Novel Technologies for Food Processing and Shelf Life Extension

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Lecture – 49
Detection of Spoilage in Food Grains

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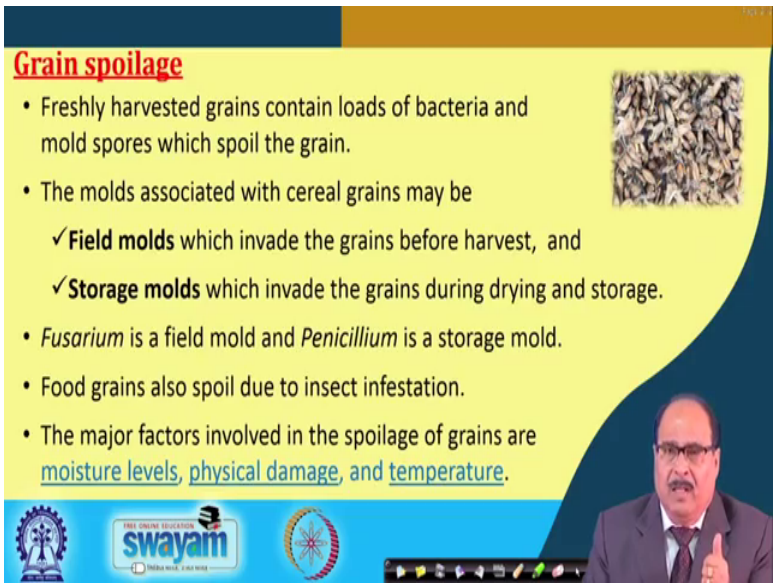

Well friends. In this lecture, we will study Detection of Spoilage in Food Grains. You know there the grains, when they are harvested from the field, they are harvested at different conditions, so depending upon the agronomical practices and other environmental conditions at the time of harvesting. The grain may contain less or more moisture, also the grain may contain loads of microorganisms such as bacteria, mold, theirs spores, etcetera and these all spoil the grain.

The molds associated with the cereal grain spoilage, which are the major causative agents that they may be field mold or they may be storage mold that is the field molds are those which invade the grain, before its harvest, they attack the grain in the field. Storage molds, generally invade the grain during its post harvest operation like drying, handling, storage etcetera if they found, the conditions in the grain favorable for their growth.

The Fusarium and Penicillium, these are the two important molds for which attack are which grow in the cereal grains and spoil their quality. So, in the Fusarium is a field

mold that it is normally invades are in effects the grain in the field itself, before harvest. Penicillium is a storage mold. So, apart from this mold growth, the food grains also is spoiled due to insect infestation right. And these mold, bacteria, insect and all those things, they may get the that is the various factors which might facilitate their growth or multiplication in the mold.

So, the consider the major factor among the various factors major one are the they have told you moisture level in the grain, the physical damage to the grain, if any and importantly the temperature of the grain temperature in the storage environment. So, these are the some so when these agents, I had turned the grain. They bring about a different changes in to the grain in different attributes right. So, these attributes are sometimes or many a times are quite often are used to detect and identify the spoilage level in the grain.

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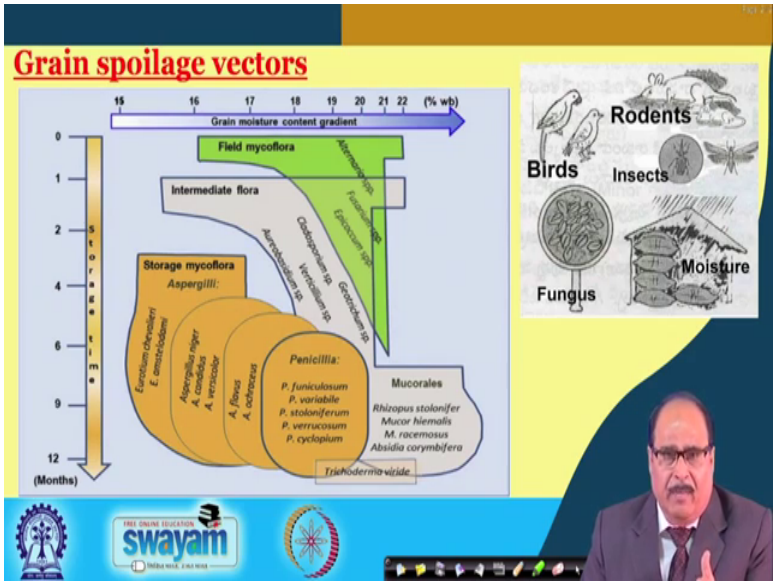

So, as I told you the grain is spoilage vectors are rodents, bird, insect, fungus, moister, temperature etcetera. And in this picture, you can see that the storage month that is starting 0 at the top and 12 months in the bottom. And this and x-axis with the grain moisture content, may be initially it may be 15 percent that is the are; so that is the at the time of harvest.

Then it may increase that is the grain moisture content may go 15 to 22 percent range is taken here and the storage month 0 to 12. So, when there is a high moisture content that

is which may be that in the field are at the time of harvest, I told you. So, this field mycoflora right, fusarium, another case which is indicated by the green line. Then in the drying operations etcetera, after it is harvested. Then the moisture content is brought down, the other conditions in the grain are the factors, they may be controlled. So, some other flora intermediate flora, which is shown here in the white name of the various microorganisms etcetera are the.

Then finally, in the when the during the storage period, further again starting from less moisture content to higher moisture content that is when the grain is put inside the storage, it may have comparatively lower moisture content. And then during the period, if the proper conditions are not maintained inside, the grain moisture content may go high in. So, all this will influence different. So, this gives and or we have the microbial ecology system present inside the storage environment, and which ultimately work or grow on the grain or multiply in the grain and produce undesirable changes.

