Post-Harvest Operations and
Processing Fruits, Vegetables, Spices and Plantation Crop Products
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Lecture – 25
Cut Fruits and Vegetables: Part II

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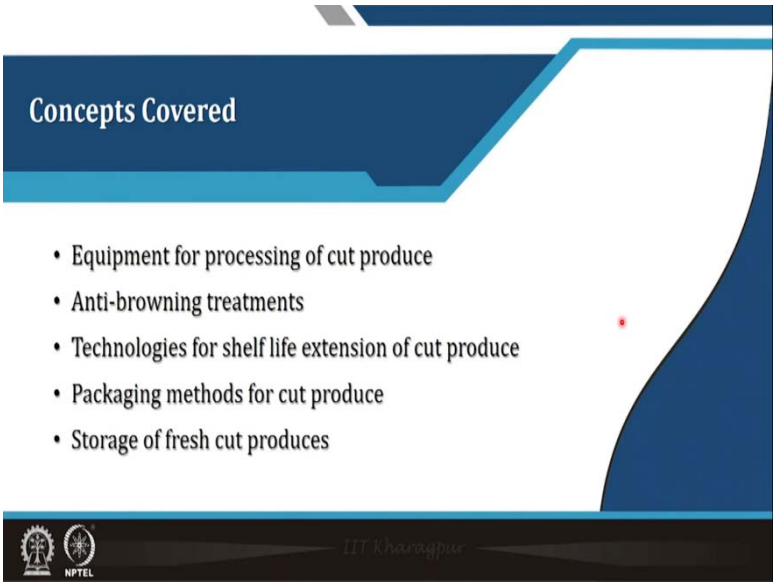

Hello everybody, namaskar. In this lecture, second part of Cut Fruits and **V**egetables, we will discuss the equipment for processing of cut produces, anti-browning treatment, technologies for shelf life extension of cut produces and the packaging methods and storage of fresh cut produces.

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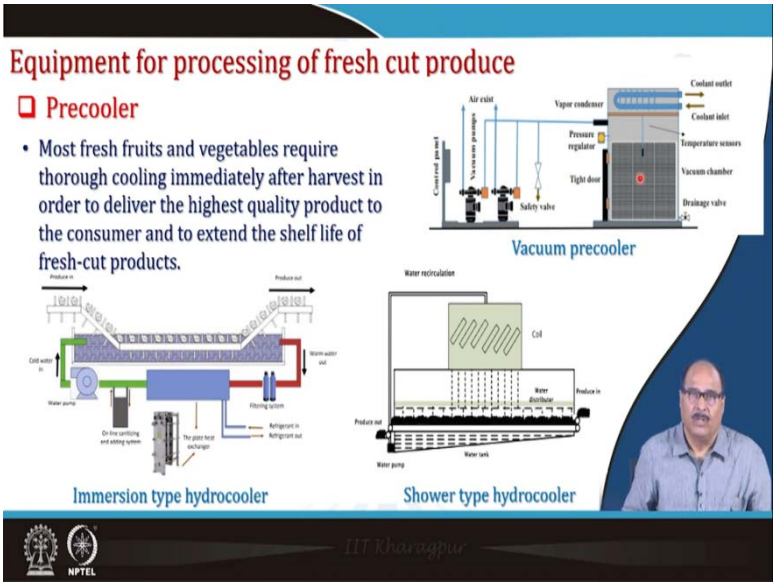

So, equipment, the operation process we studied in the earlier lecture. So, the various equipment that is the pre-cooling. So, you can say that the immersion hydrocoolers or shower type hydrocooler or vacuum pre-coolers. These are the equipment used for pre-cooling of the produce before it is sent for slicing or cutting operations.

Even details also, how this system works in earlier classes, we had discussed that the principle of mechanical operations and principles of these equipment. So, in the immersion cooling, there is basically the fresh produce comes in the form of some suitable conveyor belts and it is immersed in a cooled water which contains some sanitizer, sanitizing agent or even that disinfecting agents, anti-browning agents, etc

Then for a particular time, depending upon the commodity and it is taken out. Then the heat transfer takes place that is the material get cooled and the water may become warm then water goes to the heat exchanger and then it is further cooled out and it is recirculated. So, in shower type hydrocooler that is here, the cold water is just sprayed, sprinkled on the commodity. And in the vacuum pre-cooler, there is a vacuum chamber i.e. commodity space where product is pre-cooled by the the condenser.

