysis, polysaccharide synthesis, degradation of certain natural pigments, glycolytic changes, etc.

- Each reaction class can involve different reactants or substrates depending on the specific food and the particular conditions for processing & storage.
- They are treated as reaction classes because the general nature of the substrates or reactants are similar for all foods.
 - ✓ Non-enzymatic browning involves reactions of carbonyl compounds which arises from diverse reactions like oxidation of ascorbic acid, hydrolysis of starch, etc.
 - ✓ Lipid oxidation may involve primarily triglycerides in one food or phospholipids in another, but auto oxidation of unsaturated fatty acids is the primary event.

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Each reaction can involve different reactants or substrates depending upon specific food and the particular conditions for processing and storage. They are treated as reaction

classes because the general nature of the substrates or reactants is similar for all foods. For example, non enzymatic browning involves a reaction of carbonyl compounds which arise from different diverse reactions like oxidation of ascorbic acid, hydrolysis of starch, etc. Similarly, lipid oxidation may involve primary triglycerides in one food or phospholipids in other food, but the oxidation of unsaturated fatty acid is the primary event.



A brief overview of the chemical interactions among the major food constituents and which ultimately bring about certain changes in the quality is given in this slide. These changes may be desirable or even may be undesirable. In any food material, the three major pools are lipid, carbohydrate and protein. When lipids come across oxygen, heat or other catalysts, it may be converted into peroxide. These peroxides may interact with proteins which may be oxidized. Similarly, carbohydrate pool of the food if come across various factors like heat, strong acid, strong base, it may be converted into different reactive carbonyls. These reactive carbonyls further may interact with pigments, vitamins, flavours and finally, result to off flavor, off colour, loss of nutritive value, loss of colour etc. Even the peroxides may also react or interact with reactive carbonyls; protein pool may directly interact with the reactive carbonyls and the chain may follow. Depending upon the water activity, temperature etc., they may get degraded or may interact with pigments, vitamins, flavours, etc. which may result in change in flavour, colour, nutritive value, taste etc.

Desirable changes in quality during processing of a food

- Many desirable changes occur in foods during processing. These changes can influence sensory properties, functional properties, and / or nutritive value
- A few such changes may be
 - ✓ Development or preservation of pleasing colours and flavours
 - ✓ Improvement or preservation of texture
 - ✓ Improvement of the functionality of food ingredients
 - ✓ Inactivation or control of enzymes & microorganisms
 - ✓ Inactivation of anti-nutritional substances and other approaches to improving nutritional value

swayam

When the food is exposed to certain factors during processing, many desirable changes can also occur. These changes can influence the sensory properties, functional properties or nutritional value of the food. Few such changes include development or preservation of pleasing colours and flavours, improvement or preservation of texture, improvement of the functionality of food ingredients, inactivation or control of enzymes, and microorganisms or inactivation of anti-nutritional substances or other approaches for improving the nutritional value.

Development / preservation of pleasing colour / flavour

- Desirable colours and flavours can develop during the
 - ✓ Processing of food tissues (meats, coffee beans, nuts, olives)
 - ✓ Processing of fabricated foods (bakery products, confectionery products, snack foods, breakfast cereals)
 - ✓ Fermentation (cheese and alcoholic beverages)
 - ✓ Post harvest ripening of fruits
 - ✓ Disruption of plant tissues
- Preservation of color and flavour is often achieved by the
 - ✓ Addition of chemicals, such as antioxidants
 - ✓ Removal of undesirable components, such as glucose from egg white to retard browning of the dried product

swayam

Regarding development or preservation of pleasing colour and flavour during processing, there are different examples in the food to this effect. The desirable colour and flavour develop in food during processing of foods like meat, coffee beans, nuts, olives etc. The

freshly harvested coffee beans do not have characteristic flavour or colour, but it develops during the roasting process. Similarly in processing of fabricated foods like bakery products, confectionery products, snack foods, breakfast cereals etc., they might differ in taste and flavour depending upon the raw material and other ingredients as well as process used. In fermentation processes like cheese, alcoholic beverages etc., the desirable change in flavour can be easily noticed. The desirable changes in colour, flavor, taste etc. can be seen even when the fruits ripen.

The preservation of colour and flavour is also often achieved by addition of certain chemicals like antioxidant etc. or by removal of undesirable components from the food. Like for example, glucose is removed from egg white to retard the browning of the dried product. Before it is put to the thermal processing or heating or drying, the egg white is given certain treatment or even sometime it is allowed to be acted upon by certain microorganisms which eat away the glucose pyramid; so it retards the browning reaction.



