

Food Packaging Technology
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Active packaging - Part 2

Welcome back to the fourth module. Another session of active packaging. Before we start today's session, I'll just have a recap of what we learned in the last class. We went through active packages and how they respond to stimuli. They maintain the environment in the package so that the shelf life of the product is extended. We talked about a number of active packaging systems like your oxygen absorbers, example your iron powder.

We talked about carbon dioxide absorbers, ore emitters, ethylene absorbers which prevent your ripening in fruits and vegetables. Ethanol emitters which act as antimicrobial agents. We talked about a very important active system which is an oyster absorber which maintain the moisture level inside the package. Antioxidant packaging again incorporates antioxidants into your package and prevents oxidative rancidity of the product.

Antimicrobial packaging again prevents microbial growth and your last one which we discussed was the flavor and odor absorbers and emitters. Today we'll discuss another few of other active packaging systems and then go on to intelligent systems. The ninth active packaging system is the microwave susceptors. So, most households use a microwave but when you have a microwave susceptors, these are points which absorb this microwave energy and convert into heat. So actually, they enhance the performance of the package in addition to your detection.

We have a convenience here. They act as susceptors or points which will increase the performance of the microwave packaging and making the product brown and crispier when you do a microwave. And the susceptor material consists of polyester films and into this optically thin layer of metals aluminium has been incorporated. So that actually concentrates your microwave energy and creates these brown spots which will make your food more attractive. Coming to the tenth very interesting active packaging system is your self-heating and self-cooling package.

We already discussed in the last video that when we want a food to be either hot or cold but you do not want to heat it up on the flame or put in the refrigerator or freezer, how do

you get a product hot or cold? This is the system or this is the answer for that. So, when you have a package which has these embedded components which can heat it, when you heat it, you have an exothermic reaction taking place or you have to have an endothermic reaction taking place which will absorb the heat and cool the product. So usually, this system actually first came in the army. The defense system they have these points where they had their war friends in areas where they will not be able to access these kinds of conveniences then these kinds of packages system was very popular in the defense system. For the exothermic reaction you generally can use quick lime and water and these two react together produce heat can be transferred to the product to heat it.

Another very important one is your more expensive one which is used in the army the magnesium oxide. The equation is shown magnesium with the water will produce magnesium hydroxide and heat and this heat can be used to heat your product. So other than your quick lime magnesium oxide or magnesium can be used which is generally used by the army it's more expensive and the equation is shown here magnesium with the water when it reacts you produce heat which again heats the product. Now retortable plastic trays it's not only cans that can be used as a self heating or self cooling medium you can have retortable plastic trays and this is usually based on a six-layer PPEVOH copolymer structure and they have this underlying layer of calcium oxide. Now to heat the product or the pouch it is placed inside the plastic sieves containing this flameless reaction heater those are these components so when they are crushed you can actually have them reacting together and producing the heat.

Self cooling cans on the other hand they have been commercialized in Japan and as I said their endothermic reactions taking places and it's based on the dissolution of ammonium nitrate and ammonium chloride. So why is this more difficult to commercialize? The problem is though the reaction is known the optimization of this controlling of this is more important and the design also is important. So, these things are still taking place in the research field and we hope to see it commercialized everywhere soon. This can be done for coffee tea and ready meals. Changing gas permeability is another active system basically for fruits and vegetables.

So, when fruits and vegetables are sealed, they are still respiring so you have when you respire, they take in the oxygen and release the carbon dioxide. So, there is a buildup of this carbon dioxide and there will be an equilibrium between these. So, if you want to adjust it the package itself can change the permeability of the gas. So, it's a beneficial atmosphere so you cannot have a high amount of carbon dioxide in the atmosphere because a certain level of oxygen is needed. So, in this case it becomes more permeable to the oxygen and the oxygen can permeate in and respiration can continue.

So the respiration rates can increase more with the temperature than do the gas permeability of the films. So, for these, generally they use crystallized polymers. So, these crystallized polymers they can change the permeability of the film as and when required. So, they respond to stimuli. If there is a need, they will allow the permeation of the gases in or out and they currently being used for a wide range of fresh fruit producers.

You can have them in mixed cut vegetables that are seen in the supermarkets, cut broccoli, cauliflower, bananas, strawberries. All these cases these components can change the gas permeability of the package depending on the need inside the package. There's another interesting active packaging system it's called widgets. So, this is a device that is useful for a particular job. For example, you have especially for beer.