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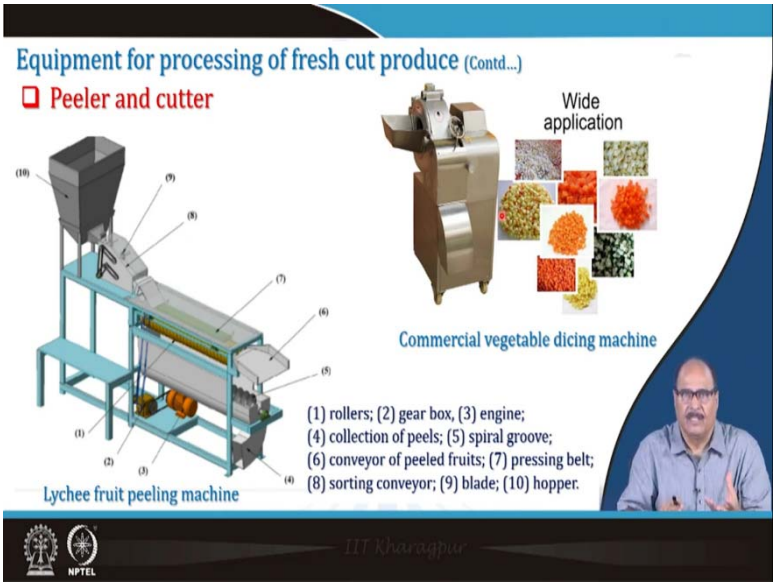

Then peelers and cutters, you can see these machines are here. That is one lychee fruit-peeling machine is shown which has various components like rollers, gearbox, engine and collections of peels. So, it is basically provided with the conveyor and also the spiral which is containing spiral grooves, so, the material comes with these hoppers comes inside the spiral groove and basically by this rubbing action the peels are removed.

Peels are collected in the belt here. It is conveyed and the peeled fruit is collected separately. This is a sort of very popular commercial vegetable dicing machine, where the different types of cutting devices are there internally. It may cut into different shapes and sizes, cubes, dice and so on.

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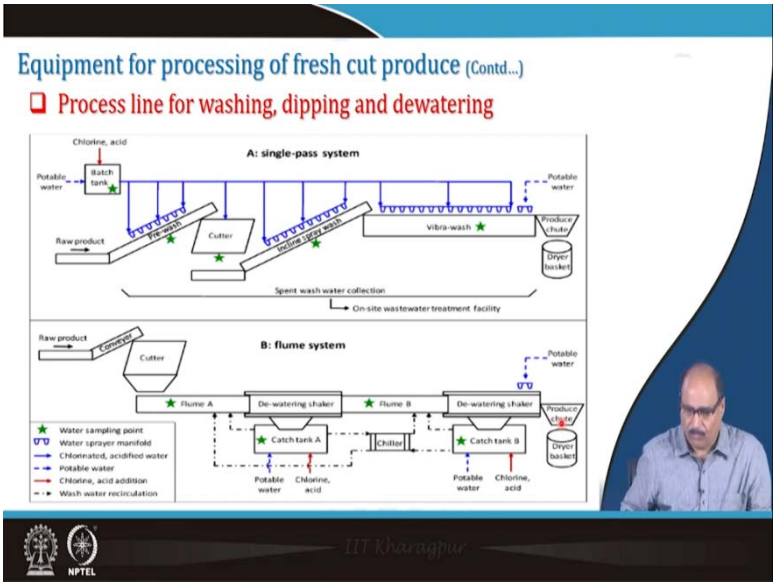

This is the process line for washing, dipping and dewatering of fresh cut fruits and vegetables, may be a single pass line. Here you can see that the raw produce comes and it is a portable water which containing some appropriate amount of chlorine or acid etc. So, it is sprinkled here and the commodity is washed. And after that it is sent for the cutting operation and cut vegetables. It is a basic conveyor. It is inclined spray wash.

So, the material is going there and then the water is spread here and after that it comes vibra wash. Vibra wash where it is by abrasion, the material is removed then produce chute and the spent wash water comes. So, this is the single line.

And then there may be a flume system in which the raw product comes conveyor belt, this is a cutter and after cutting it comes a flume A, where a portable water and chlorine and acid mixed with it. Here, product is dipped then it comes to flume B. Here the same operation is done and finally the surface water is removed and the product chute. So, these are the processing line for washing, dipping and dewatering of fresh produces.