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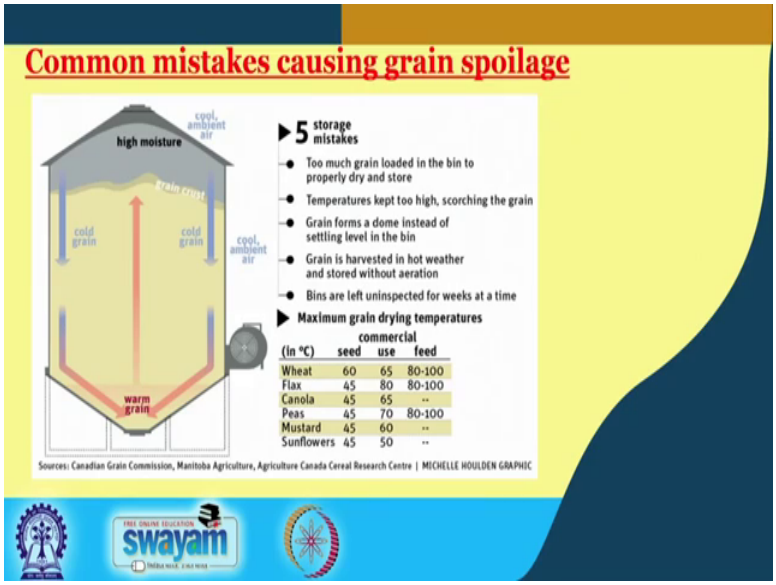

So, here this, it is a; that is the Canadian grain commission that is the slide taken from their intention. So, they say that the five common mistakes which had done that is five storage mistakes, which results into the grain spoilage or that is the too much grain loaded in the bin to properly dry and store that is the density of the grain that is the thumb, it should not do very highly density it is not loading should not be very high. Otherwise, it will that is the grain which respires that is removal of the heat of the

respiration etcetera. Maybe not proper even aeration that is the grains which are on the top are on the sides, they may have different environment than those which are the interior grains which are in the interior.

Then again second says the grain temperature temperature kept too high, it should not be very high temperature inside the storage environment, otherwise it may result in to the scorching of the grain. Grain farms a dome instead of settling level in the bin that is if that is the iron that is there it is dome is far, then again in not a good practice.

Grain is harvested in hot weather and stored without aeration. So, they have to moisture migration is a tower of more moisture. If the aeration is not proper that, then it may serve as a vector for the mold growth or other. Our bins are left uninspected for weeks at a time. So, the maximum grain drying temperature for different purposes that is the for the seed purposes, for the commercial use food purposes, for peat purposes in different seeds, they have recommended the storage temperature.

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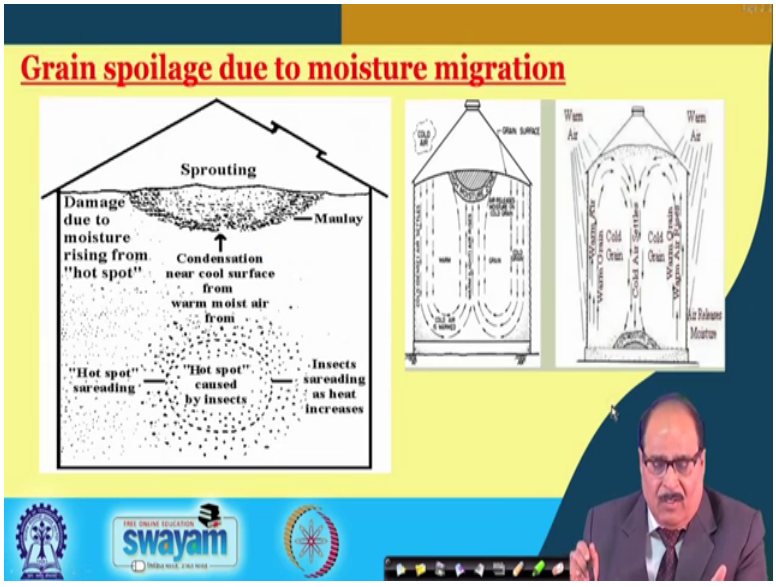

So, and this just in this picture, I have tried to show you that is it is a well known fact that how there is the proper aeration. In the earlier class, also we discussed this aspect that is when the grains are stored in the storage facility, the proper aeration should be maintained, proper temperature should be maintained, some by a following appropriate fumigation or disinfestations method means that is the proper conditions, inside the storage facility must be maintained to keep the grain for longer period of time.

So, depending whether outside the atmosphere is more or low that is hot, weather during hot season or during colder region or colder seasons, so one has to make keep the arrangement or one has to either blow hot air inside the storage facility or blow cool air inside the storage facility. And the grains should be kept in such a way that at least almost individual grains should have a similar environment.

So, if that is a like hip is there or proper conditions are not there, we can say that insects when they grow, they cause, they respire, they produce heat. Also the grain respires, they produce heat, so it causes that hot spot. So, this hot spot means that grain temperature, may be interior inside the grain temperature becomes high.

And this because of the high grain temperature causes sub moisture to evaporate. And this moisture evaporates, and may be and the surface if the outside temperature is lower or even this grains, which are in the side they may have a lower temperature, so because of this temperature gradient, there may be condensation of the moisture occurs.

And this green further, it in; it is moisture content increases, so that is the condensation. And so also the more moisture content may result into a more humidity moisture content, may result into the sprouting of the grain. So, the sprouting or the damage to the due to moisturizing from hot spot etcetera will take place and ultimately grain may spoil either by fungus flow there, and these conditions even insects birds.

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So, the different these factors, when they work under grains alright in the improper storage; environment improper storage of the better conditions, then obviously they have certain effect that is they cause the change in the quality attributes alright. And this is manifested in terms of certain that is the consequences are there.

So, in this slide or in the tabular form, I have tried to summarize you that what are the effects of the grain spoilage that is the either microbial growth or the temperature change or the humidity change or whatever, so it has some effects. And these effects are visible in terms of certain observations, and which finally results into the quality change are gives the consequence.

Like for example, that is the heating of the product, it may be observed bin burning. And it will ultimately result in to the damage to the product and even premises, there may be possible degrading, rejection, extra cost are could lead to fire burning or explosion. The adverse quality changes if they are effect, there may be, it may result into the dull appearance of the grain must be others, visible molds might be they are reduced germination and so on.

And the consequence of all these changes maybe that is the grain may be degraded, it may lose its marketability, it may be rejected by seed germinators are it can, it may not be good for seed purposes alright. It may be even for food purposes in by the factory, if you that is, it is grain if quality deteriorated, it may not be accepted by the factory for the its conversion into different products etcetera. So, means that it is very important to know that first that is to maintain the proper environment proper conditions in the storage facility.

And then one should monitor that what are the that is by taking appropriate measures, there are different methods which I will tell you in the next slides that is by taking samples and analyzing it was various control, because these factors they influence, they affect the quality of the grain, they affect the color of the grain, they affect the flavor of the grain so and so on. So, all these attributes can be used for finding out for analyzing the spoilage are detecting the infestation, another is spoilages in the grain ok.

