FOOD SCIENCE AND TECHNOLOGY

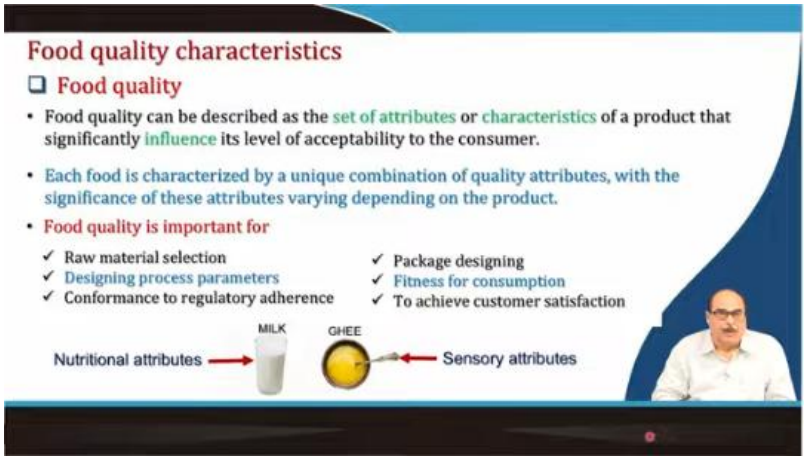
Lecture06

Lecture 06: Food Quality Characteristics

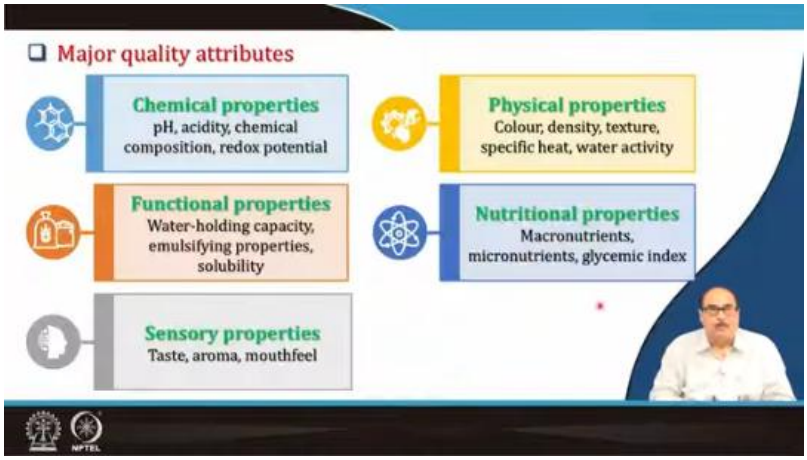
Hello everyone. Namaste. Now we are in module 2 of the course, and the next 5 lectures of the second module will be devoted to food structure-function relationships.

So, the first lecture of the second module will talk about food quality characteristics.

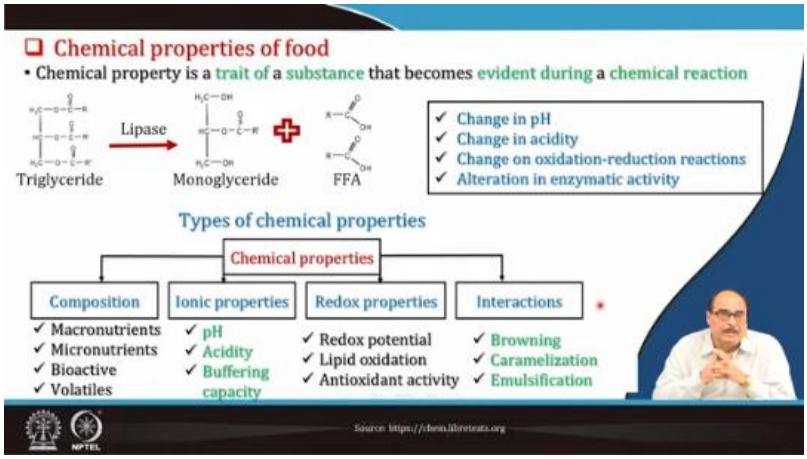
The concepts which we will cover in this lecture include what is food quality or an introduction to food quality, major quality attributes of food, interaction between chemical composition and physical structure of foods, changes in food quality and the factors that influence them and finally, we will also talk about the measurement of food quality attributes briefly.



So, let us discuss what food quality is. The quality of food can be described as the set of attributes or characteristics of a product that significantly influence its level of acceptability to the consumer. We say that this food is of good quality. It is liked by the consumer. Each food is characterized by a unique combination of quality attributes. The significance of these attributes varies depending on the products, it may be of good quality, but the goodness of a product varies based on consumer preferences, like in some cases, in milk when we consume, it is basically nutritional attributes. But for the ghee, when you buy the ghee, sometimes it is the sensory attribute. So, people judge its quality considering its flavor. Similarly, sometimes the color of some food influences our choices and whether the food is good or bad. We decide on the basis of its color. So, food quality is obviously important for raw material selection, designing process parameters, conformance to regulatory adherence, package designing, fitness for consumption, and achieving customer satisfaction. That is, in all aspects, all these processes, when we consider them, are prime criteria. The quality of the food should be intact. When you are designing the packaging for food, the food inside the packet must be good. It must be of good quality until it reaches the consumer. Similarly, the raw material should be selected; if you do not select good quality raw material, you cannot expect a good quality product. So, the quality of the raw material is also important. Then, designing the process parameters: what should be the processing at what temperature, what pressure, and so on. But the main aim is that during processing and distribution, all these things, the quality should be intact and retained. That is the major consideration.

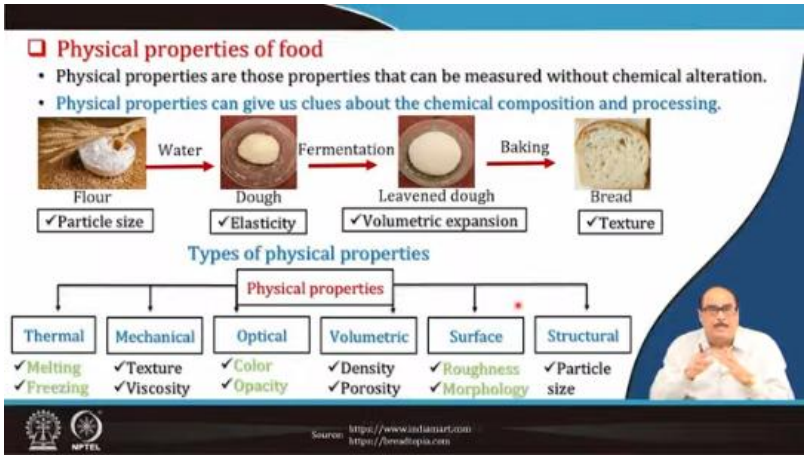


So, the major quality attributes of food are, that is, number one chemical properties like pH, acidity, chemical composition of the food, its redox potentials, etc. Then, physical properties like color, density, texture, specific heat, and water activity. Functional properties like its water-holding capacity, emulsifying properties, and solubility. Nutritional properties include micronutrient content, bioactive content, major nutritional value, macronutrients, glycemic index, and so on. And then finally, sensory properties: its taste, aroma, mouthfeel, look, and all those things. So, all these properties of the food, in fact, they vary differently; different foods may have, but they make the important criteria for nutrition, for choosing the food during processing operations, even, for example, functional properties like its water-holding capacity, etc. That is, during various process operations, it helps in the processing of the food and selecting the proper process parameters.