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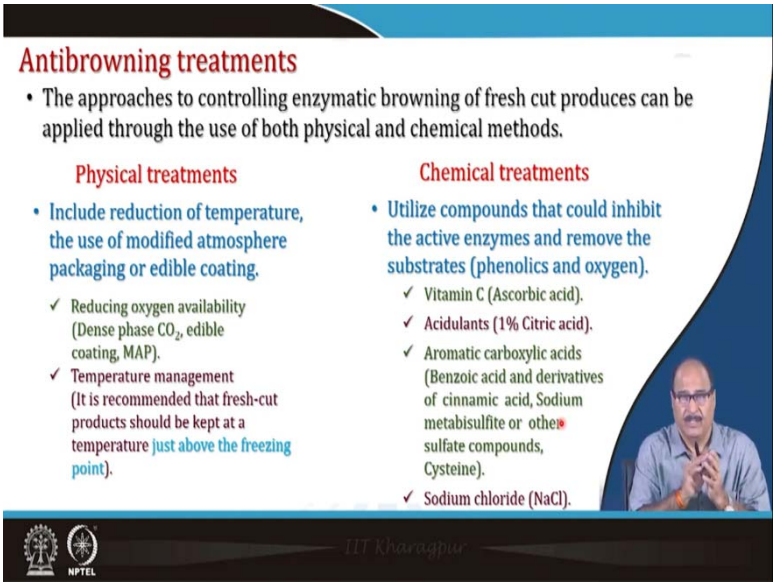

Anti browning treatment. In the earlier class we discussed in detail. It is very very important aspect. It may be physical treatment as well as chemical treatments. That is the along with the washing, that they should be dipped in various chemicals or by physical treatment by reducing the availability of the oxygen or temperature management. And it is recommended that fresh cut products should be kept at a temperature of about just above its freezing point. So, that to avoid any form of enzymatic action or browning.

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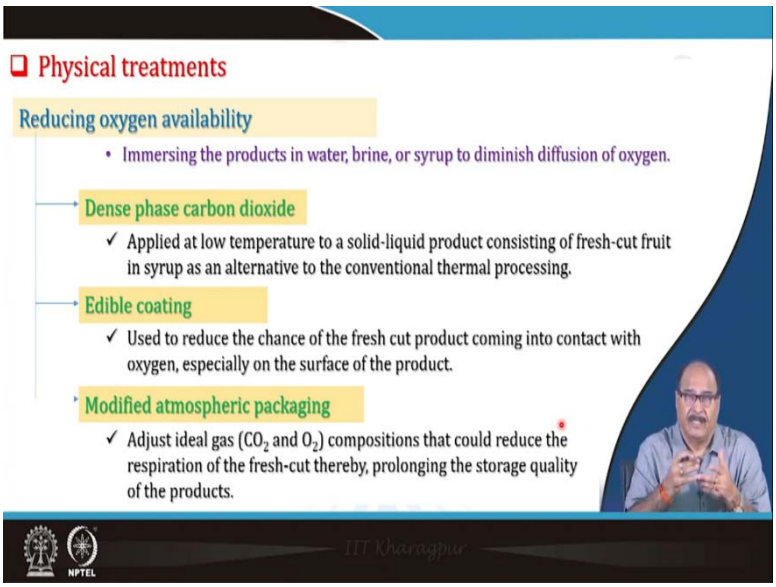

So, reducing the oxygen availability, physical treatment may be immersing the product in water, brine, syrup to diminish diffusion of oxygen, dense phase carbon dioxide, applied low

temperature in a solid-liquid product consisting of fresh cut fruits in syrup as an alternative to the conventional thermal processing. Or even edible coating or modified atmosphere packaging is used and which eliminates the contact of the commodity with the oxygen and enzymatic activity is reduced. So, these are the 1 way of reducing the oxygen availability.