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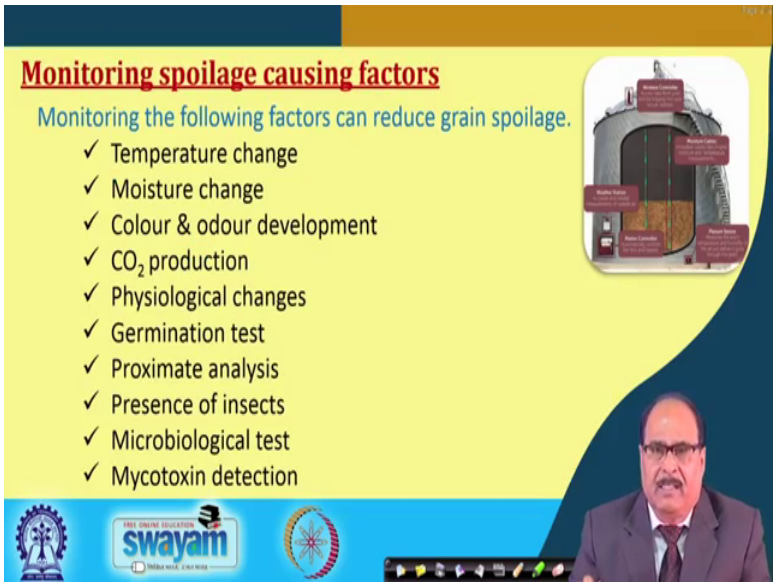

So, is that is how you can monitor the spoilage that is the air just you see that what are the factors which cause the spoilage. So, those factors; that is whether those factors are properly maintained or the fluctuation in those factors how to change in the quality.

Like for example, maintaining and monitoring, the changes caused in the grain due to the change in the temperature, due to change in the moisture, due to change in color are these changes are spoilage, they may result in to the change in the color or order of the there may be carbon dioxide production, there might be certain physiological changes in the grain, even germinability; germination of the grain may be reduced or there may be changes in the proximate composition, there may be presence of visible insects like mold, colonies, fungi, etcetera.

Microbiological changes can be found out are even mycotoxin molds etcetera. They may grow, they may develop some toxin in the food material, like mycotoxins etcetera which are common problems in the biology of the oil seeds and so on. So, monitoring these factors and the changes in the grain into these their particular labels is used to detect the spoilage in (Refer Time: 13:59).

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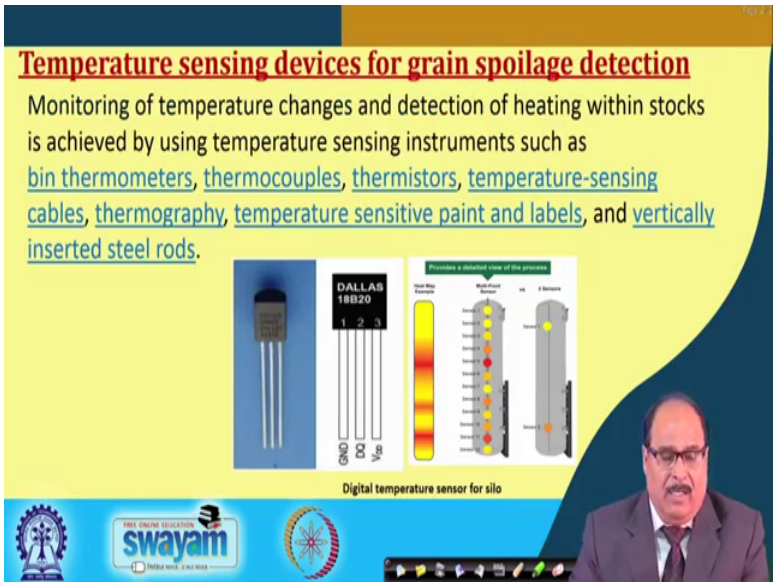

So, I will just elaborate one by one that is a first number one is the temperature sensing devices that is the sensing. For sensing the changes in the grain are based upon the temperature changes had to know that how to that the proper temperature is maintained inside the storage facility in the grain are different thermo temperature sensing and maintaining devices are thermostat sensor, thermocouples, etcetera are available. And they can be used and in fact, different digital temperature sensors etcetera, for silos, for bins, all those things are even for a small scale, for large scale measurement, for online measurements. These are available is a plenty in the market, so they can be used.

So, there are big thermometers, thermocouples, thermistors, temperature-sensing cables, thermography, temperature sensing paint and label or even vertically inserted rods sometimes used in the which the increase in the temperature in the rod just some to measure the temperature inside the grain. So, there are various method, they can be used and to make sure that the desired level of temperature is maintained; and once if the desired temperature is maintained, obviously the spoilage can be prevented.

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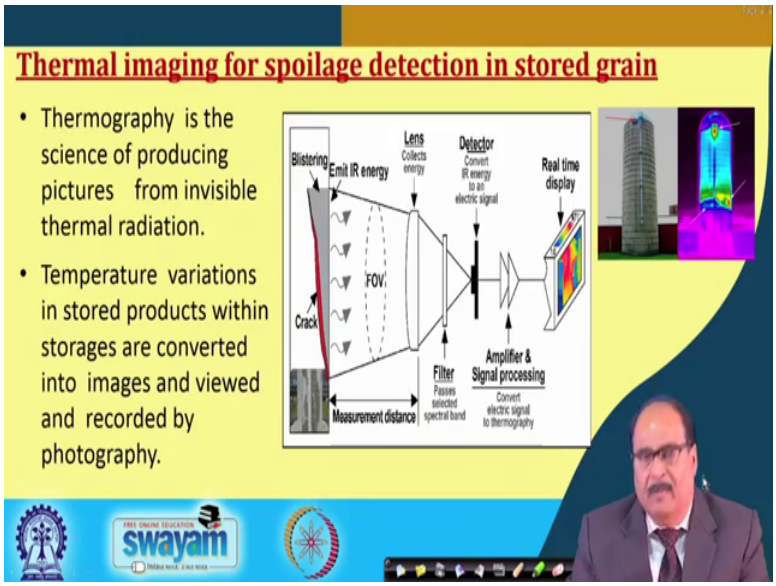

Then thermal imaging for a spoilage detection in the stored grain that is another upcoming and major important technology which is now becoming practiced by some agencies in countries. Like thermography, you can see here by taking the images of the grains or of the materials, which are changed due to effect in the due to the temperature change etcetera.

