Food Packaging Technology

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MA and Aseptic packaging

Hello everybody. Welcome to the fourth session of the module four of the food packaging technology course. We have been dealing with the different advanced packaging technologies. I hope you remember that we discussed an important advancement, the active and the intelligent packaging in the last class. I hope you remember that these active packages, they respond to stimuli and not only conduct the abnormal fundamental function of containment, protection and preservation. But in addition, it detects traces and communicates the same to the consumers.

This session we will be continuing with two advanced technologies. One is Aseptic packaging and one is the Modified Atmospheric Packaging. Though these are not completely related, I've included both of them in this session because it is a relatively smaller topic, but the equipment part will be dealt in the next module. Okay, let's start with Aseptic Packaging.

If you look at asepsis, what do you mean by asepsis? Asepsis is the absence or the removal of any harmful microorganism. Nowadays, we're very familiar with all these tetra packed products, especially milk, which have a shelf life of around one year, kept outside. How is it possible that you can keep milk outside and not refrigerate and still have a shelf life of around one year? That is possible because of this aseptic packaging. In aseptic packaging, in a just a nutshell, it is actually as you see in this picture, you have the product, whether it's milk or any other juice, you can have the product, it is sterilized. You have the packaging material, which is separately sterilized.

And both of these, that is a product is packed inside the packaging material in an aseptic environment. You wouldn't have many humans handling it in an environment where there will be UV rays, you will aseptically package it. And these kinds of containers can even have a shelf life of more than one year. So it is, if you see in this slide, it's the filling of sterile containers with commercially sterile products under aseptic conditions, and then sealing the container hermetically. Now let me tell you all each of these points one by one, what are these terms? It might be new for many of you all.

What is asepsis? Aseptic means like I told you before also, it is the absence of the removal of unwanted microorganisms from the product and from the package, which is the most important step in aseptic packaging. The second term that we see here is hermetically sealed or hermetic. What is that? Airtight. When it is usually have fulfilled in a can or without pouches, can also be done in a tetra pack. So, when you can air tightly pack your product in a package, what happens is, if the entrance of the gases is excluded, the microorganisms will also be inhibited from entering into the product.

That is what you say hermetically sealed. And it is commercially sterile. See you cannot have 100% sterile. Commercial sterile means that there is the absence of organisms or if there are spores present, they are incapable of reproducing under normal conditions, okay, under normal storage conditions. So, if they do not reproduce or they do not grow under normal storage conditions, you can say they are commercially sterile.

So these three terms are very important in aseptic packaging. What are the fields of application of aseptic packaging? Two fields, one is if you have to package pre-sterilized products. That's what we just discussed. Pre-sterilized product. For example, you can have milk, dairy products, desserts, fruit and vegetable juices.

So the product is sterilized separately and it can be packed in the aseptic package. That is one. The second one is you can pack non-sterile products. One very easy example to understand is the dairy products like the yogurt. That can be aseptically packaged.

It's not sterile but you increase the shelf life of the product by packaging it in a sterile packaging material under a sterile environment. Now why go for aseptic packaging? What is the use of aseptic packaging? Now in all these cases, you will see that the product is generally processed at a higher temperature. You must have heard of high temperature short time, HTST or ultra-high temperature which is UHT. Now both these heat processing methods are uses high temperature for a very short time. So once that is done, your product is almost sterile.

So if these products, you have to take advantage of this process, it's always good to go for aseptic packaging. Number two, you can use containers that are usually not suitable for in-package sterilization. So that can be used for your aseptic packaging. And the third one, naturally you can extend the shelf life of the product for a very long time and non-refrigerator conditions. So, these are the very important reasons why we go for aseptic packaging.

If you look, go down through the historic developments, it all started in 1913. So, in 1913, the first aseptic packaged food, that is milk, it was aseptically packaged in metal cans. Again, milk was sterilized, put in the metal cans and it was carried out in Denmark by a person called Nielsen. And around 10 years later, 1921, it was patented. In 1917, in the US, Dunkley, he painted it sterilized cans.

