

Food Packaging Technology
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Product characteristics and packaging requirements

Welcome to another session of course. In today's class we are going to discuss about product characteristics and packaging requirements. So, food characteristics it is influenced by internal and external parameters. Under the internal parameters we have nutrients, moisture, pH and its physical structure. Under the external parameters we have temperature, atmosphere that is presence and absence of oxygen and packaging. So, these characteristics they determine the shelf life and the preservation methodologies that need to be adopted and based on this only we choose the packaging materials.

Now the food contains many components. The major components are moisture, proteins, carbohydrates, fats and we have micro components like minerals and vitamins and some roughage which is contributed by fibres. Then moisture is a very important component and it is the main reason why a food gets spoiled. So, it is always necessary that moisture need to be removed or it need to be arrested so that microorganisms they will not survive and they will not multiply.

It can be moisture content or water activity. Moisture content is a quantitative amount of water whereas water activity is a qualitative value and moisture content it determines or gives an idea about bound water and free water. In a food product we have free water that is the water that comes out easily and bound water is something which is held in position by the macro components. So, it binds tightly to the macro components like carbohydrates, proteins and fats and it is not easy to release them. And this is not available for microorganisms but free water is something which can be reduced or which the amount can be removed so that microorganisms will not utilize them.

And water activity concentrates on the amount of free water and it is the measurement of energy status of the water in a system. So, it is a qualitative value and both moisture content and water activity are important when we have to understand about the microbial growth or shelf life or the how it is going to influence the product quality. Now moisture content it is the difference in weight before drying and after drying upon the initial weight and it is expressed in percentage whereas water activity it is the ratio of vapor pressure of food and the vapor pressure of pure water. So, it is in consideration with the

pure water. Now if you look at the figure here it shows the water activity and moisture content of different food products.

So, if you look at the initial part, the water activity it ranges from 0.1 to 0.9 and you have potato chips, crackers they are extremely dry products which has a water activity of 0.1 to 0.3 and most of the microorganisms they will not thrive at these conditions.

Whereas products like foods and vegetables, milk, meat, fish they have high water activity is almost near to 0.9 and 1 and at the same time they have high moisture content also. So, they are more prone to microbial attack they will deteriorate easily and hence they need a good preservation and packaging system. So similarly, if we plot relative reaction rate that is reaction rate of food as a function of water activity and moisture content, we can understand many activities that may happen inside the product. So, let's see the enzymatic activity over here.

So, at 0.3 water activity that has food that has low water activity the enzyme activity is less but as the moisture content increases, enzyme activity also increases. So, if the enzymatic activity increases the autolysis may also happen and lipids may also undergo hydraulic rancidity that is why you can see here it is coming down here. The lipid is getting deteriorated and high moisture content, it may contribute to enzymatic browning reactions, it may also contribute to mold growth, yeast growth, bacterial growth. So, you have high water activity and high moisture content all the microbes will grow in this region. We can connect all these activities the biochemical and physical activities that may happen inside the food the changes that may happen in the food they can be connected to water activity and moisture content. Similarly, protein it is the second most important component. We have plant-based protein and animal-based protein. You can see here. There are different pulses are given which are rich in protein and soya it is a plant protein, avocado is also a plant protein and we have animal-based proteins chicken, egg. We have all animal meats. Cheese, dairy products; these are animal-based proteins and basically the animal-based proteins are considered as complete proteins that contains all the essential amino acids.

Now, proteins they have many functions, the major ones are (i) it supports the expression of DNA and RNA (ii) it is essential for hormones or body function and other metabolic activities (iii) it supports the body and (iv) above all it is a main component of muscle. So, it helps in contraction and movement and it is also important as a part of digestive enzymes and antibodies. So, it has numerous functions and a proper functioning of the body protein is very essential. Usually, we get protein from our food what we eat so it can be from either plant sources or it can be from the animal sources. Now why protein is important. We need protein so that malnutrition can be avoided. Protein needs

to be protected and for that we need a proper preservation and proper packaging system that's how we have to relate to the components. So, protein it may undergo denaturation; that is usually what we see. The different structures are there; primary, secondary, tertiary and quaternary structures of proteins are there. These get denatured and the protein it loses its integrity and these are irreversible denaturation. Once it is denatured, the protein loses its integrity and one such example is albumin which is water soluble it becomes insoluble when it is subjected to heating. It is a basic example that can be shown. And again, the next most important component is fat.