So, thermography is the science of producing pictures from invisible thermal radiations. There is a temperature variations in stored products within this storages or a storage environment are converted into images and viewed and recorded by photography that you can see here in this case. So, this pictures clearly shows the difference in the temperature ok.

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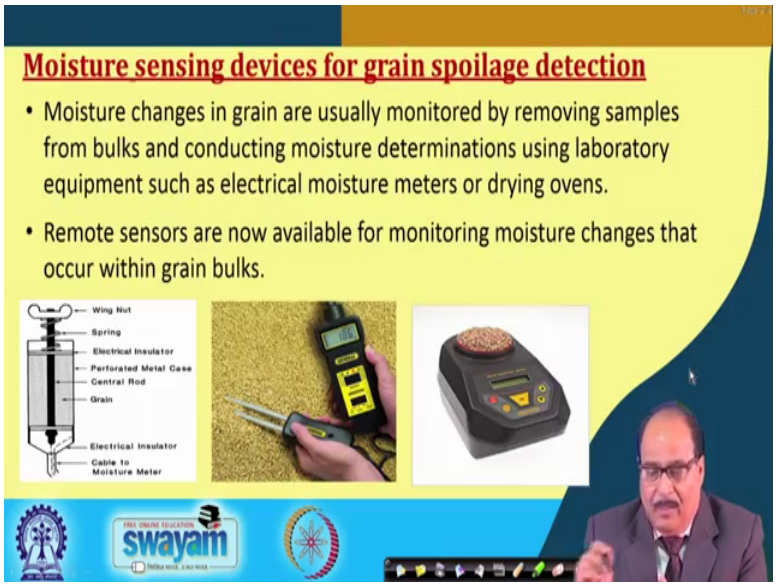

Similarly, the moisture sensing devices are a lot of in the earlier class also. And we are discussing food storage, grain storage there I told you that the different types of moisture sensors are available. Even quick moisture meter that is online monitor meter probes are there which can be directly inserted, and it gives you the details you can see in this figure right.

Then NIR or ER moisture analyzers are there. So, all this they are used. So, quick meter are even the chemical methods using moisture meters are using drying ovens etcetera, can be means that is the in the sense to detect the to know that whether the grain is spoiled or it is not spoiled. The moisture can be analyzed, samples can be taken right moisture and to make sure that is ensured that with the moisture content is not up to the mark. So; obviously, it will lead to this spoilage are in the spoilage, spoilage grain that is the moisture content may be more or a so.

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For selecting that the type of moisture meter to be used are these different factors, which one can take into consideration include resolution, repeatability, reliability etcetera. And this in the earlier class, last class also I elaborate a little bit.

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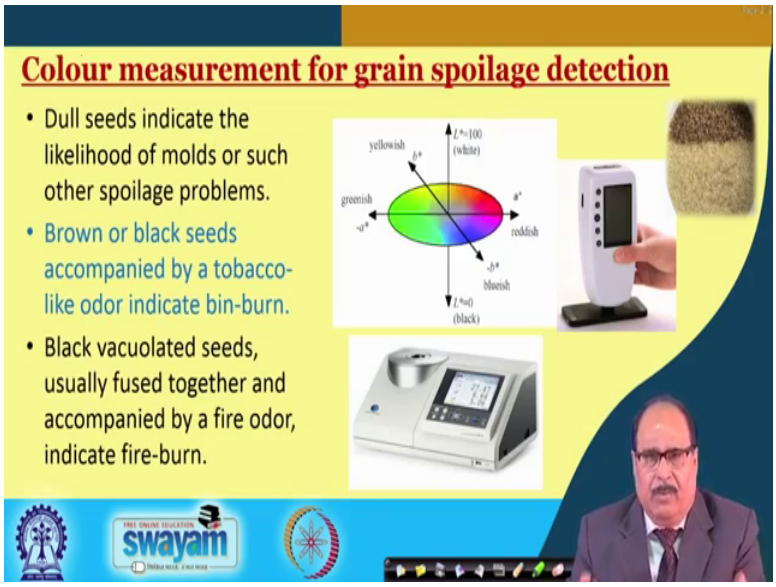

Then another parameter which can be used to detect the spoilage in the color measurement, because there is the many a times then; when insect grow or this fungi etcetera. They bring about changes in the color of the food materials, because even the heat produced in the grain, it may cause that is change in the color. So, this color change,

there are various spectrophotometers or color analyzers etcetera there available that is even.

And the color is; are even by other spectrophotometer methods, these hunter lab calorimeter and although in they can be used ok. For detection of the color or finding out that LAB value etcetera. And then on the basis of this one can find that visible change in the are this; change in the quality of the food are that is for example that is the dull seeds indicate the likelihood of mold or such other spoilage problems.

If the grain becomes brown or black, so the brown development of black or brown color accompanied by a tobacco like odor indicate the bin-burn that is the grain, the temperature inside the bin was too high and the grains. Similarly, black vacuolated seeds, usually huge together and accomplished by a fire color indicate the fire-burn inside the grain. So, by measuring the color of the grain one can find out whether the quality of the grain is good or bad or there is any deviation in the quality or spoilage label.

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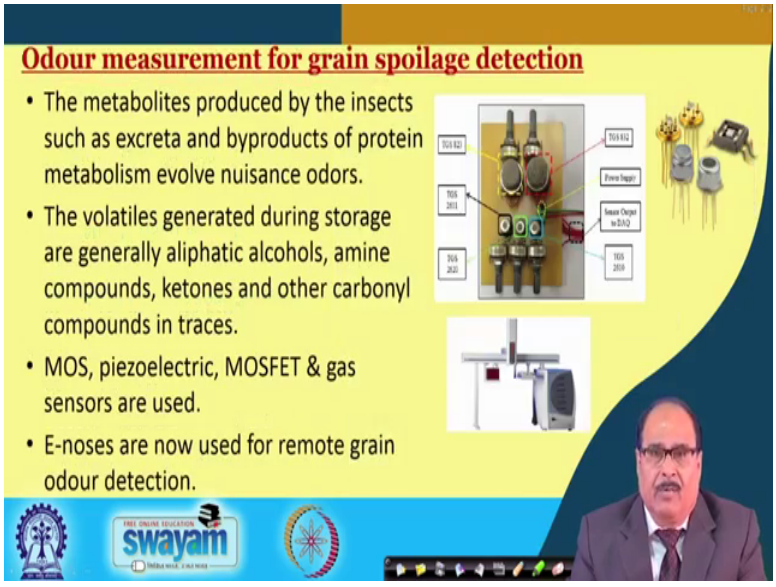

Similarly, the odor measurement can be used another criteria for detection of the spoilage in the earlier class, we have seen that E-nose we use that E-nose basically, analyzes the flavor volatiles are smell volatiles etcetera.