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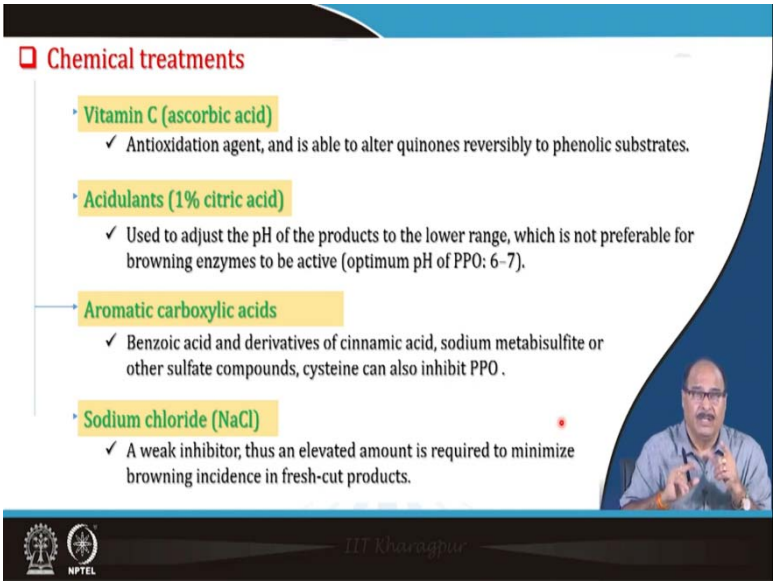

And then the chemical treatment like vitamin C, vitamin C is a very well-known antioxidant. So, it reduces the oxidative process. Then acidulants, for example, 1 percent citric acid dip. It is used to adjust the pH of the product to a lower range and which is not preferable for the browning enzymes to be active. Then by citric acid dip, the pH is brought lower and the enzyme is not able to act.

Similarly, aromatic carboxylic acids like benzoic acids and their derivatives cinnamic acid, sodium metabisulfite etc, they are dipped, so that the enzyme activity is inhibited. Sodium chloride very common, even in the case of potato chips making and potato slicing where sodium is commonly used for brine solution, 1 percent or 2 percent brine solution. It is a weak inhibitor, thus elevated amount is required to minimize browning incidence in fresh cut products.

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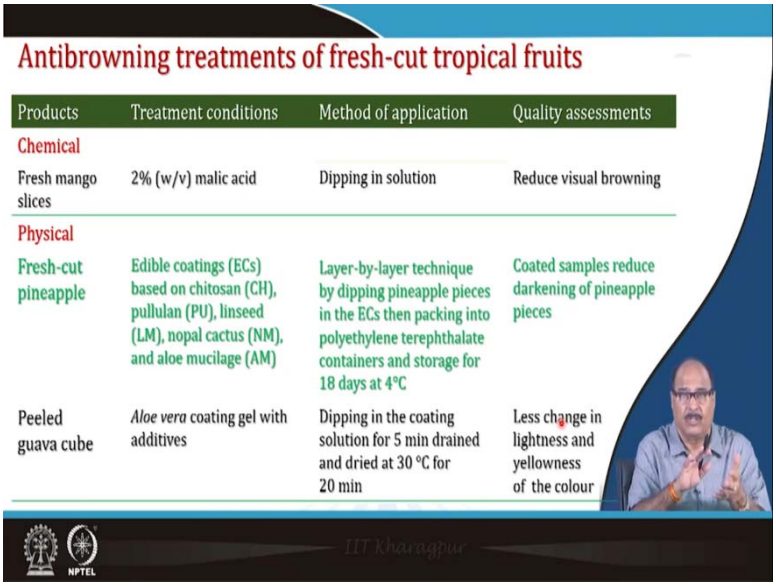

These are the some of the fresh cut products that is the anti-browning treatment for the fresh cut tropical fruits. That is chemical treatment in the raw mango slices, 2 percent weight by volume malic acid treatment is given. In the solution, slices are dipped and it reduces visual browning.

In the peeled guava cube, the treatment method is aloe vera coating gel with additives. And in this coating gel, the peeled guava cubes are dipped, that is dipping into the coating solution for about 5 minutes and then draining the solution and drying at around 30°C for 20 minutes. So, it results in less change in lightness and yellowness of the color.

Similarly, in the fresh cut pineapple, the edible coating, that is the coating based on chitosan, pullulan, linseed, nopal cactus and the aloe mucilages and here layer-by-layer deposition of the coating material is done and obviously coated sample reduces the darkening of pineapple pieces.