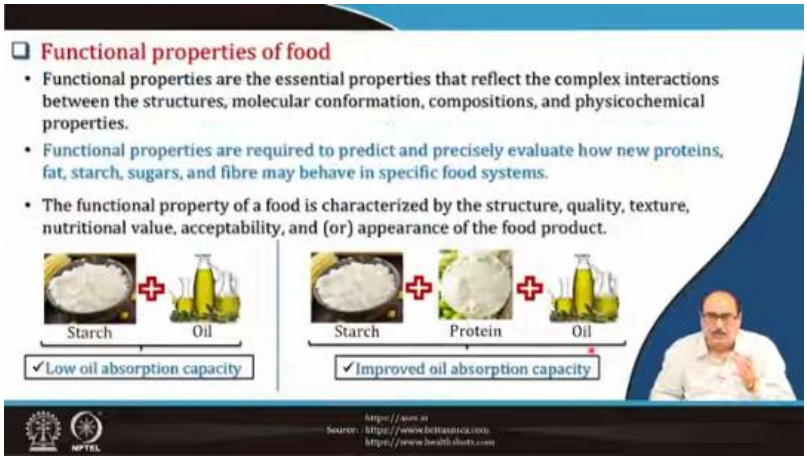
Now, we will take up, one by one, the details of this, like the chemical properties of the food. A chemical property is a trait of a substance that becomes evident during a chemical reaction. You know that food, as we discussed earlier, contains different chemicals, and

these chemicals actually constitute its chemical properties and when the food is processed, during handling, depending upon the various conditions, there are certain changes that these chemicals undergo, leading to different reactions. For example, if you see the triglycerides, that is the fat, and during handling, etc., if it comes in contact with the lipase enzyme, then lipase may break down triglycerides to monoglycerides or diglycerides, and ultimately, free fatty acids may be released into the system. These free fatty acids may result in or may influence, the quality of the oil or fat itself. So, this chemical quality may be changed with the changes in the pH, changes in the acidity, changes in the oxidation-reduction potential, or alterations in the enzyme activities, etc. So, in different chemical properties, again, we talk about what are the different types of chemical properties, composition, micronutrient content, bioactive compounds, and volatiles; they make the composition one very important chemical property of a food material. Then, ionic properties like pH, acidity and buffering capacity. Redox properties like redox potential and lipid oxidation. Antioxidant activity comes under the redox property and then various interactions during processing and handling, different chemicals of foods which are present in this, undergo various interactions and reactions, resulting in browning reactions, caramelization, and emulsification reactions, and these become very important aspects during processing, preservation, and handling of the food material, and many times these reactions may result in desirable changes in the food as well as the same similar type of reactions may result in many foods in undesirable changes. So one has to very meticulously decide to study or understand these components, their behaviour, how they interact with each other during processing, handling, etc., So as to control them when they are undesirable or encourage them or enhance their rate when these reactions become desirable.

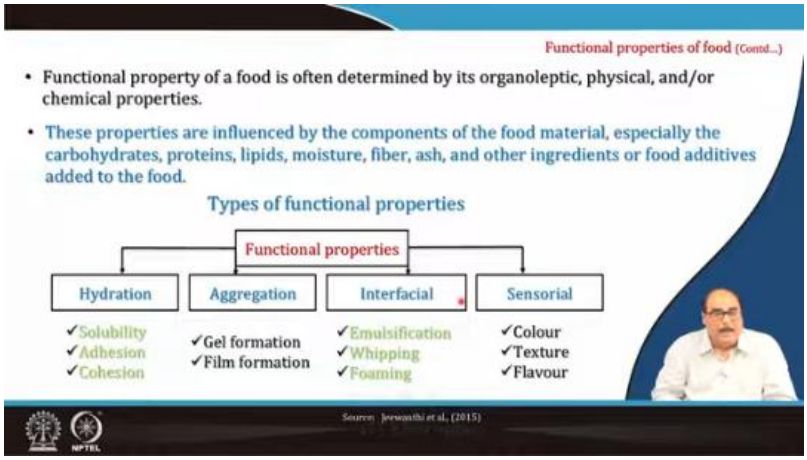


Similarly, physical properties of the food. Physical properties are those properties that can be measured without any chemical alteration. These physical properties can give us clues about the chemical composition and processing. For example, you can see that during bread manufacturing or such other product manufacturing, we take the wheat flour. So what are the characteristics of the wheat flour when you go out with physical properties? It is particle size. We find one important consideration is the particle size of the flour. So if the particle size is a desirable condition, it will influence the other characteristics like when the water is added into it, when the proper dough is formed, then starch and protein interact, gluten formation, etc. And then what are the dough characteristics? You can find out with the elasticity. So the initial particle size of the flour is also influence the dough characteristics, elasticity, etc. Then the same dough will be sent to the fermentation process or leavening process during which the carbon dioxide gas production takes place, causing leavening and rise in. Then in leavened dough the volume expansion is measured. Normally, in the bakery industry, it is considered that two times the volume expansion is required. And finally, when it is baked at a particular temperature, so all this, how much volume expansion is there, What are the types of air bubbles that are formed inside the dough, and all those things that finally give that texture, particularly the texture of the crumb, as well as finally the crust, crumb, crust, etc. So, this is one example of a process. Similarly, there are many, many important operations where these physical properties, even chemical components and their physical nature, influence. So, the physical properties may be thermal properties like melting and freezing, Mechanical properties like texture and viscosity, then optical properties like colour and opacity. Even density and porosity become volumetric properties, then surface properties like roughness, morphology, and structural properties like particle size. So, in the whole subject here, whenever we are particularly studying processing and other related things, these properties will play very important roles as and when necessary. We will discuss the details of all these things. But these are the various physical properties which Must be considered many times depending upon the type of food, type of process, etc. to regulate the food quality characteristics.