So, when the microorganism to grow, insect consume the grains etcetera. They bring, they produce secondary metabolites even the moisture changes etcetera. They may it

may cause into hydrolysis of the products either by chemical means or by biological means led by enzymatic action and although things, many secondary metabolites may be produced might be produce in the grain, and which give the different colors and [ma/many] many a times many foul smells are sensed or noticed.

So, the volatiles generated during the storage are generally aliphatic alcohols, amine compounds, ketones, another carbonyl compounds, may be some cases in little more or less in. So these odor odors compounds, they can be used qualitatively as well as they can be analyzed qualitatively or quantitatively using systems like E-nose, we have already studies which has metal oxide sensors or there are certain systems which we use piezoelectric sensor or MOSFET or gas sensors in the case of gc are etcetera. So, they can be used to realize the flavor or flavoring compounds, and then deviation in the flavor in might indicate the spoilage of the grain. E-nose are now used commonly they are being used for detecting the odor.

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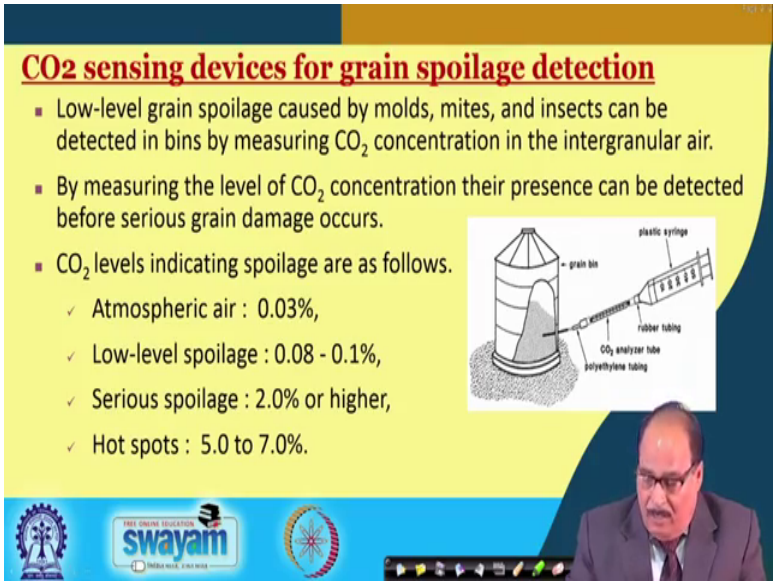

Similarly, the carbon dioxide sensing devices can also be used to detect the spoilage. Like when the grains are aspire or even the so during respiration, the carbon dioxide is produced, and the level of carbon dioxide in the storage facility may go high. So, this high level of carbon dioxide, if it goes beyond a certain level, it may cause the spoilage or it may lower down the oxygen, it may adversely affect the respiration and therefore the grain may get spoil.

So, CO 2 level, but we analyzed and detected and it can be used or it is used in to as indicator for the grain spoilage. For example, you can see that in the atmospheric air the carbon dioxide levels, which are normally 0.03 percentage. So, if this level of CO 2, inside the storage atmosphere found to the range of 0.08 to 0.1 percent means that is a at least slight accumulation of carbon dioxide. So, you can say that yes, this is a stage where the spoilage might get initiated a low level-spoilage right.

But, if this CO 2 grows in the storage atmosphere more than 2 percent that is if it is found, it might indicate there is a serious spoilage are in if the CO 2 is 5 to 7. So, it may say that yes the hot spots are generated inside the grain and it is a further problematic. So, in fact, the CO 2 concentration or CO 2 level even can indicate the even beginning of that spoilage is at are low level initiation of the spoilage. So, by this one can take appropriate preventive measures to reduce the level of spoilage are to stop the deteriorating processes by these methods.

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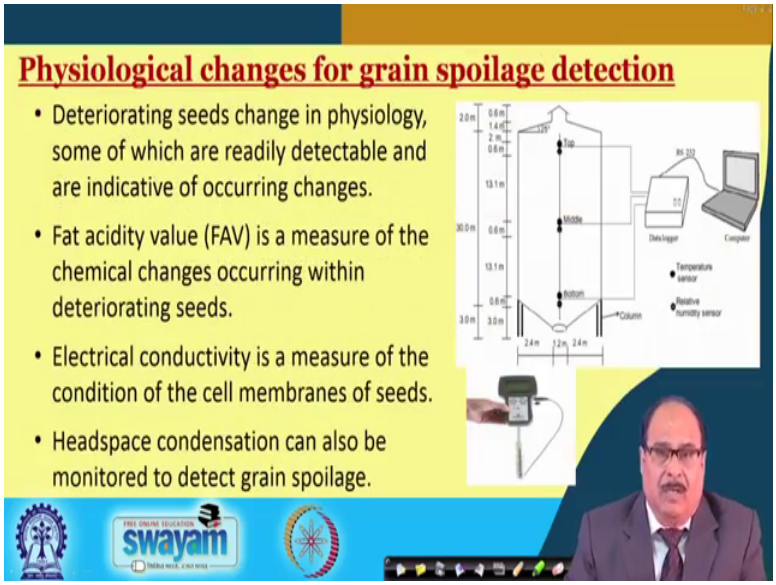

Then the by measuring the physiological changes in the grain or such other materials to detect the spoilage, because it deteriorating seeds they change in their physiology their physiological reactions, even some of these changes are readily detectable and are indicative of the occurring changes in the grain.

For example Fat Acidity Value which is everywhere that commonly as FAV, it is a measure of the chemical changes occurring within the deteriorating seed. So, if the FAV value; FAV goes beyond that standard limit. So, it indicates that is the grain is a spoil.