Improvement or preservation of texture

- Example of desirable modification of texture include
 - ✓ Softening of plant tissues by heat
 - ✓ Firming of plant tissues through the action of calcium and endogenous pectin methyl esterase (the later being intentionally decompartmentalized and activated by the mild heat treatment)
 - ✓ Tenderization of meat by addition of proteases
 - ✓ Development of a desirable texture in meat analogs
 - ✓ Gelling, coagulation, or firming of egg products, puddings, and bakery products by heat
 - ✓ Formation of cheese by the development (fermentation) or addition of acid to milk
- Hydrolytic reactions, many of which are enzyme catalyzed, appear predominantly among the processes that cause softening of texture

The slide features a yellow background with a dark blue wave-like shape on the right side. At the bottom, there are logos for 'swayam' and 'All India Council for Technical Education' (AITE), along with a small video inset showing a man speaking.

Examples of desirable modification of the texture in food during processing include softening of the plant tissues by heat, firming of plant tissues through the action of calcium and endogenous pectin methyl esterase, tenderization of meat by addition of proteases, development of desirable texture in meat analogs, gelling coagulation or firming of egg products, puddings and bakery products by heat.

Formation of cheese by the development or addition of acid to milk; even certain hydrolytic reactions many of which are enzyme catalyzed appear predominantly among the processes that cause softening of texture of the food.



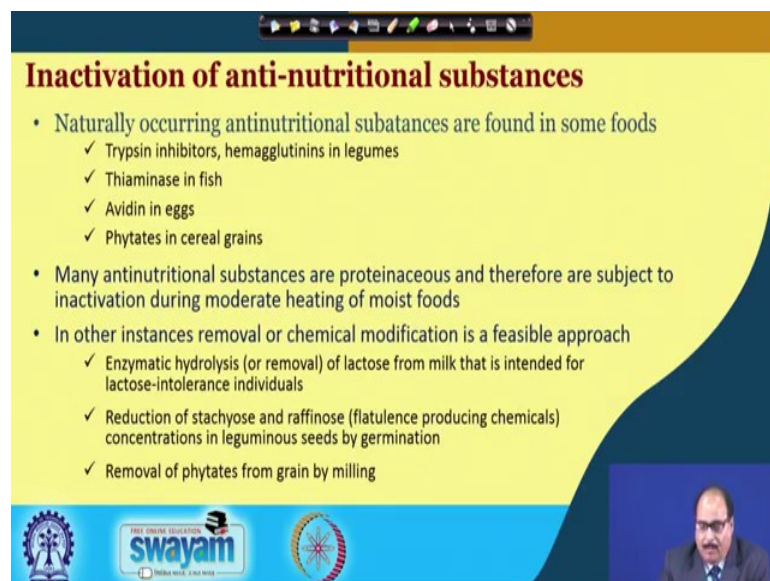
Improvement of the functionality of food ingredients

Examples of improved functionality by processing include

- ✓ Heat denaturation of whey proteins in dried milk intended for bread making
- ✓ Pre-rigor freezing of meat intended for sausage making (to enhance its water holding properties)
- ✓ Alteration in the functionality of starch by gelatinization or chemical modification
- ✓ Alkali processing of soy proteins to impart new textural properties
- ✓ Control of thiol-disulfide interchange reactions in gluten to develop proper rheological properties in bread doughs
- ✓ Increasing the sweetness of corn syrups by isomerizing glucose to fructose

Logos: Swayam, All India Institute of Medical Sciences, and others.

Examples of improved functionality of processed food include heat denaturation of whey protein in dried milk intended for bread making, pre rigor freezing of meat intended for sausage making, alteration in the functionality of starch by gelatinization or chemical modification, alkali processing of soy proteins to impart new textural properties, control of thiol-disulfide interchange reactions in gluten to develop proper rheological properties in bread dough or increasing the sweetness of corn syrup by isomerizing glucose to fructose. In all these processes, the functionality of the food is improved by processing.



Inactivation of anti-nutritional substances

- Naturally occurring antinutritional substances are found in some foods
 - ✓ Trypsin inhibitors, hemagglutinins in legumes
 - ✓ Thiaminase in fish
 - ✓ Avidin in eggs
 - ✓ Phytates in cereal grains
- Many antinutritional substances are proteinaceous and therefore are subject to inactivation during moderate heating of moist foods
- In other instances removal or chemical modification is a feasible approach
 - ✓ Enzymatic hydrolysis (or removal) of lactose from milk that is intended for lactose-intolerance individuals
 - ✓ Reduction of stachyose and raffinose (flatulence producing chemicals) concentrations in leguminous seeds by germination
 - ✓ Removal of phytates from grain by milling

Logos: Swayam, All India Institute of Medical Sciences, and others.

During processing there may be inactivation of anti-nutritional substances. The foods contain various natural anti-nutritional substances like trypsin inhibitors, hemagglutinins in legumes, thiaminase in fish, avidin in egg, phytate in cereal grains and many of these are protein in nature, and therefore, are subject to inactivation during moderate heating of moist food.