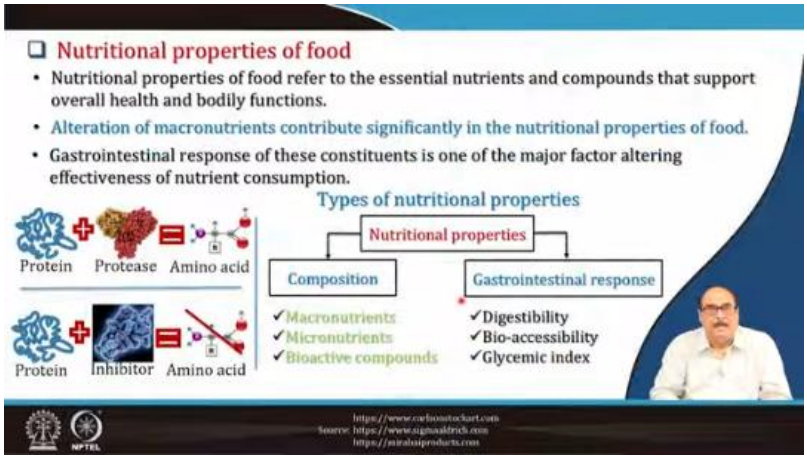
Then, the functional properties of the food.



Functional properties are the essential properties that reflect the complex interactions between the structure, molecular conformation, composition, and physico-chemical properties. Functional properties are required to predict and precisely evaluate how new proteins, fats, starches, sugars, fibers and all of this behave in a particular food system. Like when you are adding different components in formulating a food, then what is its functionality, how they interact with each other and all those things. For example, there is starch and it comes in oil. So, starch plus oil may not have this functionality, which is water absorption capacity. It may have low water absorption capacity. But, if this starch also contains a protein, the mixture of protein and starch improves and increases the oil absorption capacity. So here you can see that both of them interact between the starch and protein. Then it improves the oil absorption, and this is a functional characteristic. So, the functional properties of food are characterized by the structure, quality, texture, nutritional value, acceptability, and appearance of the food products. These again play a role in how the various processes and various quality attributes are modulated during processing. So, functionality becomes very important. Functional properties of food are often determined by their organoleptic, physical, and chemical properties and these properties are influenced by the components of the food material, especially the carbohydrates, proteins, lipids, moisture, fibre, ash, and other ingredients or even the additives, etc. if there are any added into the food. There are many additives like gums and all those things, hydrocolloids, etc. which are added to food to improve its functionality. So the different functional properties, when we talk about this, may be hydration, like solubility, adhesion, cohesion or there may be aggregation like gel formation, film formation.

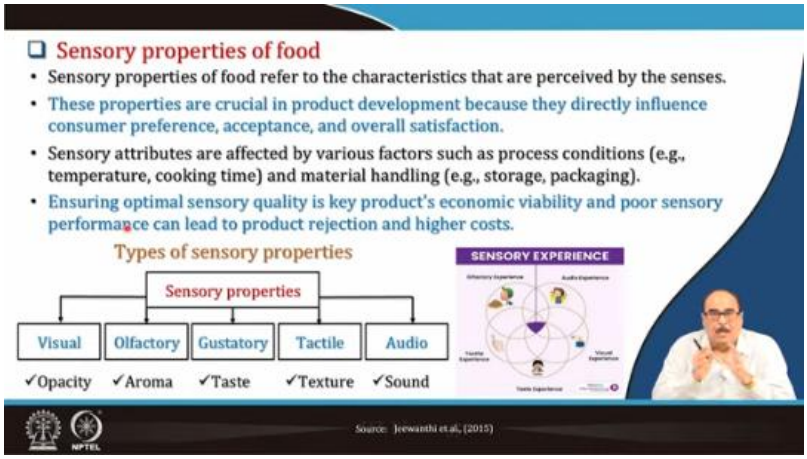


Then interfacial properties like emulsification, whipping, foaming or sensorial property functionalities mean texture, flavour, and colour. So, all these things become functional properties, and they are influenced during processing and handling, and proper characteristics of the food have to be ensured.



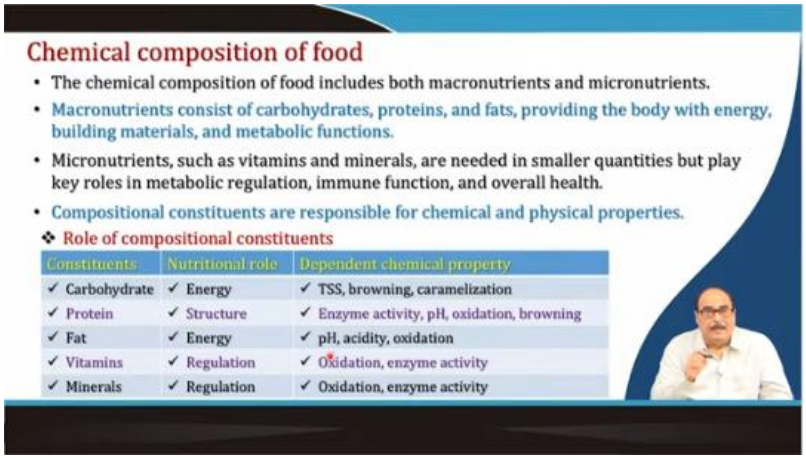
Then comes the nutritional properties of the food. In the earlier module, we discussed that food basically we eat as a source of nutrients. Those nutritional properties of the food are those essential nutrients and compounds that we get from the food that support overall health and bodily functions. So, alteration of micronutrients contributes significantly to the nutritional properties of the food. Even gastrointestinal responses of these constituents are one of the major factors, altering the effectiveness of the nutrient. You can say that protein breaks by protease, which produces amino acids. Sometimes there might be some inhibitors, etc. and these inhibitors may bind the protein, and then it is an amino acid generation or decomposition or hydrolysis of the protein, or it is a utilization. Actually, there is a protein when you consume broken down in our system in the form of amino acids, and then these amino acids further go into the reaction. But if there are some systems, like

some foods, they contain inhibitors, etc., like in soybean trypsin inhibitors, and there are many others. So, these inhibitors block the protein; they bind the protein. These protein inhibitors then make the protein unavailable, or if the protein enzyme is there, which is responsible for the digestion of the protein. However, the inhibitors block the enzyme activity, and therefore the protein goes undigested. It is not broken down; it is not digested into amino acids, etc. So then the nutritional properties may be composition, like micronutrients, micronutrient bioactive compounds, and it is a gastrointestinal response. What is its digestibility? What is its bioaccessibility? Glycemic index, etc., which we discussed in the earlier class. So, all this comes into the nutritional properties. Now, the sensory properties.