We can get fat from plant sources. We can also get it from animal sources like fish. Fat from fish, it is known for PUFA that is polyunsaturated fatty acids and oil sardines are also rich in PUFA. PUFA, it has many health benefits. It protects heart. It protects brain and it has many other benefits. Similarly, plant fats also fat it's a combination of glycerol and fatty acids.

So, we have a backbone of glycerol so that you can see here in the figure this red balls it shows the glycerol part and these are the fatty acids. So, this together forms the fat. We can have three different fatty acids. So, we can have a single type of fatty acids and fatty acids they can be saturated and unsaturated. So, you all know that saturated fatty acids mean it has single bond throughout and unsaturated fatty acid it will be having one or more double bonds which starts from the methyl end. So, in case of this fatty acid, this is the methyl end that is the Omega end and from here the at the third position we have a double bond. So, it is an Omega 3 fatty acid. Now why do we require fat. Again, fat helps in brain development. It is a component of cell, it helps in absorbing shock that also contains fat soluble vitamins, which is also very important vitamins. They are very important and it is also important for heart health and it's a source of energy. So, it has numerous benefits in the body. If we need fat to be protected, we need to adopt suitable preservation and the food need to be protected well.

Lipids they undergo oxidation and this is a very common oxidation pathway. Oxidative rancidity or autoxidation, the unsaturated lipids where double bonds are there, they are converted to peroxy radicals which leads to rancidity the spoilage of fat is called rancidity and this is done in three steps that is initiation propagation and termination. So here we see that initiation is given unsaturated fatty acid it is converted to lipid radical and this process continues in the presence of oxygen and water so if we have an antioxidant, we can terminate this reaction or else it will continue the process will continue and all lipid will be oxidized and the product will become rancid.

And as a part of rancidity, hydroperoxides, it may interact with proteins, it may interact with amino acids, which may lead to denaturation and which may also lead to discoloration. It may also produce byproducts like ketones, alcohols, aldehydes,

hydrocarbons epoxides which will also add to the rancid flavor. So that is one aspect and also, it will cause loss of flavors loss of vitamins so once the lipid is lost even the fat-soluble vitamins are lost these are the indirect effects of fat oxidation. The idea behind food preservation is to protect all these components and when we adopt the preservation that product need to be protected well. Now, this is again it shows the oxidative stress. So, we have a ripe tomato here. Tomato it undergoes stress and it is spoiled. These normal cells, at the free radicals, it attacks the cell and it is subjected to oxidative stress and it is lost the cell integrity is lost. So, this is what observe in many food products so this can be reduced oxidative rancidity can be reduced if you can reduce the temperature or there is no water.

So, for this if you take the suitable packaging material where it has high gas barrier properties or water barrier properties you can protect the particular food. Now, next product is carbohydrates. Carbohydrates are very important because they are source of energy. They are directly related to energy; they undergo glycolysis and ATP molecules are generated and you all know ATP is the powerhouse of all living organisms. They need energy and these are the different sources. We have vegetables, cereals and oil seeds which are the source of carbohydrates. They can be monosaccharides, disaccharides and polysaccharides and these are simple and complex forms of carbohydrates. Under polysaccharides, we have starches, fibers which are plant polysaccharides, glycogen is an animal polysaccharide and then simple sugars. They are again depending upon the number of monomers. They can be monosaccharide and disaccharide. Monosaccharide examples can be glucose, fructose and galactose and disaccharide can be maltose, lactose and sucrose. Now carbohydrate it may undergo many deteriorations. It may be; the carbohydrates may be converted to smaller moieties which may again further undergo deterioration or degradation which will be converted to acids and this will also reduce the pH. Then this will also play with the texture, texture is also influenced by the carbohydrate. So, in plants you will find the cellulose and hemicellulose and lignin. They are the building blocks. So, degradation of carbohydrate will influence the texture changes or it will lead to texture changes. It is involved in browning reaction. Free sugars will participate in browning reactions and lead to the formation of furfural or Maillard byproducts which will lead to browning in products. For example, we have browning in apple. When it is cut and exposed to oxygen, the surface turns to brown and similarly for potato when it is cut the surface gets browned. That is one reason, that caramelization is charring of sugar.