So, electrical conductivity in is a measure of the condition of the cell membrane of the seeds, this headspace condensation can also be monitored to detect the grain spoilage another. So, the when the microorganism grow or other factors cause, they it may bring about certain physiological behavior and which ultimately may result into the various process, this can be analyzed there are standard laboratory methods or probes.

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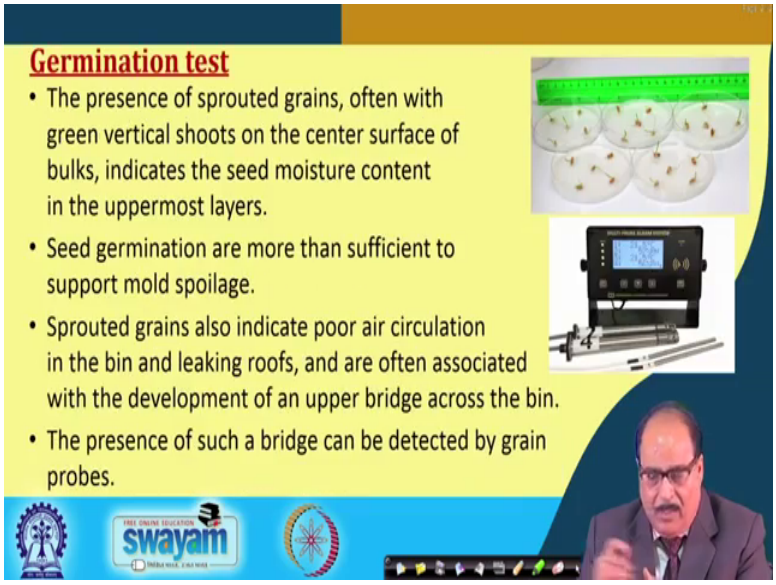

Similarly, that the one of the major physiological change, you can say the germination. That is the spoil grain, it is a germination ability may get reduced, so that is the grains may be particularly, it this test is important. If the grain is stored for seed purposes, so its viability should be tested, its germination should be tested. The presence of its sprouted grains often with green vertical source, and the center surface of the bulk indicate that the seed moisture content is more particularly in the uppermost layer. So seed germination are more than sufficient to support mold growth.

A sprouted grains also indicate poor air circulation in the bin and leaking groups, and are often associated with the development of an upper bridge across the bin. The presence of such a bridge can be detected by grain probes etcetera. So, there are different tests that is a which one can use to find out, whether the seed viable or not or it is a viability is

completely lost and then maybe that you can say that the seed at least spoiled for it is not fit for seed huge.

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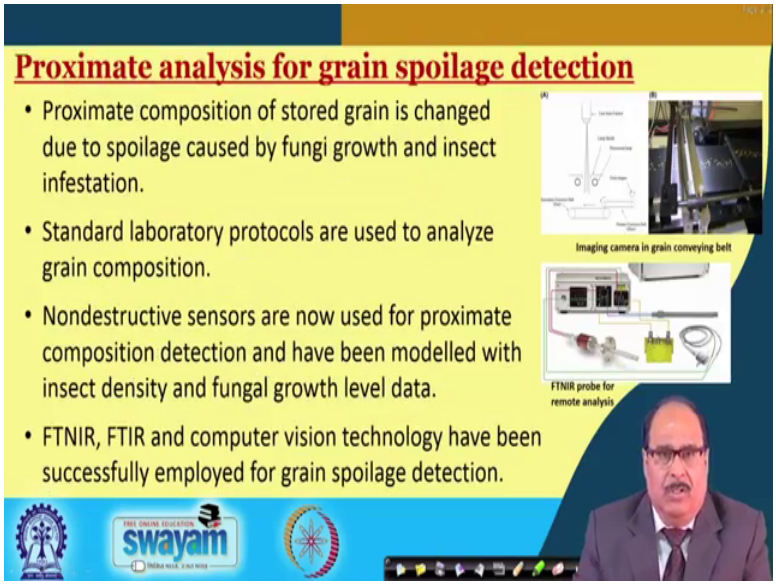

Then proximate analysis of the grain that as I told you when the grains are infested, when they are contaminated, when the microorganisms grow, they eat away that the insects etcetera. They eat away the grain, starch another components, they bring about changes in the grain and nutritional value, the protein both quantitatively and qualitatively can be changed, sugars maybe get changed that is oligosaccharides, polysaccharides, etcetera.

So, the changes in their proximate the fat, another tent that is the proximate value like moisture, protein, fat, ass and carbohydrate of the fresh grain and its intergrain may be different from those of the spoiled grain and all these sets are there that is a standards of the what is the at below, what level like in the if the grain, it is a free fatty acids are in the oils, fat, triglyceride level, it deteriorated trifid acid goes beyond a certain level the grain can be considered that is spoiled.

Similarly if the moisture content increases beyond a certain level, then the it becomes that is a good vector grain that is a microorganism sector. Like for example, that is a 14 percentage the safe storage moisture content. So, the sugars which are present in the form of a starch in the grain so, the microorganism they cannot it will consume that starch, but when grain moisture content increases to more than 16 percent starch role. If starch is hydrolyzed into glucose, and then this glucose can be easily consumed by the

microorganism's right, and then various product like alcohol and other products are formed.

So, the change that is the starch composition is changed, the alcohol content might be there its other characters. So, these value where there are different a standard methods, and standard analytical procedures in the earlier class, we have seen the earlier lecture. We have seen that FTIR and FTNIR methods or other methods, they can be used to find out that is the quickly determined are using laboratory techniques, they can be determined and this will give a good idea indication of the quality of the.

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In then detection of insect and the level of the infestation, there are various methods in the entomology alright. There are different traps which are available now for use, for the detection and identification of the insects etcetera. Like pit fall traps, TNAU insect trap, TNAU insect removal bins that is these are used with the insects can be removed. And then these bins can be used for quantification of the level of infestation that is the amount of insects present in the grain Then pheromone traps, bucket insect trap UV-light traps, barlese funnels so, all these traps etcetera, they can be used to detect the infestation level.