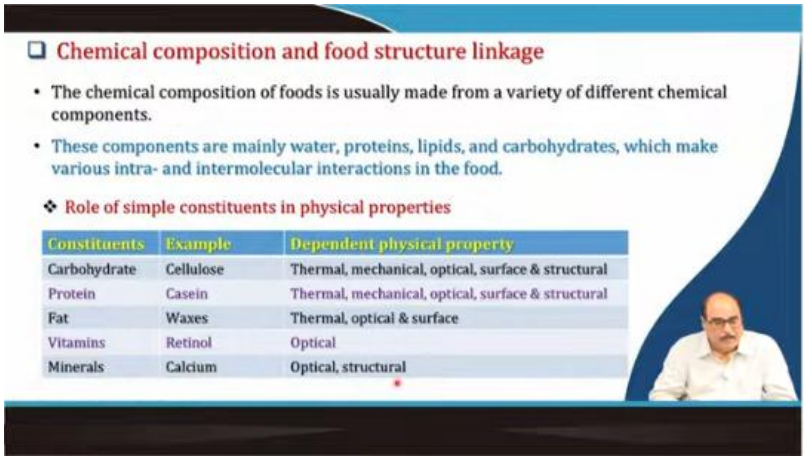


Sensory properties, again, the food refers to the characteristics that are perceived by the senses. These properties are crucial in product development. Because they directly influence consumer preference, acceptance, and overall satisfaction. Sensory attributes are affected by various factors such as process conditions, temperature, cooking time, and even material handling like storage, packaging, and so on and thus ensuring optimal sensory satisfaction. Quality is the key to a product's economic viability, and poor sensory performance can lead to product rejection and even higher costs. So, the sensory perception, when we talk about sensory experiences, there are five sense organs like visual, olfactory, gustatory, tactile, or audio, such as opacity, aroma, taste, texture, and sound, respectively. So, these are the bases of what we evaluate. For example, when we smell any food, there are sensors. It goes through the sensors in our nose, and it sends the response to our central nervous system immediately. This data is analyzed, and then it determines whether the smell is good, bad, or anything else. So, in the olfactory system and others, that is how the sensory organs become particularly important in food; this sensory property

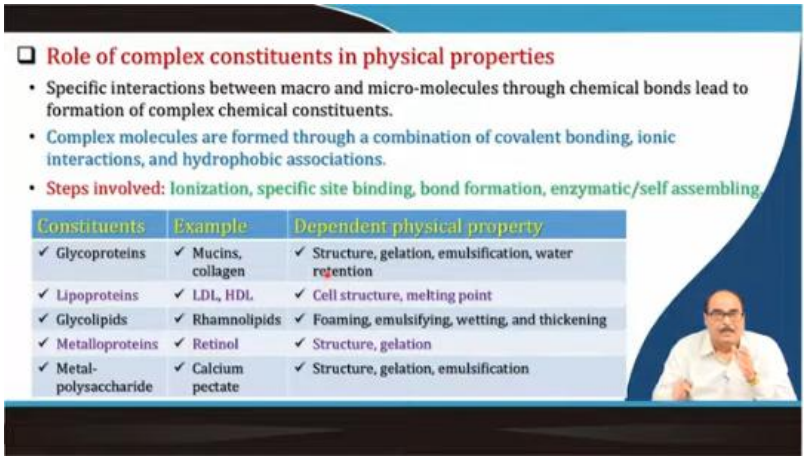
is very important. Overall, if it is not good organoleptically, the consumer will not like it, the consumer will not buy it, and the entire effort may go to waste.



The chemical composition of the food, as discussed in earlier classes, includes both macronutrients and micronutrients like carbohydrates, proteins, and fats, which provide energy, building materials, metabolic functions, etc. Micronutrients like vitamins and minerals are needed in smaller quantities, but they play a very key role in metabolic regulation, immune function, and the maintenance of overall health. The compositional constituents are responsible for chemical and physical properties. So what about the role of chemical constituents or compositional constituents, like, for example, carbohydrates. Its nutritional role is energy, and it depends on the chemical properties, which are influenced by the carbohydrate chemical properties of food, like total soluble solids, browning reactions, caramelization reactions during processing, etc. Here, the contributor is carbohydrates. Similarly, if you look at protein, it builds up the body structure, but in the property, how it contributes is through enzymatic activity in the pH, oxidation, browning reactions, again, that is the maillard reaction, enzymatic protein enzyme where protein-sugar combination reaction, Maillard reaction, browning. Then fat, again, its nutritional role is energy-giving, but it influences by pH, acidity, and oxidation reactions, etc. like the fat may get oxidized, giving various chemical compounds and all those. Then vitamins and minerals. These vitamins and minerals are nutritionally important for the regulation of body processes, such as oxidation, enzyme activity, etc. Here are some chemical properties which are influenced by the minerals and vitamins.

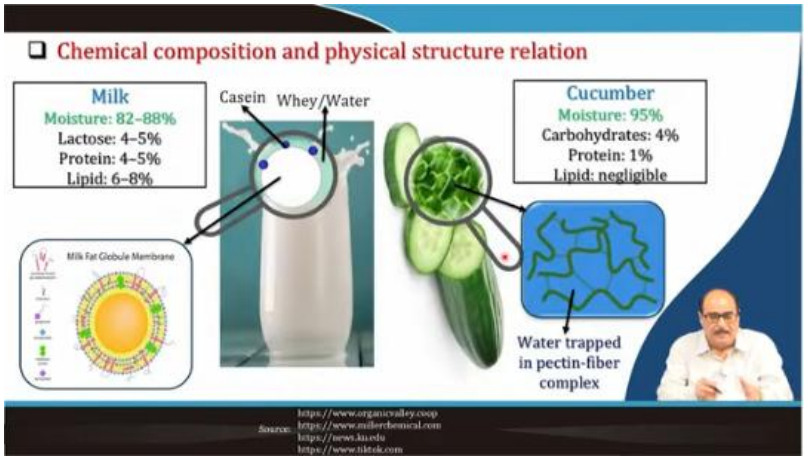


The chemical composition and food structure linkage are also very important. The chemical composition of food: it is usually made of a variety of different chemical components. You see various chemicals, that is, small chemicals, small molecules, big molecules, large molecules, etc. that make the food products. These components actually give various intra and intermolecular interactions in the food, meaning various processes and various reactions are encouraged by these. They interact with each other and these interactions at many times may increase or may decrease, as I said, depending upon the environmental conditions, conditions during storage, conditions during processing, and during handling, etc. These various interactions influence and give desirable properties, undesirable properties, etc. So, for example, with carbohydrates, you can see that cellulose content or fiber content is more or less influenced by the thermal properties, mechanical properties, optical properties, and even the surface and structural properties of the food itself. Similar to the thermal properties, mechanical, optical, surface, and structural properties apply to proteins. For example, in milk, it is the casein. So, how much is the protein content? How much is the casein? How is it present inside the milk? In the matrix, that will all influence. Similarly, the fats, that is the waxes, etc. Then, the dependent physical properties include thermal properties, optical properties, and surface characteristics. Let us say optical properties, minerals, calcium how the calcium is present inside the food, etc., inside the food matrix, that is like in the dairy itself, in the calcium, present in the form of calcium caseinate, and this calcium caseinate, etc., when the protein gets coagulated in different structures. So, all these things, different minerals, proteins, etc., How they are present there, they influence their physical characteristics and their properties.