So here again, they started using sterilized cans by using steam. They sterilized the cans using saturated steam and the cans were filled with pre-sterilized products. So that was done in 1917, which was again the starting of aseptic packaging. 1923, the first aseptically packaged milk was brought all the way from South Africa and reached London in absolute perfect condition. Okay, 1933, the American Canning Company, they developed a filling machine, which was a heat-cool-fill system.

And 1940s, slowly we started having the industry coming in, the dairy enterprise, Alpura and the machinery manufacturer in Switzerland, they developed the UHT process. So that was the beginning of your ultra-high temperature processing. And 1953, you had the cans till now. Slowly we are coming into a modern age of Tetra-packs in 1953. The UHT sterilized aseptically canned milk was marketed in Switzerland and Alpura, which was the dairy enterprise and Tetrapak in Sweden.

They both developed this aseptic packaging using the cartons that we have today. And the first milk with the long shelf-life was sold in Switzerland in October 1961. So, if you see in a matter of a few years, you had the aseptic packaging technology developed to what it was today. And this gives you a picture. Most of you all have had your Tetra-packs.

Most of these Tetra-paks, they usually have at least six layers now, but made of only three materials. The three main layers of a Tetrapak are, you have the polyethylene. You have your paper cardboard and you have the aluminium foil. What is the role of each of these? The polyethylene that you have, it's actually a protection from the outside moisture. Moreover, it's the one that will heat seal.

So it is, if you see, it is the inner layer and the outer layer and the middle layer. And also helps you can actually stick your paper board onto your polyethylene, which is easier. So that is why you have a layer inside also of polyethylene. So, you'll have four layers of polyethylene and then you'll have a layer of paper. Why paper board? That is the one that gives stability, strength and smoothness for the printing surface and it gives you the actual structure.

And the aluminium foil is the most important, which is the barrier against oxygen, against light. It is one of the best barriers. So that is the one that helps as a protection once you have aseptically packaged it. And that is exactly the one that helps in hermetically sealing your cheddar pack. Now that you have understood what is aseptic packaging, what are the layers in aseptic packaging, let's go to the principles of sterilization.

Now we'll go into separately talking about how to sterilize your product and how to sterilize your packaging material. When you start with a product, the sterilization process usually has two methods. One is the HTST and one is the UHT. In HTST, which is the high temperature processing, you have to heat it at a higher temperature but for a little longer time than your UHT, which is few seconds to 6 minutes. The temperature in UHT, which is ultra high as the name suggests, it is much higher.

You go up to 130 to 150 degree centigrade for just 2 to 8 seconds. Now both these are acceptable. Milk is sterilized or the product will be sterilized. And there is a definition for the UHT milk which is milk subjected to a continuous flow heating process at a high temperature for a short time and afterwards is aseptically packaged. And that is what actually gives you your long life, shelf-life milk.

Now from a commercial point of view, when you have to sterilize any product, you need to go for the highest temperature at the lowest time. And for that purpose, they usually use heat exchangers. Heat exchangers are basically equipments that will pass on or transfer the heat to the product. And these heat exchangers can be of two types. They can either be direct or indirect.

In indirect as you see, the product is not coming in contact with the heat exchanging fluid. The heat exchanging fluid heats the surface and the heat is passed on from the surface to the product. So, you've got three heat exchangers under this indirect heat exchangers. One is the tubular heat exchangers, the plate heat exchangers and the scrape surface heat exchanger. This is a pictographic representation of that.

You have taken it from this side. Where you have the tubular heat exchangers, you've got tubes. They will be double in layer circular double tubes where you will have the product flowing through one tube and the heating medium through another. The product is not coming in contact with the heating medium. You can have a number of tubes in a shell and so it will be called a shell and tube heating medium.

It's an indirect method of heating. Another very important and very very common one is the plate heat exchanger which is very popular in the milk industry, dairy industry. Here you will have a number of plates. You will have, you can see the red and the blue color. The red will be your heating medium and the blue will be the product that has to be heated. So, it can be milk and this must be your steam or hot milk.

So that is in alternate sections. So, this increases the surface area. So, the time that you take is just 15 seconds. Usually in milk you go in for HTST heat processing. It's for 72 degrees centigrade for 15 seconds and it is possible only because the space between the plates is too less. So that increases the surface area of the milk and that helps in better heat transfer.