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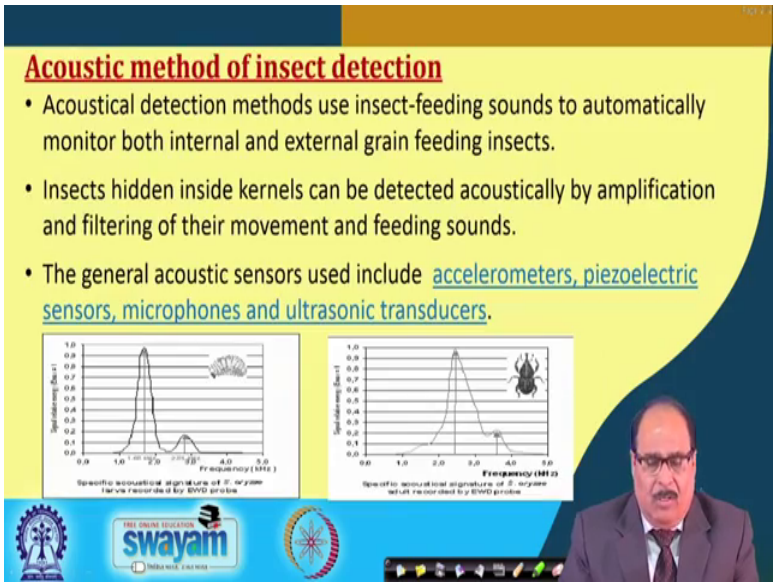

Then acoustic methods are there which are even some agencies, they use it or which has a good potential of use for detection of insect which are infestation level, due to insect in the grain. You know that whatever when there is a this acoustical detection methods use insect-feeding sounds to automatically monitor both internal as well as external grain feeding insects.

Insects hidden inside kernels can be detected acoustically by amplification and filtering of the movement and feeding sounds. The general acoustic sensors, which are used may be accelerometers, piezoelectric sensors, microphones, ultrasonic transducers etcetera that is so this some sound, they attract the insects. And the insects may come out from their hidden places inside the grain and they can be detected.

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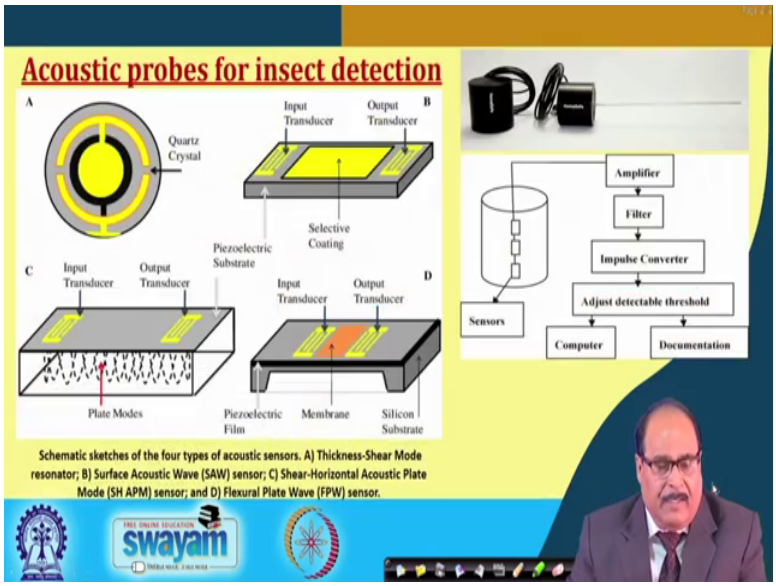

The different acoustic probes for insect detection are there like thickness shear mode resonator or surface acoustic wave sensor, shear horizontal acoustic plate mode or flexural plate wave sensors and so on that is these different sensors are available which are uses can be used.

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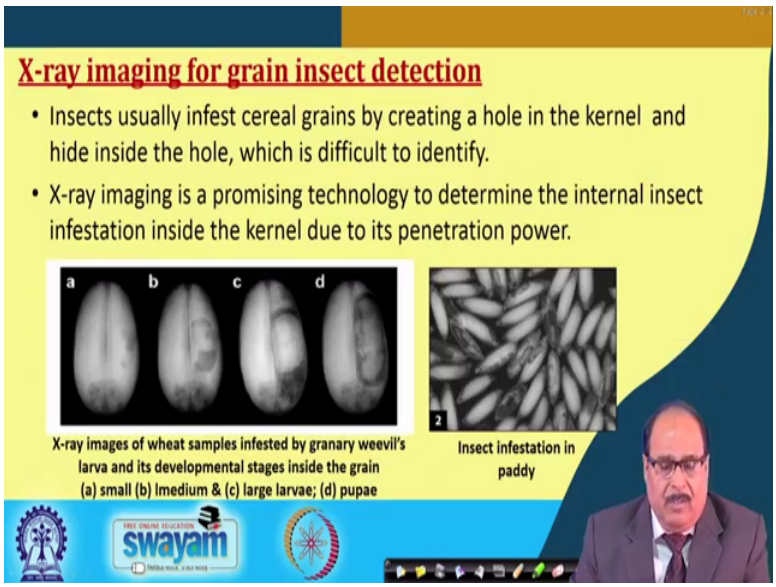

Then we studied in the earlier class hyper spectral imaging. So, this X-ray imaging which works in the similar principle, but, in the hyper spectral imaging normally, we take the image and the surface of the grain. X-ray because of its penetration power, it can take

the image inside the grain. So, normally what happens, when they insects they attack the grain, they make hold the infest cereal grains and make holes, and they reside inside the [ho/hole] hole. So, by sometimes if you see from outside, they are not visible.

So, X-ray imaging facilitates the even inspection of the infestation that is the hidden insects, which might be hidden inside. The grains in the holes etcetera, they can be evaluated ok. It is a promising technology to determine the internal insect infestation inside the kernel ok.

So, in this picture you can see that is different which are a, b, c, d here that is by x-ray imaging that is the X-ray pictures or X-ray images, so that the even there is small larva or medium larva, then large sized larva, and finally once develops into pupae. So, even different stages of the insects different life stages can be found out insect infestation in the paddy etcetera. Similarly, you can see here all this by X-ray imaging one can identify.