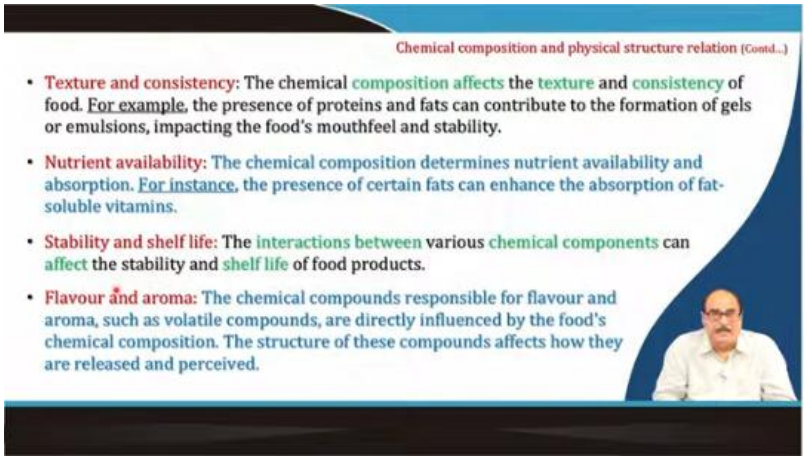


The role of complex constituents in physical properties is that they play very significant roles, like specific interactions between macro and micro molecules through chemical bonds, which lead to the formation of complex chemical constituents. Complex molecules are formed through a combination of covalent bonding, ionic bonding, interactions, hydrophobic associations, etc., and the steps involved in all these may become ionization, specific site bonding, then bond formation, enzymatic or self-assembling, and so on. So, again if you see that complex constituents like glycoproteins, such as mucins, collagen, etc. and influence the dependent physical properties this becomes structure, gelation, emulsification, water retention, etc. All these things are influenced by these glycoproteins, etc. Similarly, if you say lipoprotein, LDL or HDL, low-density lipoprotein or high-density lipoprotein, they influence cell structure, the melting point of the lipid or body or lipoproteins. Then glycolipids like rhamnolipids, the foaming characteristics, emulsifying properties, wetting, thickening, all these things are dependent on these. Then metalloproteins like retinol structure and gelation structure. Metal polysaccharides like calcium pectate. It is the calcium pectate that influences the structure and its gelation behavior, its emulsification properties, and all those things. So these are how these complex, even individual components as well as their complex forms, etc., are important; they influence the chemical properties, etc.

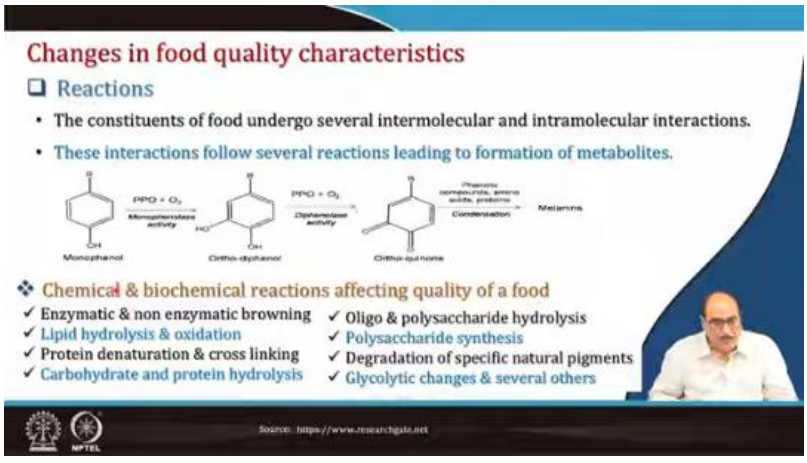
Here, one very good example you can see is that it is not only the constituents, these chemicals, their quantity, how much quantity they are present, but more importantly, how they interact with each other and in which form they are present in the food matrix.



This decides the physical form of the food, whether it is a liquid food, solid food, it is in gaseous form or even other components, such as its colour, texture, and flavour. So if you have taken the example of two foods. One is the cucumber and the other is milk. In the cucumber, it contains a moisture content of about 95% and sometimes it may contain as high as 96 to 98% water, and there are 2 to 3% solids in it. On the other hand, milk, if we take it, contains about 82 to 88% depending upon whether it is cow milk, buffalo milk, breed, etc. Then about 12 to 14% or 12 to 16% of the total solids. So now you see that a food which contains about 12 to 18% solids is a liquid food, whereas a cucumber, which contains only 2% solids, is a solid food. So, it means that these solids are carbohydrates, fats, lipids, etc., in both, but their quantity, of course, varies in the manner in which they interact with it. You can see in the cucumber that water is trapped in the pectin fiber complex. So, it is basically why when you squeeze the cucumber, you can release the water. So, that becomes a major pectin fiber complex. It gives a solid material, and water is trapped inside it. In the milk, there are milk fat globule membranes, and all these are present in the form of an emulsion. It is a water continuous phase, and other constituents are present in the fat. They are present in the form of an emulsion, and in these emulsions, lactose, wheat proteins, etc. milk proteins, etc., they are all present and properly associated; it becomes a major phase, which becomes the water, and it becomes a liquid phase. So, what I am trying to emphasize is the property of the foods. There is a definite relationship between the composition of a food and its physical structure. Even a food which has more amount of water is a solid food, which has comparatively less amount of water is a liquid food. So, it depends. That is how these constituents, solids, interact with each other.

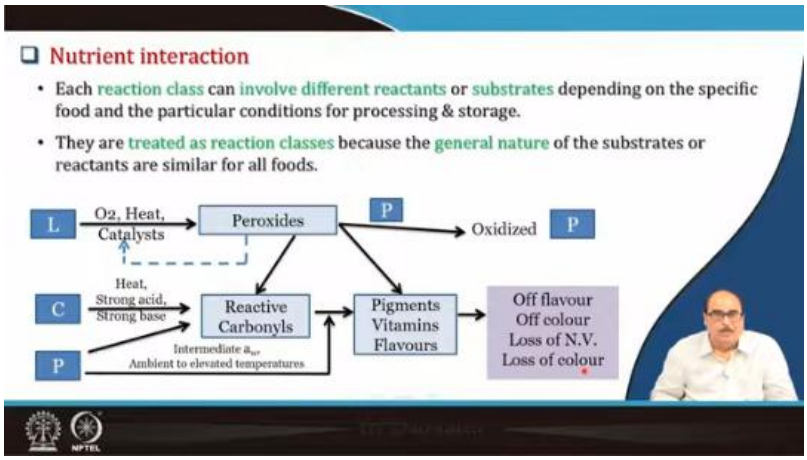


Also, the texture and consistency. The chemical composition affects the texture and consistency of the food. For example, the presence of proteins and fats can contribute to the formation of gels or emulsions, impacting the food's mouthfeel and stability. Even the availability of nutrients, the chemical composition determines nutrient availability and absorption. For example, the presence of certain fats can enhance the absorption of fat-soluble vitamins. In our system, that becomes more bioavailable. Similarly, stability and shelf life are the interactions between the various chemical components. Can affect the stability and shelf life of food products. The chemical compounds responsible for flavour and aroma, such as volatile compounds, are directly influenced by the food's chemical composition. The structure of these compounds affects how they are released or how they are perceived.