In other instances, removal or chemical modification is a feasible approach for inactivating anti-nutrients factors. For example, enzymatic hydrolysis or removal of lactose from milk that is intended for lactose intolerance individuals. Reduction of stachyose and raffinose; this stachyose and raffinose are the flatulence producing chemicals present in pulses etc. So, their concentration if it is reduced in leguminous seeds by the processes like germination etc. then it may provide beneficial effects or results in the inactivation of anti-nutritionals. Similarly, removal of phytates from grain by milling is an example of this. Bran and hulls of cereal grains contain some undesirable substances called phytates etc.; when the grains are dehulled or polished, these phytates are removed.

Damages to texture during processing

Common examples include

- ✓ Excessive softening of fruits and vegetables during thermal processing
- ✓ Toughening of fish muscle during frozen storage
- ✓ Firming of bread during storage at refrigerator temperatures
- ✓ Emulsion destabilization by heating or freezing
- ✓ Coagulation of sterilized milk during storage
- ✓ Cold shortening of red meats when excessively cooled while in a pre-rigor state
- ✓ Adverse textural changes in tissue foods during air drying

The slide features a yellow background with a dark blue curved shape on the right side. At the bottom, there are logos for Swamyam (with the tagline 'FREE ONLINE EDUCATION swamyam'), a gear icon, and a circular logo with a sun-like pattern. A small inset photo of a man in a suit is visible in the bottom right corner.

There might be certain damages to the food texture during processing. The common examples include excessive softening of fruits and vegetables during thermal processing, toughening of fish muscle during frozen storage, firming or staling of bread during refrigerated storage, emulsion destabilization by heating or freezing, coagulation of sterilized milk during storage, cold shortening of red meats when it is excessively cooled

while it is in a pre rigor state, or adverse textural changes in tissue foods during air drying.



The image is a screenshot of a presentation slide. At the top, there is a navigation bar with various icons. The main title of the slide is "Food safety" in a bold, dark font. Below the title, there are three main bullet points, each starting with a black dot. The first bullet point states that safety is the first requisite of any food. The second bullet point explains that in a broad sense, food safety means the food is free from any harmful chemical or microbial contaminant at the time of consumption. The third bullet point notes that this concept is often used in an operational sense for practical reasons. Under this third point, there are two sub-points, each starting with a checkmark. The first sub-point discusses the canning industry, where commercial sterility for low acid foods means the absence of viable spores of *Clostridium botulinum*, which can be translated into specific heating conditions for a product in a specific package, allowing for optimization of other quality attributes. The second sub-point discusses peanut butter, where operational safety is defined as the absence of aflatoxins, and steps to prevent mold growth may or may not interfere with the retention of other quality attributes, though safety conditions must still be met. At the bottom of the slide, there are three logos: the Indian Institute of Technology (IIT) logo on the left, the Swayam logo in the center, and a circular logo on the right. A small inset video of a man in a suit is visible in the bottom right corner of the slide.

Food safety

- Safety is the first requisite of any food.
- In broad sense, this is taken to mean that a food is free from any harmful chemical or microbial contaminant at the time of consumption.
- Often this concept of food safety is used in its operational sense for practical reasons.
 - ✓ In the canning industry, commercial sterility as applied to low acid foods is taken to mean the absence of viable spores of *Clostridium botulinum*. This, in turn, can be translated into a specific set of heating conditions for a specific product in a specific package. Given this information, one can approach optimization of retention of other quality attributes.
 - ✓ Similarly, in such a product as peanut butter, operational safety may be taken as the absence of aflatoxins. Steps taken to prevent the growth of mold in question may or may not interfere with the retention of some other quality attributes; nevertheless, the conditions of safety must be satisfied.

Safety is the first requisite of any food. In broad sense, the food safety is taken to mean that a food is free from any harmful chemical or microbiological contaminant at the time of its consumption.

Often this concept of food safety is used in its operational sense for practical reasons. Few examples include; in the canning industry, the commercial sterility as applied to low acid foods is taken to mean the absence of viable spores of clostridium botulinum. This in turn can be translated into a specific set of heating conditions; for a specific product in a specific package and given this information, one can approach optimization or retention of other quality attributes.

Similarly, in a product such as peanut butter; operational safety may be taken as the absence of aflatoxins. Steps taken to prevent the growth of the mold which is responsible for the production of aflatoxin, may or may not interfere with the retention of some quality attributes; nevertheless the conditions of the safety must be satisfied.

Food safety hazards

Refers to all those hazards, whether chronic or acute, that may make the food injurious to health of the consumer.

- **Hazards inherent to foods**
 - Natural toxins
 - Allergens
 - Intolerable ingredients
- **Hazards associated with environmental contaminants**
 - Persistent organic pollutants
 - Heavy metals
 - Radionuclides

The slide features a yellow background with a dark blue wave-like shape on the right side. At the bottom, there is a blue banner with logos for 'swayam' and other educational institutions, and a small inset video of a man in a suit.