So when they have these widgets added onto a beer bottle you can produce a stout beer which will have release more carbon dioxide. So that will give you a creamier head and the widget itself it's actually placed inside a small plastic or aluminium sphere, nitrogen filled sphere and this as soon as it's open this nitrogen is released into the component and you get this foam produced. This is very interesting. They're actually a specific job for a particular purpose that it is done not for all the product. As soon as you open it the nitrogen is injected into it and you get these foams that is produced.

In 2002 canned milk coffee also had these widgets incorporated into it and marketed. Now they've come to end of active packages. I hope you all have understood the different systems that can be incorporated as a part of the package to make it more responsive than the usual passive packages that we used to have over the years. Now in addition to being active what if your package could communicate all that's happening inside your package before you open the package and that can be even more interesting. So, the consumer sees just by looking at the package what is happening inside the package and that is when the intelligent package comes into role.

So intelligent package as the picture shows it can detect, it can sense, it can record the changes taking place, it can trace, communicate it and help in the decision making of the consumer. So, you would think how is this possible. So, in the coming slides we'll show you how the package not only responds to the stimuli it also communicates by any change in color and any detectors and stimulators they will convey the message to the consumers. So intelligent package is defined as a package that contains an external or internal indicator to provide information about the aspects of the history of the package or the quality of the food. What is this history of the package? History of the packages sometimes where especially in the supply chain which are the points at which it is.

Now you have noticed in national geography movies and documentaries you must have

seen how they put these RFID clips to different animals, note down their migratory route. The same thing happens to packages also. You can know where the package has been, what points, how long just like you trace your different postal letters in your speed post you can do the same thing with this but this is with an RFID indicator and you can also know about the quality of the food. Suppose your food is unacceptable the color changes as such. If it is fresh consumer which just has to look at the color and you will know if it's fresh or not.

So, it's a very interesting kind of package which is coming up in the market. So, what are the devices they use for these intelligent active packages? Two types of devices they use. You can either have a chip incorporated, you have an integrated circuit incorporated into the package or you can have chipless smart packaging. You don't need a chip; you have other biosensors but there is no chip. So, there are two ways in which you can have modified or design your intelligent packaging either with a chip or the circuit or without the chip and when you the functions are monitoring vibrations.

We've already gone through the transport worthiness test and we saw how vibration is important. What are the vibrations experienced by the package? So that is recorded by these intelligent packages. So, you can find out the acidity at a particular time. The shock, the humidity, light, heat, everything that the package has gone through is recorded and detected and communicated to the retailer or the consumer. We will go into deep into the topic intelligent packaging.

There are three categories. One, it indicates the product quality. Second, it provides more convenience and third, it provides a protection against theft. The first one is indicating product quality which is a very important function of this intelligent packaging. Now when you say product quality, you can either have quality indicators or time temperature indicator or gas indicator. Quality indicator is, if you look at this picture here, it was taken from this particular paper in 2022.

When you see the quality indicator, it's almost like a freshness indicator. Depending on the color change, so this is a fresh package of meat and this is a spoiled package. You can see this color change here green and yellow. So that itself helps you to indicate whether the product is fresh or not.

The same thing here. Ripeness indicator on the other hand, again a color indicator depending based on the ethylene that is there produced or you can also find out with the color how ripe is your product. Just by looking at the package, you don't have to open the package. A second type of indicator is a time temperature indicator. What is the condition of it? So, this is just by the color change, you can say this is a warm and this is cold and

you know when you have this retort processing and things like that, you want to see if your product has gone up to the particular level of temperature that it was supposed to go through. That again shows the indicator, the time temperature indicator.

Gas concentration indicators, that's an interesting one. I'll show you the picture here. This again was taken from the Journal of Intelligent Food Packaging by Yousafieh and company in 2019. So, if you look at this, I told you when we talked about active packaging, two very important gas concentrations are the oxygen concentration and the carbon dioxide concentration. These two can finally determine the quality of your product.

If you want to have, just look at the color, so this is an oxygen free package that is less than 0.1. So, your package if it has less oxygen, it indicates the package as a pink color. But if your oxygen present is more than 0.5, color changes to blue, very evident to the consumer.

Similarly for carbon dioxide, based on the carbon dioxide concentration, your color can change. All of you are familiar by using a litmus paper for pH indication. So, whether you have it as acid or neutral or basic, you can have it just by just same way you actually have this kind of intelligent packaging which will detect or sense the level of carbon dioxide and change the color accordingly. So, if you have a three-person carbon dioxide, you have a green color and if you have a 23 percent carbon dioxide, you've got a dark red color, which is quite obvious. So that these are the three quality indicators of an intelligent packaging.

The second one I said was providing convenience. Intelligent packages first and foremost were to indicate what is the quality of the freshness of the product. Second is to provide more convenience. Now this convenience adds value but at the same time it comes with a price tag. Prices are much higher but for the consumer there are a lot of convenience that is added into the package.