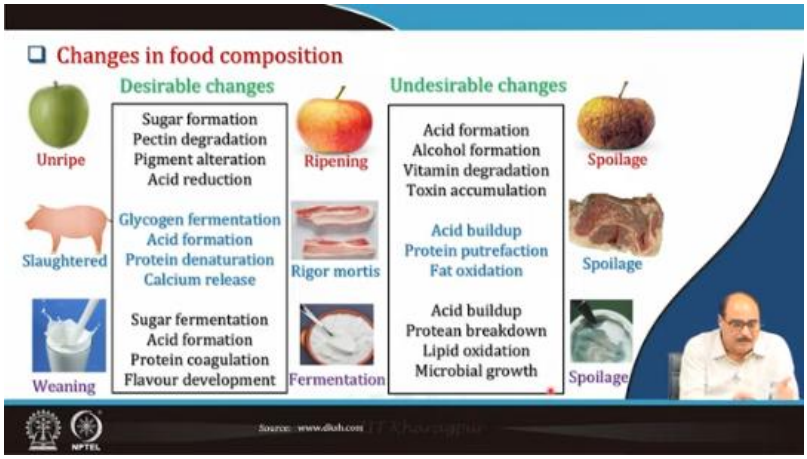
Then let us briefly talk about changes in the food quality attributes. It is basically when the food is processed, when the food is subjected to various conditions, then there are interactions, as I told you earlier, between these components. These components, depending upon the environmental and other factors, undergo various changes, and these

result in the finally sometimes visible or invisible quality change. The constituents of food undergo several intermolecular as well as intramolecular reactions, and these interactions follow several reactions, leading to the formation of metabolites like monophenols. Then, the PPO enzyme, monophenolase activity, may get into orthodiphenol. Then, diphenylase activity, that PPO plus O_2, gives orthoquinone, and is finally a condensation product, melanins. And it is how enzymatic browning takes place. So various chemical and biochemical reactions affecting the quality of food include enzymatic and non-enzymatic browning reactions, lipid hydrolysis and oxidation, protein denaturation and cross-linking, carbohydrate and protein hydrolysis, oligopolysaccharide hydrolysis, Polysaccharide synthesis, degradation of specific natural pigments, glycolic changes, and several others are the various reactions. As I told you earlier also, these are the reactions which are also involved in both desirable and undesirable changes in the food.

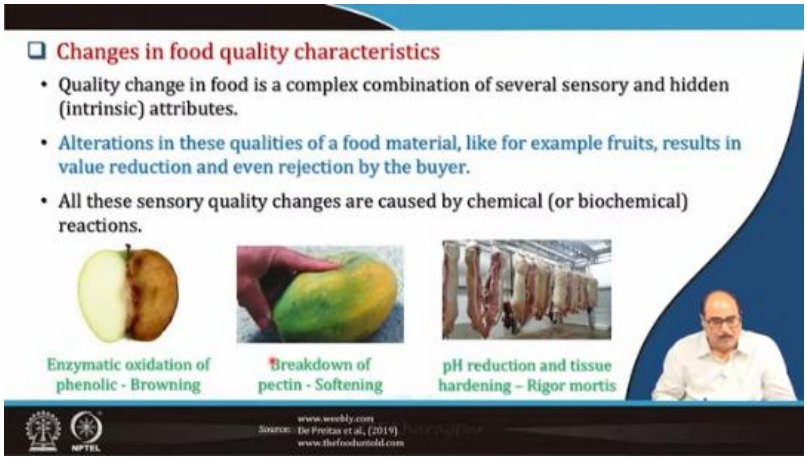


In case of the nutrient interaction, how they influence almost all the properties, like color, loss of nutritional value, loss of flavor, etc. Then there may be, like, each nutrient; let us see lipid pool, carbohydrate pool, and protein pool. So, the lipid pool, if it comes in contact with oxygen, heat, or some catalyst, might get converted into peroxides and then this peroxide may interact with protein; it may get oxidized protein. Similarly, carbohydrate pool, there may be heat depending upon its contact with heat, strong acid, or strong base; it may be converted into reactive carbonyls. Even this peroxide also may decompose into reactive carbonyls and reactive carbonyls, all these peroxides, reactive carbonyls, and even the protein, depending upon intermediate AWR ambient to elevated temperature. This also may include these reactive carbonyls, and all these may interact with the pigments, vitamins, flavours, and all these compounds which are responsible for this and then, finally, it may lead to the generation of off-flavour, off-colour. There may be a loss of nutritive value. There may be a loss of colors. So, all these reaction classes can involve different

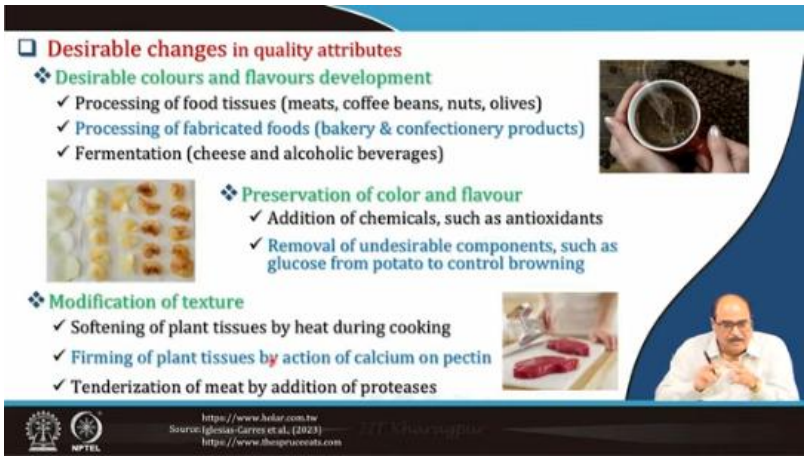
reactants or substrates depending upon the specific food and particular conditions of processing and storage. They are treated as reaction classes because the general nature of the substrate or reactant remains the same.



So, the changes in the food composition may be desirable changes or undesirable changes. The apple is there. For example, when there is a raw apple or any fruit product, when it is green, it ripens. During ripening, there is sugar formation, pectin degradation, pigment alteration, acid reduction, all these may result in desirable changes. And, if it is not consumed at that time, the change will continue which will result in undesirable changes like acid formation, alcohol formation, vitamin degradation, toxic accumulation, etc. and the apple becomes spoiled. Similarly, in the animal after slaughtering, there may be desirable changes like glycogen fermentation, acid formation, protein denaturation, calcium release, etc. and it may give proper texture, etc. by the development of rigor mortis. Then finally, if it may result in undesirable changes, acid buildup, protein putrefaction, fat oxidation, and it becomes spoiled. Similarly, in weaning foods, sugar fermentation, acid formation, protein coagulation, flavor development, etc., may be desirable changes. Then it becomes fermented food and good quality characteristics. But further if proper care is not taken, then there may be acid buildup, protein breakdown, lipid oxidation, microbial growth, etc., and the food may become spoiled.