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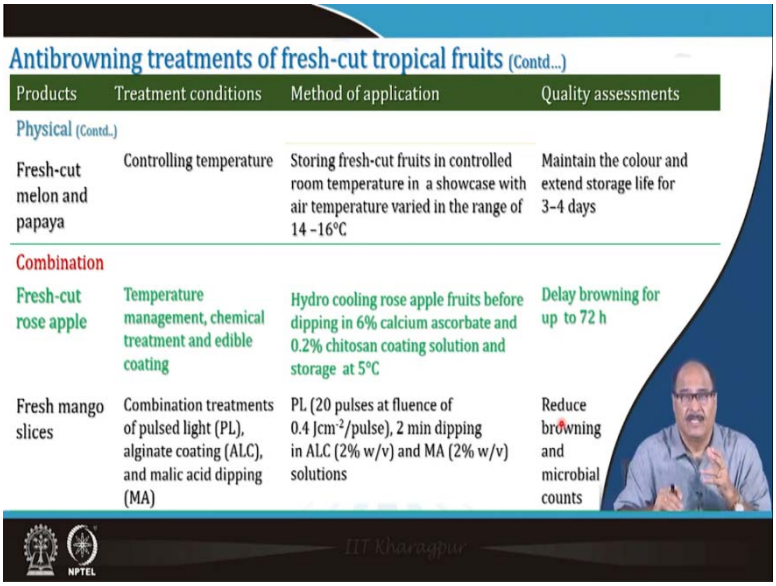

Similarly, in the fresh cut melons and papaya, the controlling atmosphere is a recommended method and it maintains the color and extended the shelf life for 3-4 days. The combination method of physical as well as chemical for fresh cut rose apple is recommended. the temperature management, chemical treatment and edible coating, all these three delayed the browning for about 72 hours. Fresh mango, the pulsed light and 2-minute dipping in the alginate coating solution and malic acid about 2 percent weight by weights solution are the combination treatment, it reduces browning and microbial count in the fresh mango slices.

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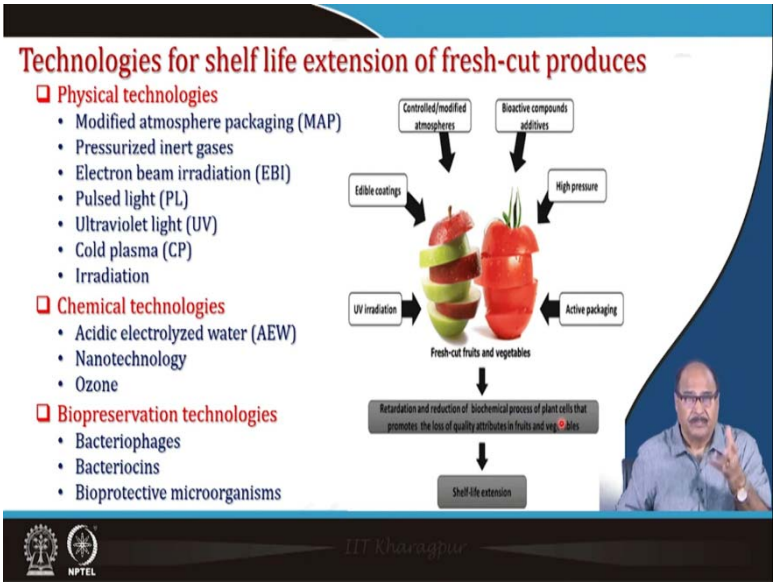

Technology for the shelf-life extension, again, that is the physical methods like modified atmosphere packaging, pressurized inert gas, then electron beam irradiation, pulse light, ultraviolet light, cold plasma, irradiation. Chemical technologies like acidic electrolyzed water, nano technology, ozone treatment. Or biopreservation techniques like bacteriophages treatment with bacteriophages, bacteriocins or bioprotective microorganism. These can be used for the shelf life extension of fresh cut produces. In fact, many of these we had discussed earlier.

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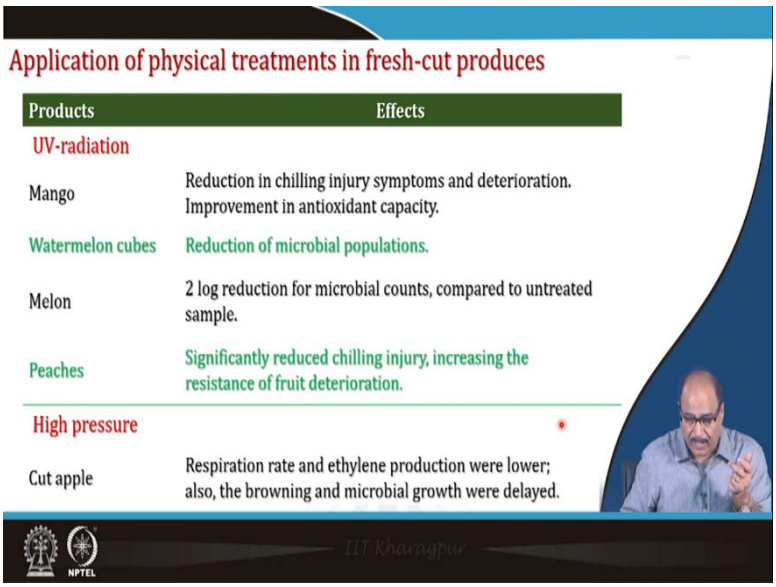