The first one is they'll have thermochromic inks that is there, which again, see suppose you have a package and the product is you have an endothermic reaction taking place and the temperature is not in a state where you can consume it immediately. So, at that time there will be an indication on your package which says too hot and when it cools down to a temperature where you can consume it, indication changes to drink now. So, this is again a convenient, it's not necessary, none of these are necessary but it adds convenience and convenience comes with a price tag. A lot of avenues that can be explored in this area. The second one is in the convenience one is microwave doneness indicator.

Suppose you microwaved the product, it is a microwavable product, you have microwaved it, you are not sure unless you open it whether it's done or not but if you have an indication of the package done or not done, it can be very convenient right. So that is exactly what is done in a microwave doneness indicator. The third one is for convenience is an RFID in the identification. So here they use a small device known as a tag which is a microchip and this is actually convenience more for than for the consumer, it's actually for the supply chain management and for logistics. If you want to trace your package, where is the package right now, you can just do it with the chip.

You can actually find out where the package is and how long it has been at a particular point and this is not usually added into your primary package, it's usually added into secondary or tertiary package. And the third one is providing protection against theft, counterfeiting and tampering. So, but this is generally not used for all the products, this is used for very very valuable products. So, they use holograms and special links and dyes, laser labels and electronic tags and these intelligent tamper evident technologies, they can say stop or I will change color if you tamper with me, some things indications will be there. So as soon as somebody tampers with it, the color changes, then the consumer will be able to identify if somebody has opened it, tampered with it, there's a theft that has taken place, all these things can be identified with this third convenience provided by an intelligent packaging.

So just of what we just did, this is taken from 2006 Kerry's paper, there is tamper evidence that we talked about, we talked about indicators of product quality, we talked about traceability of the product by using intelligent package and product authenticity. Nowadays there are a lot of duplicate products, so just by looking at only by identifying it with this hologram, you will know if it is an original one or a duplicate one and all this is taken done dealt with the intelligent packages. Now other than the package, today we have also come up with smart labels, the same thing that's the future right now, the same thing whatever you do in your packages, you can do it for your labels too. You're making the label smarter or intelligent, so you have a programmable radio frequency identification tag that is what is RFID tag and that transmits the data via radio frequency to an RFID reader and they use silicon chips and antenna to actually see where it is and trace it, it's not the package, it is the label that is acting as an intelligent one. So you have these smart active labels, SAL as they're called or intelligent labels, they respond to the external stimuli, suppose you damage it, tamper with it, color changes, its temperature has gone up more than where it has to, suppose the storage conditions you must have seen on all the labels, store it in a cool place, store it in a dry place, suppose it is stored in a place which is not very dry and humidity is high, color will change, suppose it's temperature which is higher than what was recommended, again the temperature changes, so it is not the fault of the producer, it will be the fault of the retailer, those are

the smart labels that you'll have.

Now the types of smart labels that you have are the same like this my type of intelligent packages, you have the freshness indicators that can be done by your labels, time temperature indicators again by the label, whiteness indicator just like in your package but not the package, it is a label that will be a smart one and you have an oxygen indicator or inkjet printed oxygen indicator, now all these will make the package label more intelligent and communicative with the consumer. Okay now that we have seen the advantages of intelligent packaging why isn't it very popular, why isn't it completely commercialized, so there are a few hinges to this, one is extra cost because of these extra things value that you're adding to it, it will finally add to the cost of the product which is sometimes not very much acceptable. Second one is there going to be a migration or is there some of these components can it be passed on to the consumer and can it be harmful finally that's another question. Third one is unreliability of the indicating system, now this is not usually a problem but sometimes the food it must be unsafe but it shows it's safe can happen so these are problems that can happen in an intelligent packaging. The fourth one is safety and regulation problems, migration problems there are regulations which say this is the number of components that has to be in the food but the migration from the package which will again hamper your safety of the food.

The last one is recycling features when you incorporate all these components into your package finally is it going to be recyclable, is it going to be environmentally friendly, these are questions that we can answer but in future I'm sure this is going to be a technology that is going to be very popular. So we've come to the end of the second session of the active and intelligent packaging it was an extensive class and I hope that you all have now got an idea about the different systems that are available in the active packaging especially to reduce your oxygen content increase the carbon dioxide level and reduce your moisture content and in addition to that we talked about intelligent packages which will sense, record, trace and communicate the same to the consumer which makes it a more high-tech package. So, I'll meet you in the next class with some more advanced packaging technologies. Thank you.