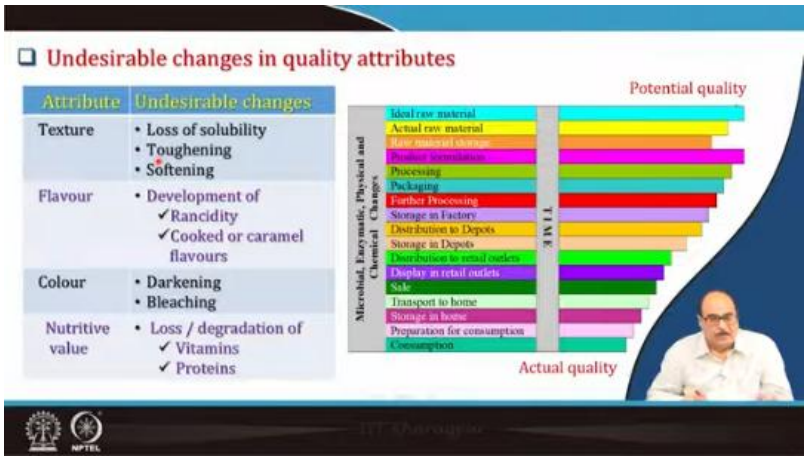


Then these other changes in the quality attributes may be quality changes in the food, which are complex characteristics. Several sensory and hidden attributes are there. Alteration in these quality attributes of the food material results in various value reductions and even rejection by the buyer. All these sensory quality changes are caused by various chemicals and biochemical processes like enzymatic oxidation, browning, or breakdown of pectin. It may cause softening or pH reduction in tissues. It may be hardening or rigor mortis, etc.



Then, similarly, the desirable changes I told you, desirable development of colors and flavors, like processing of food tissues, processing of fabricated foods in bakery and confectionery products, in fermentation, cheese, and garlic beverages, and you can see how the characteristics of the food that is there during processing, it changes. Similarly, there may be the preservation of colour and flavour, which can be obtained by the addition of chemicals such as antioxidants the removal of undesirable components or even there may be modification of texture, like softening of plant tissues by heat during cooking, firming of plant tissues, or tenderization of meat by the addition of proteases, etc. All these things may be desirable changes.

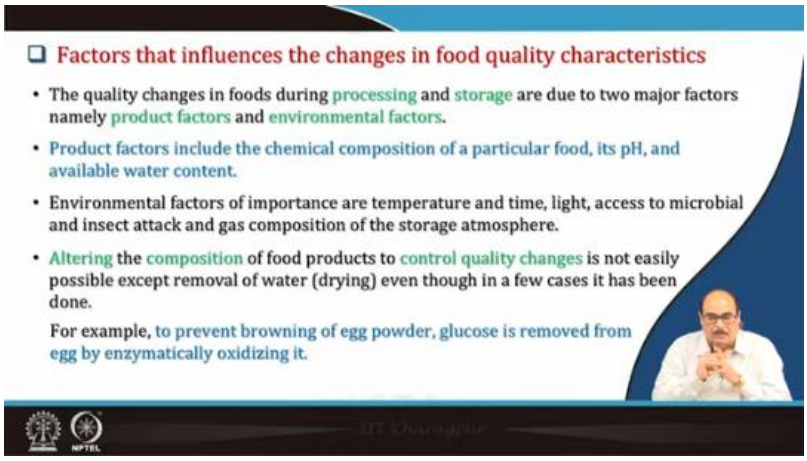
Similarly, there may be changes in the functionality of the food ingredient like heat denaturation of whey protein in dried milk, pre-rigor freezing of meat intended for sausage making, alkali processing of soy protein to improve its textural properties. Then during inactivation of anti-nutritional factors like reduction of stachyose and raffinose, removal of phytate from the grain desirable changes occurs. Texture modification during processing may be toughened up fish muscle during frozen storage, emulsion destabilization, coagulation of the sterilized milk during storage, and so on.



that is, there may be changes during texture, flavor, color, nutritional value, and all these either loss of solubility, there may be development of rancidity, cooked or caramel flavor, or color may darken, color may bleach and the loss of, there may be loss or degradation of vitamins and here in this figure, that is during the complete value chain, right from the ideal raw material storage till its consumption. These food materials, when they come, are attacked by or come in contact with various factors like microbiological, enzymatic, physical, chemical, and all those things. And you can see the potential quality we take 100 here, except for the product formulation stage. whereby proper selection of ingredients and

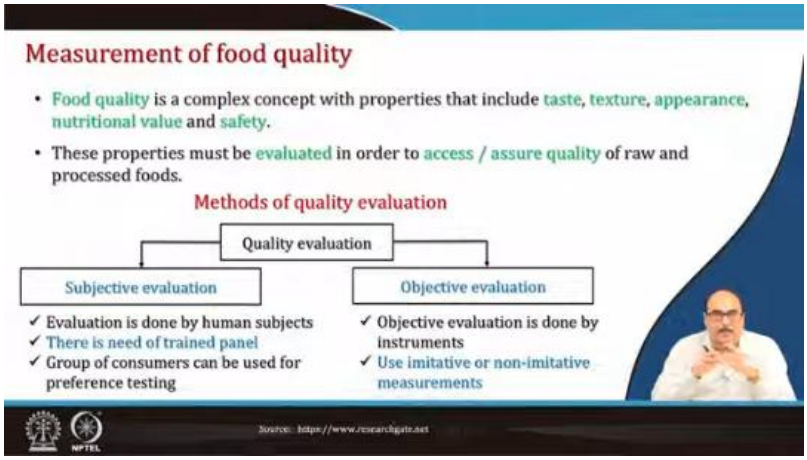
raw materials, we can manipulate and we can get the desirable quality. Otherwise, at each and every stage in the value chain, there is a potential loss, quality loss reactions take place, and there may be that end product,

If you do not take proper care, the quality of the final product after processing and at the time of its consumption, it will be severely affected. So as a food processor, our aim is that by manipulating various conditions like microbiological, enzymatic, physical, etc., we maintain that these changes are minimized as much as possible.