So, I will take up just that is principle of operation of these methods. So, you see that some product that examples we will show here. UV radiation, when mango cut products treated with

UV radiation, there is a reported in reduction in chilling injury symptoms and deterioration and it improve the antioxidant capacity.

Even melon cubes, UV radiation is reported to reduce 2 log microbial counts and compared to untreated samples. In case of peaches there is significantly reduce chilling injuries, increase the resistance of root deterioration. High pressure is reported to reduce the rate of respiration and ethylene production in the cut apples and the accordingly the browning where rate were delayed.

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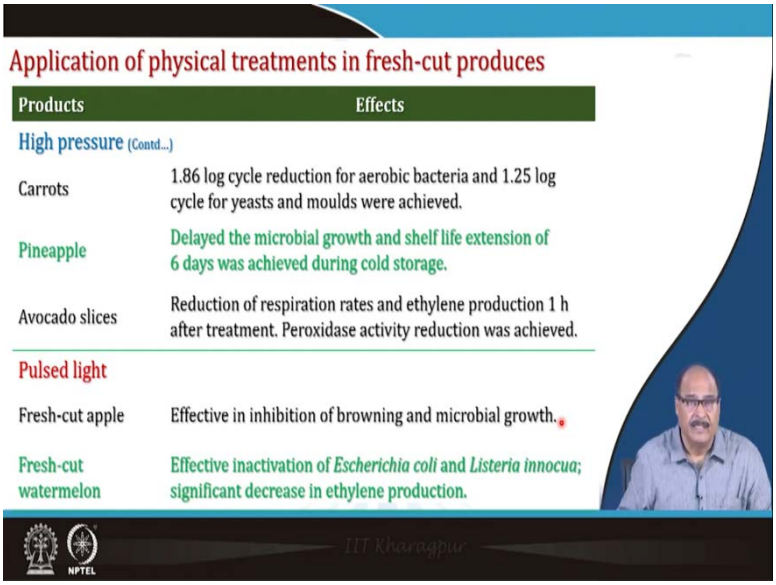

Similarly, in the case of carrots, high pressure is reported to reduce 1.86-log cycle the aerobic bacteria and 1.25 log cycle yeast and moulds. In pineapples, high pressure delayed the microbial growth and shelf-life extension was there up to 6 days. In avocado slices high pressure result in the reduction of respiration rate and ethylene production.

In pulsed light treatment, in the case of fresh cut apple, it has been found effective in inhibiting the browning and microbial growth. In pulsed light the treatment is found effective in inactivation of E coli and listeria innocua, in fresh cut watermelon. And it also resulted in decrease in the ethylene production.

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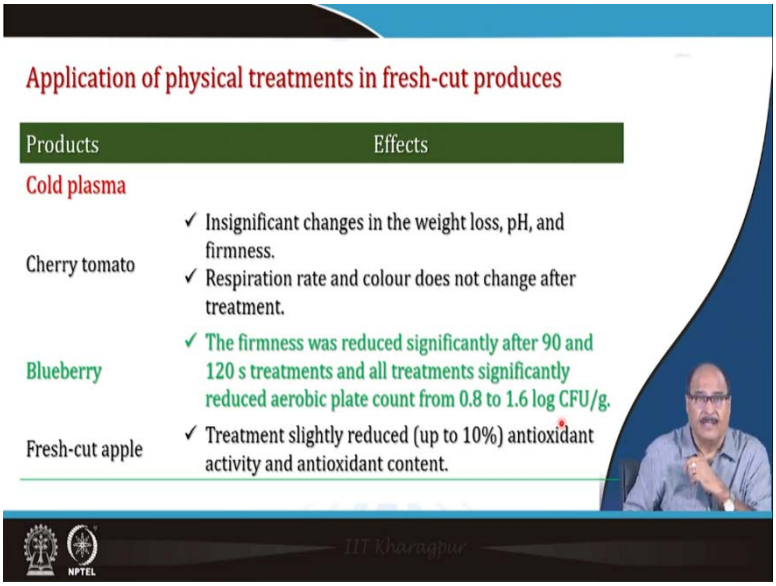

The cold plasma treatment. In the cherry, tomato it has been found although there has been no significant effect, there is no significant change in the weight loss, pH and firmness. So, the cold plasma treatment in the cherry tomato, it maintains his freshness, respiration rate and color also does not change after the treatment.