Again another indirect heat exchanger. The third one is the scraped surface heat exchanger. You can see the scraping blades here. You will have again a double jacketed chamber. You will have the heating medium in the double jacketed layer and the product inside. The scrapers will ensure that there are no products sticking to the surface.

So all of these are the usual heat exchangers that are used in indirect heat exchangers. The second type of heat exchanger is your direct heat exchanger where your product will come in contact with your heating medium. So, there itself you have the steam injection and the steam infusion. In steam injection, the word injection is you inject the steam into the product.

You will have a chamber. The milk will be in the chamber. The steam is injected into the milk and the steam heats up the milk at very high temperatures. You can go up to 134 degrees centigrade. But once that happens, the steam condenses and adds to the water in the milk. So, what do you do now? That is when they go in for flash evaporation after this to remove the excess water.

So steam injection is a method in this UHT heat treatment and steam infusion. Steam infusion is exactly the opposite. Here you will have steam in the chamber and the milk or the product is added into the steam chamber. It is steam infusion.

And here again the steam heats up the milk. The water condenses. Excess water is evaporated by flash evaporation. So, these methods that we have just discussed, the direct and indirect method will help to sterilize your product. Once the product is sterilized, the other thing that you need to sterilize is your packaging material. We discussed that both the product and the packaging material have to be sterilized.

So when you sterilize your packaging material, there are three main methods of sterilizing your packaging material. One is irradiation, one is heating and one is chemical treatment. In irradiation, they use ionizing radiations, pulsed light, U irradiation or plasma. Any of these can be used to sterilize your packaging material.

In heating, they use high temperature steam. It can be saturated steam, super saturated steam, hot air or a mixture of hot air and steam. And the third important method is the chemical treatment. Here they treat the packaging material. It's dipped in a bath of either hydrogen peroxide or paracetic acid. Now this hydrogen peroxide after it comes out, it can easily vaporize into water.

So there is no problem. The hydrogen is also released. There is no problem. Your package will be free of anything but it will be sterilized. And this sterilized packaging material is used to pack your sterilized product. So that that we have come to the end of the aseptic packaging technique. We will discuss this further in our next module where we will also discuss the equipment that are used or the machinery used in aseptic packaging.

We will move on to the second one which is the modified atmospheric packaging. What do you mean by the word modified? Modified is change. Change the atmosphere inside the package. That is modified atmospheric packaging. It has been there for a long time now and it is commercialized also.

It's a very effective method of preservation. But this method has to be coupled along with chilling. In fact, the preservative effect of chilling is enhanced when it is combined with modified atmospheric. What they do here is they'll modify the package environment in such a way that it will increase the shelf life of the product. It is very clear here in the picture that they do have this carbon dioxide, oxygen and nitrogen.

All these three can be modified. So once the gaseous environment inside the package is modified, the product actually will stay for a longer time. So, let's look at the definitions for a map. It can be defined as the enclosure of food in a package in which the atmosphere inside the package is modified or altered to provide an optimum atmosphere for increasing the shelf life and maintaining the food quality. It's interesting that you can modify the atmosphere in a package by two methods, either by the active modification or by the passive modification. In active modification, they'll completely remove the air inside the package and fill it with the desired air mixture that you want.

Any gaseous mixture, combination that you have, you can flush it in and seal it. In passive modification, what they do is they will package the product, but over time, if it is a vegetative product, they will respire and the carbon dioxide level inside the package will naturally increase. This is called passive modification. The oxygen level can decrease. But at the same time, the package material, the structure and the barrier it offers to the gas, all these are very important when you consider the passive modification.

Vacuum packaging, I'm sure all of you have heard of vacuum packaging. It's very common to see in the markets, you have vacuum packaged cashews, vacuum packaged nuts and dates. So, a vacuum packaging is actually a form of map. You would wonder we're not adding any gas into it, but actually removing the gas from the package is a modification of the gaseous environment of the package, which qualifies the vacuum packaging as a map process. And moreover, once it's vacuum packaged, like we said earlier, you can have modification or passive modification inside the package with an increase in carbon dioxide due to respiration, especially in fruits and vegetables.