Food safety hazards refer to all those hazards whether, chronic or acute that may make the food injurious to health of the consumers. These hazards may be inherent to food like natural toxins, allergens, intolerable ingredients, there may be hazards associated with the environmental contaminants like persistent organic pollutants, heavy metals, radionuclides, etc.

- **Hazards arising from microbiological activity**
 - Viruses
 - Bacteria
 - Bacterial toxins
 - Biogenic amines
 - Mycotoxins
- **Hazards emerging from food processing**
 - Acrylamide
 - Chloropropanols

The slide features a yellow background with a dark blue wave-like shape on the right side. At the bottom, there is a blue banner with logos for 'swayam' and other educational institutions, and a small inset video of a man in a suit.

Hazards arising from microbiological activity in the food such as viruses, bacteria, bacterial toxins, biogenic amines, mycotoxins etc. or even hazards emerging from food processing like acrylamides, chloropropanols etc.

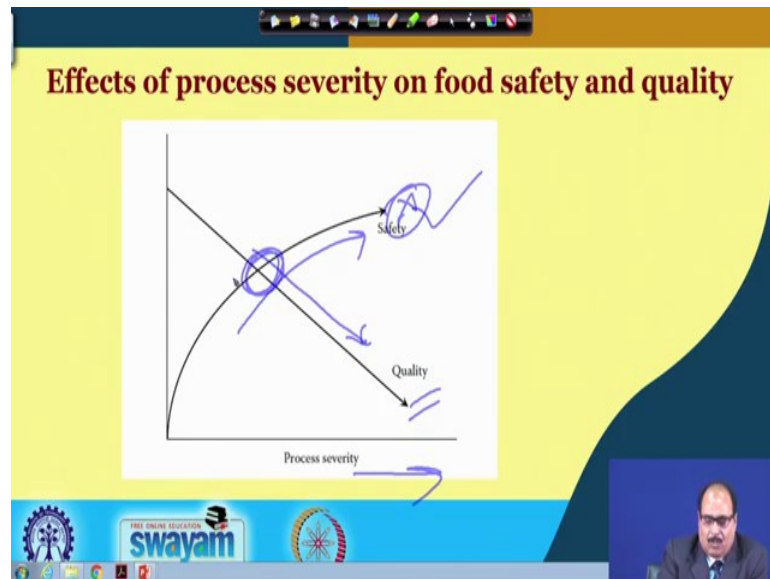
Safety concerns following food processing

- **Safety of bottled water**
 - Water source
 - Piping treatment process and bottling equipment
 - Packaging
 - Quality control system
- **Safety of soft drinks**
 - Microbial contamination
 - Packaging material
 - Chemicals, additives
 - Equipment used in processing
 - Formation of mutagens / carcinogens like nitrosamines
- **Processed foods – Trans fat**
 - Intake of trans fatty acids from partially hydrogenated vegetable oils have deleterious effect on cardiovascular health.
 - TFA are more atherogenic and high intake can promote insulin resistance.

Logos at the bottom: IIT Bombay, Swayam (THE OPEN EDUCATION SWAYAM), and a circular logo. A small video inset shows a man in a suit.

There are safety concerns following the food processing; i.e. whatever the ingredient that is being taken should should meet the quality requirements; GMP, GHP procedure should be followed. Like for example, if taken the safety of the bottled water, it is to be monitored that, what is the source of the water that has been used, piping treatment processes and bottling equipment even packaging material or what are the different quality control systems.

Sometimes gases are found in the packaged bottle when opened. So, that clearly indicates that the bottle while its packaging, the good conditions were not maintained. Similarly, in the case of soft drinks, safety aspects include microbiological contamination, packaging material, chemicals, additives, even equipment used in processing, formation of mutagens or carcinogens or even nitrosamines etc. during processing. In the process foods, even the processing conditions itself sometime create some problems; for example, the trans fats. Normally, in the virgin vegetable oils, the unsaturated groups have the cis fatty acids, but when these oils are heated, cis are converted into trans fat. Intake of trans fatty acids from the partially hydrogenated vegetable oils have deleterious effects on cardiovascular health. Even trans fatty acids are more atherogenic and high intake can promote insulin resistance.



Summary about how the quality and safety are interrelated, particularly the processing condition is given in the above slide. If a more severe process is used, it may be safe or its quality may get deteriorated. So, more severe process will ensure the safety i.e. microbial inactivation, toxin decontamination etc. but can compromise the quality.

In food processing, depending upon the requirements, the food, and its consumption pattern etc., a balance has to be made i.e. up to what extent it should be processed, so that it has a good quality as well as at the same time, it is safe for the consumption.