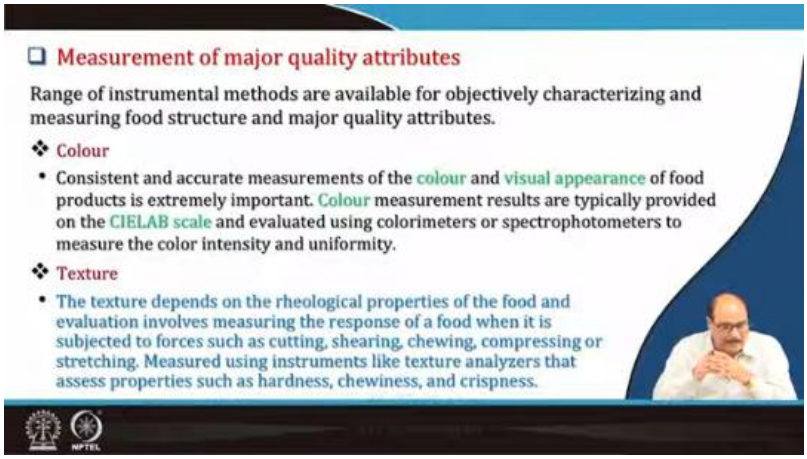


So, the factors that obviously influence the changes in the food quality characteristics, like quality changes during processing and storage, are due to two major factors, that is, the product factors and the environmental factors. The product factors include the chemical composition of a particular food, its pH, and available water content. Environmental factors of importance are temperature, time, light, access to microbial and insect attack, gas composition, storage atmosphere, etc.Then altering the composition of food products to control quality changes is not easily possible except for the removal of water by drying. Even though, in a few cases, it has been done. So for example, to prevent the browning of egg white, glucose is removed from the egg by enzymatically oxidizing it. So you can maintain or reduce these changes, etc.

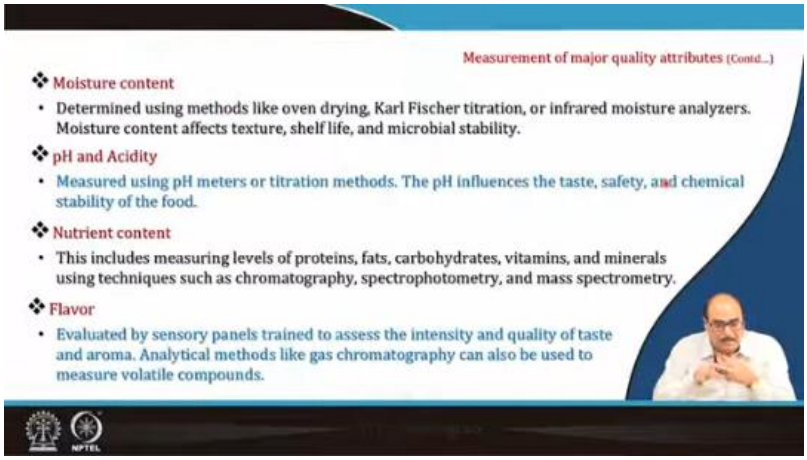
Then finally, I think we will come to the measurement of the food quality attribute. There are two methods: subjective evaluation and objective evaluation. In the subjective evaluation, it is the human panel, trained panel, or test panel that are used, and the evaluation is done by human subjects. We will devote one full week to this inspection and evaluation aspect.



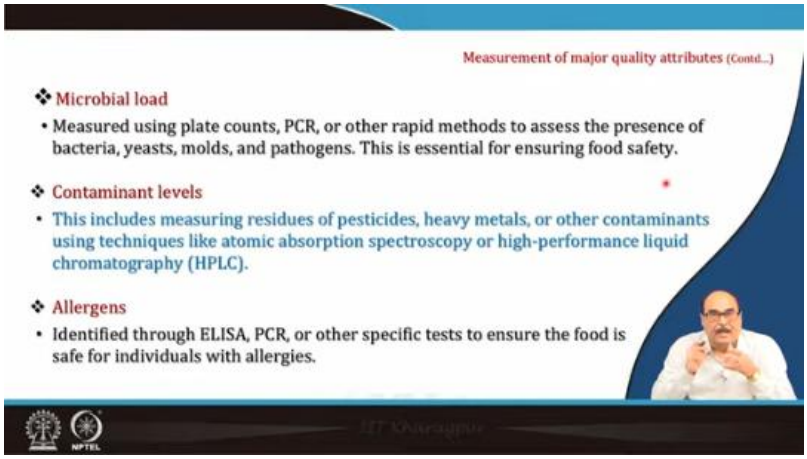
Then, in objective evaluation, there are instruments that are used. The imitative or non-imitative measurements are done, like for the color measurement, the consistency of the measurement, like color and visual properties of color measurement, results are typically provided by CIE Lab and Hunter Lab colorimeter, etc. There is various texture



analyzers, etc. They are used for cutting, searing, tubing, compressing, stretching, and these are measured using instruments like texture analyzers, access properties, hardness, chewiness, crispiness. Similarly, moisture content is analyzed by drying, corn fissure titration, or infrared moisture analyzer.



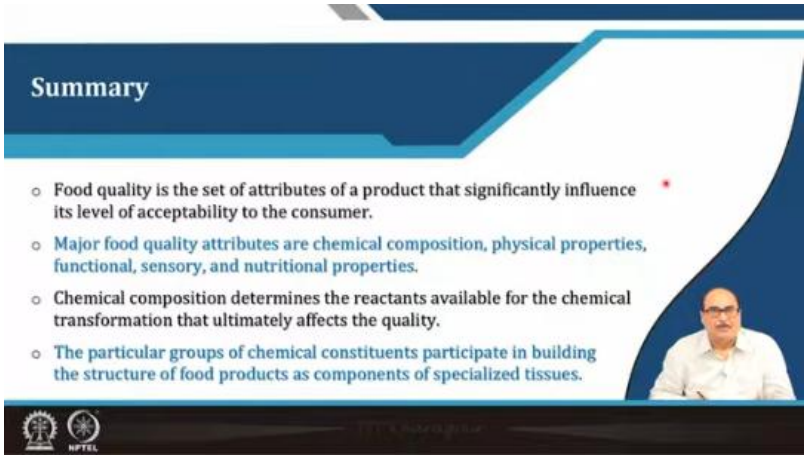
pH, either the titration method or pH meters, etc., influences taste and safety. Then, nutrient content, there are various methods like laboratory methods for the determination of protein, fat, carbohydrate, vitamins, and minerals using techniques such as chromatography, spectrophotometry, mass spectrophotometry, and even flavor, it is evaluated by sensory panels as well as e-nose and other incremental analytical methods like gas chromatography can also be used. to measure volatile components. Microbial loads are measured using plate count, PCR, or other rapid methods like rapid testing kits, microbial testing kits, sensors, etc. are available, which can be used to measure the quality.



Then, contaminant labels like HPLC, high-performance liquid chromatography, atomic absorption photometry, etc. can be used. Even allergens can be identified through ELISA, PCR, and other specific tests to ensure the food is safe for individuals with allergies, etc. So, there are various methods by which these different tests can be performed.

So finally... I will summarize this lecture by saying that food quality is a set of attributes of a product that is significantly influenced by its level of acceptability to the consumer.

Major food quality attributes are chemical composition, physical attributes, functional, sensory, and nutritional properties. Chemical composition determines the reactants available for the chemical transformation that ultimately affects the quality.



The particular group of chemical constituents participates in building the structure of food products as components of specialized tissues.

So, these are the references used in this lecture.

Thank you very much.