Another term that you would probably come across is CAP. CAP is controlled atmospheric packaging compared to map which is modified atmospheric. So as the term indicates, CAP, you're controlling the gaseous composition very strictly. You'll monitor the packaging material, the storage conditions in the room and see that the gaseous composition is kept constant throughout. While in map, you'll modify the composition of the gas, but you will not continually monitor it and keep a strict control over the composition. Over time, this will undergo passive modification, which will eventually help in the increasing the shelf life.

So that's the main difference between a CAP and a map where the CAP, you have a strict control of the composition of the gas. Look at the principles of map. It's used to delay deterioration of foods that are not sterile and whose enzymatic system may still be operative. In all the other cases, you are actually sterilizing. In a septic, we talked about sterilizing it, in blanching and all, you will inactivate the enzyme.

Here, you're neither sterilizing it nor you're inactivating the enzymes, but still, you can increase the shelf life of the product. Now usually, as we already discussed, they are used in combination with chilling temperatures of minus one to seven degrees centigrade. And many deteriorated reactions involve aerobic respiration.

We know that. Like microorganisms, they require oxygen. So, if you can decrease, modify the composition and decrease oxygen content, that helps to reduce the microbial load. At the same time, carbon dioxide increase can help in reducing the microbial load. So that again is done in your map. What are the other benefits of map packaging of fresh foods? One, you can maintain a high relative humidity.

At the same time, you can have a good shelf life. Number two, you can reduce your moisture loss. Number three, improve hygiene by reducing the contamination during handling because you have this extra package here. And the fresh produce surface abrasions, you know, between the fruits and all is reduced drastically, and that helps to increase the shelf life. But they do have some negative effects also.

One is it will slow down the cooling rate of the packaged products. And number two, there's an increased potential for water condensation, which is a disadvantage in the case of map. And this water condensation might eventually lead to fungal growth in the package. Now this is just left you to go through. These are the advantages and disadvantages of map.

Advantages, of course, the shelf life is increased from 50% to 400%. You reduce economic loss because of longer shelf life, you have decreased distribution costs, you've got central packaging and portion control. The sealed packages are a barrier against product recontamination, which is also very important. What about the disadvantages? As we mentioned, it's got additional costs, any value at cost will naturally increase. So, it has added costs for the gases, the packaging machine, the packaging material that you need to add, temperature control is important. Another one is special equipment is required and you need trained personnel to handle this kind of packaging.

Another problem that we haven't discussed till now is the carbon dioxide might dissolve in the food. And finally, that creates a vacuum and creates a collapse in the package, which is another disadvantage of a map packaging. You all know the normal air composition, the maximum three fourth of the air is composed of nitrogen 78%.

And oxygen composes of 21%, carbon dioxide just 0.04% and other gases 0.96%. Now of these different gases that you have, the three most important ones are oxygen, carbon dioxide and nitrogen. In map, we usually play with the composition of these three gases. And out of that carbon dioxide is one of the most important gases in map. One of the reasons is it has got bacteriostatic and fungistatic properties.

And that increases with the concentration of the carbon dioxide. It's very good or very effective against moles, gram negative and aerobic spoiling bacteria, especially your pseudomonas, but less effective against yeast and lactic acid. Now at slight acidic pH, which is found in many foods, this carbon dioxide dissolved that is dissolved will first hydrate to and become carbonic acid. Now acids usually can decrease your pH and in decreasing your pH is good because that inhibits your microorganisms and that can even disrupt the microbial cell membranes. For example, as you see in this equation, this is carbonic acid produced when carbon dioxide dissolves in water and then ionizes to release the bicarbonate.

So these bicarbonates can lower your pH. The antimicrobial activity of carbon dioxide will be much greater at lower temperature. That is why it is usually coupled with your chilling temperatures. As discussed in high fat or high moisture foods, this dissolved carbon dioxide will eventually result in collapse of the packaging material because it creates a vacuum and that can disrupt the whole shape of the package. It can also result in drip and exudates from flesh foods. And one of the solutions for this is absorbent pads that you can keep in your package to absorb the excess water.

The second gas that you can play with in a map is oxygen. Now oxygen though it is odorless and colorless, very reactive and it is one of the reasons for many chemical spoilages and microorganisms require oxygen for their growth. So, generally you try to reduce your oxygen content in most of the packages. But in certain cases, for example in fruits and vegetables and in meat products, you try to keep it at an optimum level. As discussed, if we completely eliminate the oxygen, the fruits and vegetables will no longer respire and that will finally result in the decay of the product.