The in the case of blueberry, the firmness were reduced significantly after 90- and 120-seconds treatment and all treatments synergistically or significantly reduced aerobic plate count from 0.8 to 1.6 log CFU per gram. Cold plasma, in case of a fresh cut apple, reduced the ten percent of antioxidant activity and antioxidant content.

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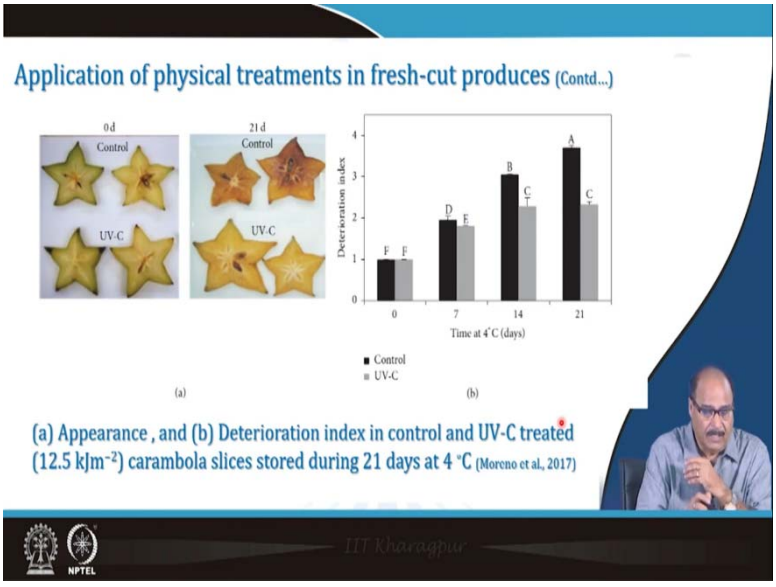

So, here, it is shown the effect of a physical treatment that is the effect of ultraviolet radiation control and UV-C radiation on the appearance and deteriorative index. That is 'a' is the effect on 0 days and after 21 days. The control sample first and then UV-C treated sample.

You see that is how it is affecting the appearance and the deterioration index also. That is, in the carambola slices, the deterioration index is reduced, even after 21 days also of the treatment. Where in the case of untreated sample, the deterioration index was high.

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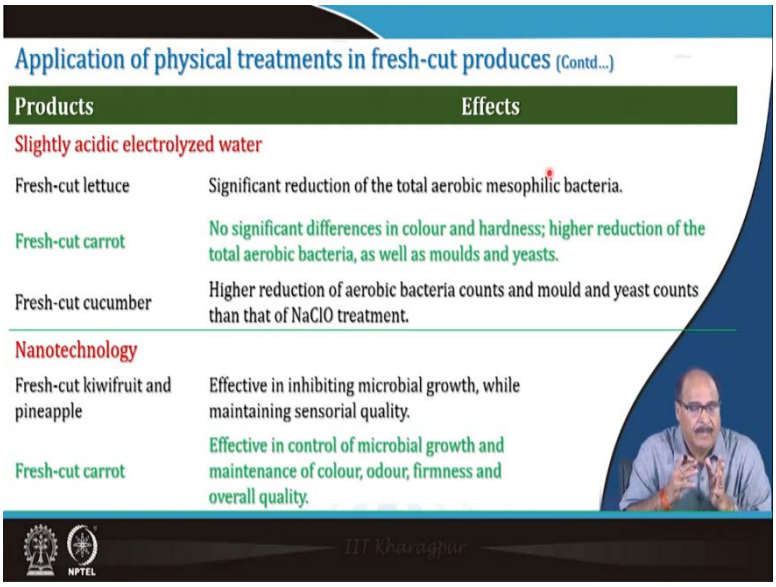

And the other physical treatment like slightly acidic electrolyzed water in the fresh cut lettuce, it is found significant in deduction of the total aerobic count. In the fresh cut cucumber there is a high reduction in aerobic bacteria count, mold count, yeast count etc. and it was found more effective than the sodium hypochlorite treatment. Even application of nano technology, nano emulsions coating etc has been found very effective in fresh cut kiwi fruits and pineapple or even in fresh cut carrots in controlling the microbial growth or in maintaining the color, firmness, etc.