Caramel is used in developing cakes because it adds flavor but caramelization happens when sugar is exposed to high temperature. So free sugars they react together and byproducts are formed. These are some of the reactions that carbohydrate will show when it is subjected to high temperature high pressure in proper conditions. And ATP this is an

example of in fish ATP it undergoes degradation when the fish is killed it is converted to hypoxanthin. Hypoxanthin is a bitter compound and it imparts bitterness to the flesh. Generally, the degradation of ATP to inosine, when the animal is dead, one phosphate is lost at each step and ATP is converted to ADP and then AMP and IMP and this is again converted to inosine. This is a slow process but from inosine to hypoxanthin it is a quick process. Once hypoxanthine is formed the fish will become bitter in taste and it is designated or it is denoted by K value. K value indicates the freshness of it. This degradation happens in the post-mortal conditions, when the fish is already dead. This is also kind of biochemical change that is observed in the body of animal. Then we have micronutrients like vitamins and minerals.

Vitamins are water soluble vitamins like B complex vitamins and vitamin C. We also have fat soluble vitamins like vitamin A, D, E, K and then minerals; major minerals and trace element. So, all these elements we recover from food. For example, fish is rich in iodine, chocolate is rich in molybdenum. So, these minerals, we get from food and only, when food is protected, when it is in safe condition, it is well preserved. Only then these nutrients can reach to the consumer. And based on the nutritional characteristics the foods are grouped into nine categories they are cereals, starchy roots, legumes, vegetable and fruit, sugar preserves and syrups, meat fish and egg, milk and milk products, fats and oils and beverages. So, these nine categories are very important and accordingly the packaging conditions need to be chosen.

And this table it shows different food products and their different composition. So, here you can see that each food has their own unique components. It is not same in all the cases. It is different from each other and if we have to protect the components the packaging material or the packaging system has to be chosen, accordingly. Now this is banana cultivars, different varieties of banana, basically, they are all banana but then within the banana we can find variations. So, water content is differing we have lowest water content 66% in one variety and it goes up to 74% in another variety. So, moisture content itself is varying in one single fruit it depends upon the cultivar. So cultivar to cultivar, also we need to check and accordingly we have to use the package material.

MyPlate concept earlier food chain was in the pyramid concept. Now it is, MyPlate so the plate should contain balanced number of fruits, vegetables, proteins, grains. So, proteins can be any source, it need not be animal protein, it can be plant protein and it can be dairy proteins also. So, it should be for a healthy lifestyle, we need to see that it is in a balanced state and all these criteria are being met. Now major causes of food spoilage, it can be categorized into physical, chemical and microbial and others.

Physical parameters that are responsible for spoilage will be temperature, relative

humidity, height, mechanical damage and chemical spoilages may happen because of enzymatic reaction, non-enzymatic reaction, the acidity and chemical interaction, microbial due to microbes like bacteria yeast and more. Along with this, we can have insect rodents which may damage the food product. So, unless we know what are the different spoilages that may happen in a particular food and from what it needs to be protected, we cannot select a packaging material. So, the packaging material when we select it, we have to understand what is the main cause from what it has to be the product need to be protected from. Shown here some spoilages the bread it is spoiled, mold growth is there so bread it should be protected from moisture so that moisture will not enter into it.

So, the packaging material need to be selected accordingly. Similarly for other food products also. And therefore, the first step of protecting the food will be adopting a food preservation method and generally food preservation we go for physical methods and chemical methods. Physical methods will be drying, chilling, freezing, canning, smoking, pasteurization and chemical methods we include salting, pickling and sugaring. So, these are conventional methods which enhance the shelf life of the food product either by reducing the water activity or making the water unavailable for microbial growth and multiplication.

So, these are the different preservation methods that we adopt for preserving food for extending their shelf life and at the same time without any change to the nutrition. But nowadays more and more studies are being done on non-thermal preservation methods like high pressure processing, microwave preservation method, ohmic heating, then UV sterilization. So, these preservations don't use the heat and thereby they protect the food. So, with this let's wind up for today and in this session, we had discussed about different food components, macro components and micro components and what are the significance of these components in food and why we need to protect this. Considering these components, we have to choose the packaging materials and packaging characteristics need to be decided accordingly.

So, let's wind up for today. Thank you.