Another one is nitrogen. You must have seen your lace packets which are pillar packed. So that is completely filled with nitrogen. So, whenever you have a high fat product, it is always better to eliminate your oxygen and you can introduce your nitrogen which is inert. So, this inert gas, it has low solubility in water and other constituents and it is usually used as a filler gas. So, in case your carbon dioxide does get absorbed by the food material and is creating a vacuum, your nitrogen can act as a filler gas in your package and it can retard the growth of microorganisms especially the aerobic spoilage organisms.

Carbon monoxide is another gas that is being used in MAP. Though it is toxic, it has got a few advantages. This carbon monoxide combines with myoglobin from a bright cherry red pigment, kaboxymyoglobin. And this is more stable than your oxymyoglobin.

A carbon monoxide concentration of 0.4% in MAP is usually sufficient for meat. And if you want a very bright red color, carbon monoxide at 5-10% combined with less than 5% oxygen is very good as a funky step. But you should also note that carbon monoxide is not approved by any of the EU, European Union countries and it is not included in the list of allowed food additives. It has been used or is being used in the US for various products. Noble gases, well known for their inertness, lack of reactivity, it includes helium, argon, xenon and neon. So, though they are chemically inert, these are biologically active and they have been used in MAP and majority shows that inclusion of these gases will prevent browning and help in the increasing the shelf life of the product.

Most common thing that they do in MAP is they use gas mixtures. They do not usually eliminate one and fill in only one gas. They have a mixture of gases in a particular ratio, depending on the nature of the food and the likelihood of spoilage. Now where the spoilage is mainly by microorganism, you need to increase the carbon dioxide level and decrease the oxygen level. And in this case, the typical gas composition is 60% carbon dioxide, 40% to 70% of nitrogen. If it is an oxygen sensitive food where spoilage is mainly by oxidative rancidity, completely eliminate the oxygen and go in for 100%

nitrogen or a combination of nitrogen and carbon dioxide.

For respiring products, that's what I have told, for any horticultural products, fruits and vegetables never go for completely 0% oxygen. You need to have some level of oxygen so that the respiration can continue. This gives you some of the organisms that and the nature, aerobic organisms, microaerophilic organisms like lactobacilli, facultative anaerobes, you have got anaerobes like your clostridium. Now all of these depending on your product and if these are prevalent, you need to adjust the gas composition in your MAP accordingly.

This is a very important slide. It shows you the gas mixtures that have been used for different products. For example, if you look at this in meat products, they do add a certain amount of oxygen because this helps to maintain the red colored meat, the oxymyoglobin. If you completely remove the oxygen, you will have a brown colored meat which is not favorable. But at the same time, similarly plants also, they need a certain amount of oxygen. But at the same time, if you look at bakery products which are highly fat products, you can completely eliminate the oxygen and fill it with carbon dioxide or nitrogen.

Similarly for pasta, you can completely eliminate the oxygen and go in for a carbon dioxide and nitrogen. So based on your product and based on the spoilage, you can modify your gas composition. This table shows you the different foods and the gas mixture that is gently applied and how long the shelf life extended.

For example, for meats, you can extend it for at least 5 days. For cheese, for 10 weeks. If you go in for coffee, you can extend the shelf life of coffee by at least 1 year by just changing the composition to 100% nitrogen. It makes all the difference and that is why MAP plays a big role in the food industry. So, in conclusion, MAP is a very simple concept. It is applied to different kinds of food but it actually helps in extending the shelf life of number of products. It is not a substitute for good manufacturing practices, HACCP programs, but if it is used intelligently and responsibly, MAP can become a very dominant method of preservation in the industry.

So I hope you understood both the aseptic packaging and the MAP packaging that we have discussed today. In aseptic packaging, you will sterilize the product, sterilize the package and pack it in a sterile environment. While in MAP, it is not necessary to have a sterilized product and it is not necessary to inactivate enzyme. But just by modifying the gaseous composition in the package, you can very well considerably increase the shelf life of the product.

I will see you in the next class with a different topic on biodegradable material. Thank you so much.