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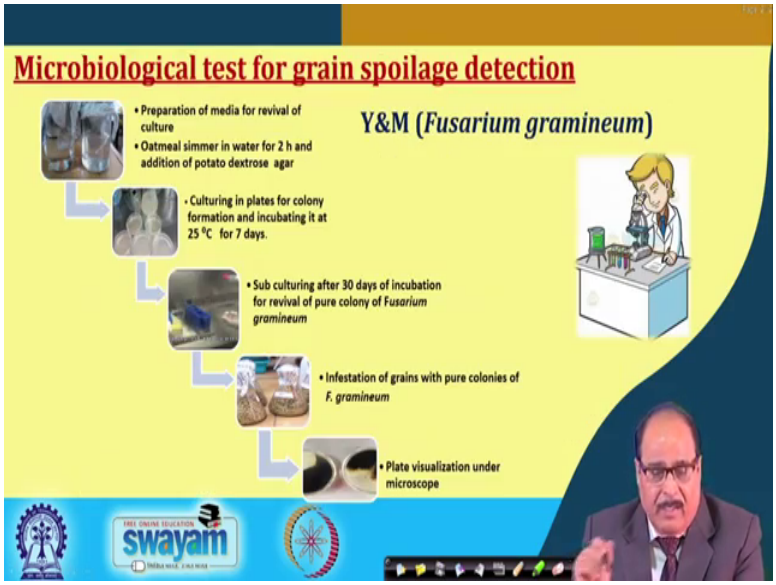

Then there are different microbiological tests which we one can perform that is in this case that is the eastern mold that is fusarium, gramineum, identification. Similarly, different these are the standard laboratory protocols are there like, preparation of media culturing of the bacteria, in inoculation, then incubation and finally counting the colonies bacterial colonies, mold colonies so on or even now there are various sensors that is our microorganism detection kits etcetera.

There is this inserts, they can detect which is based upon the Nano sensors etcetera. They can even identify or quantify the microorganisms represent and they can be used for detection of the spoilage.

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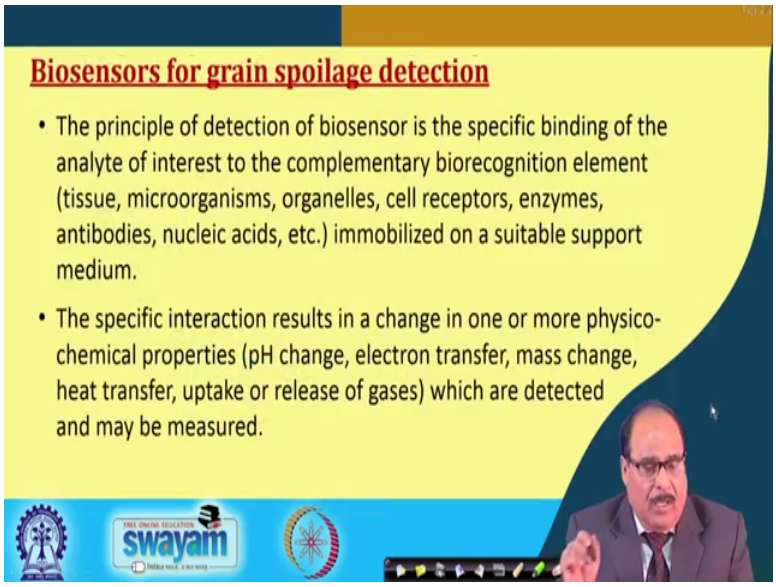

When the biosensors, I told you that for the grain spoilage detection, the principle of detection of bio sensor is the a specific binding of the analyte of interest to the complimentary bio recognition elements like tissue, microorganism, organelles, cells receptors, enzymes, antibodies, nucleic acid etcetera. All this they can be immobilized on a suitable support suitable medium and then can be sensed.

A specific interaction results in a change in one or more physico-chemical properties like pH change, electron transfer, mass change, heat transfer, uptake or release of gases etcetera which are detected, and they can be measured by using these biases are so the particular property are that is a component etcetera or even change in the characteristics or properties, they can be detected and analyzed using biosensors.

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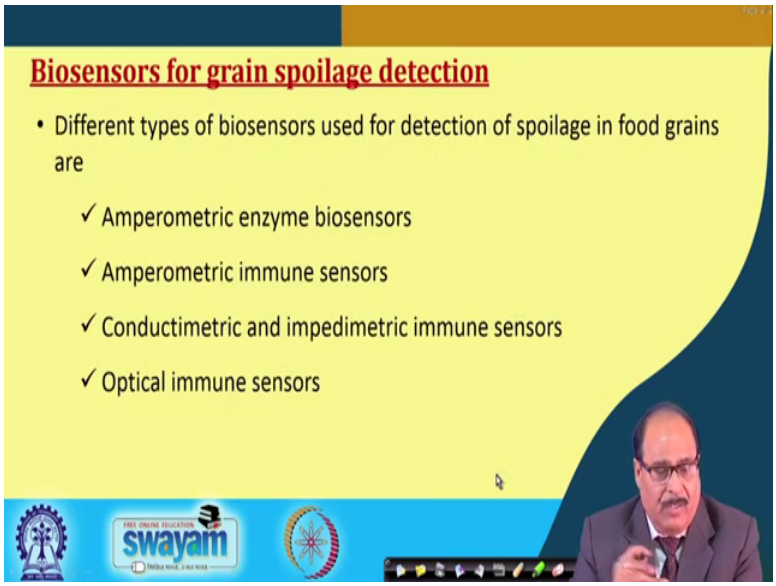

Different biosensors which are available for grain spoilage detection they may be amperometric enzyme biosensors or amperometric immune sensors, conductimetric and impedimetric immune sensors or optical immune sensors and so on.

So, friends I know, so you have seen that there are different ways by which one can different methods, which one can detect the what, ultimately you have to take the sample, you have to evaluate for a particular observed quality and see. And this can be done in both ways that is the one; that you if you have a spoiled sample using the visible change in the quality, one can go and find out what might be the problem, why this is spoilage occurs.

So, accordingly the conditions that particular conditions can be r factor that is causative factors can be controlled. So, this methods of course, therefore there might be some variations in the depending upon the conditions, depending upon the grain its components, and all those things. So, obviously these need to be standardized for grain to grain, for one food to other foods.

And in the literature many standard practices are available, and one can develop these practices depending upon ones requirement, but these become that is the analytical use of different analytical and measurement techniques may be physical measurement, online measurement or chemical measurements etcetera are the attributes as well as the changes which are brought into that would may be color change, flavor change and all those

things gives a quite a good idea about the status of the spoilage of the grain. So, this should be taken care of the purpose is that is the conditions should be maintained that. So, as to make sure that the life of the material is increased, and these undesirable changes do not take place.

Thank you very much.