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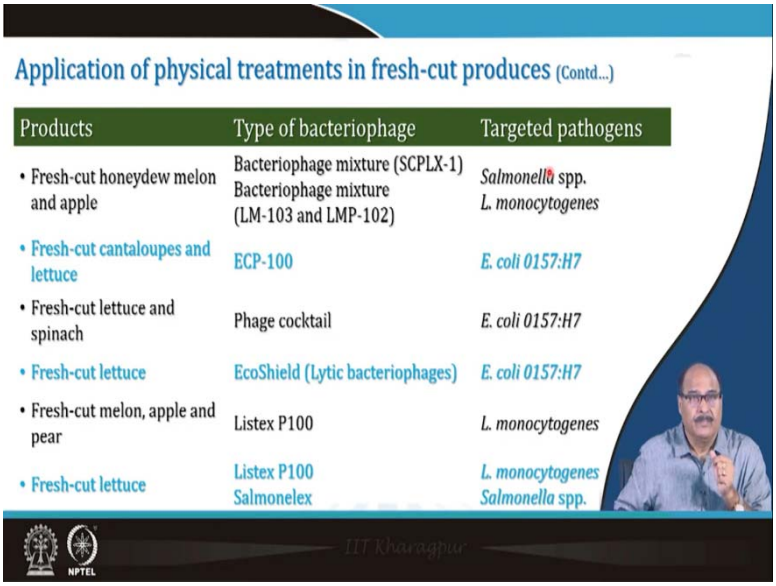

Another way of extending the shelf life is applying the bacteriophages. And there are several reports in the literature, for example, in the fresh cut honeydew melon and apple, the bacteriophage mixture SCPLX-1 and bacteriophage mixture LM-103 and LMP-102, they have been found effective against that pathogen like *salmonella* and *L monocytogenes*. In fresh cut lettuce and spinach phase cocktail has been found effective against *E coli.*

In fresh cut lettuce that EcoShield that is lytic bacteriophage has been found again effective against *E coli*. Or in fresh cut melons, apples and pears this Listex P100 bacteriophage, it is found effective against L monocytogenes. So, even there were various several bacteriophages available which can be applied and these bacteriophages, these are basically the viruses which eat away the undesirable bacteria and therefore help in increasing the shelf life of fruits and vegetables.

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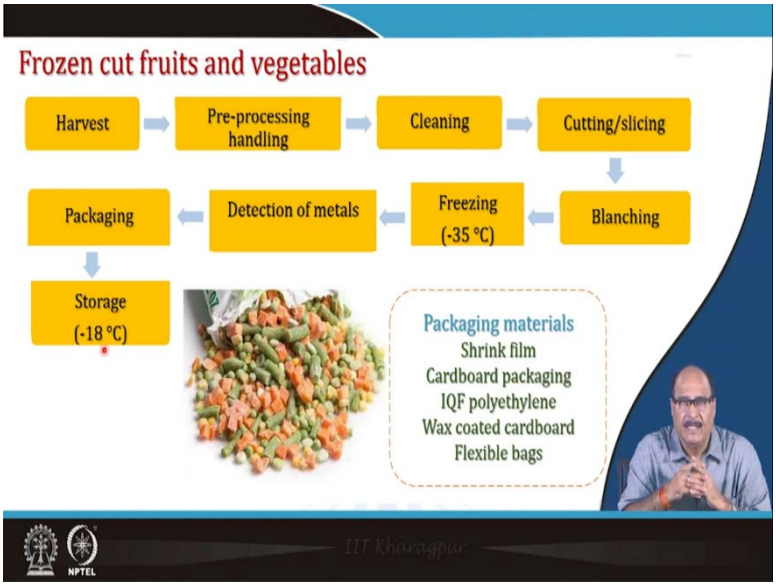

Then frozen cut fruits and vegetables, the process technology include the harvesting after that preprocessing and handling, cleaning, cutting, slicing, blanching, the freezing, detection of metal, packaging and storage at minus 18 degree Celsius. There is freezing operations, at low temperature, all the water present in the material in the fresh cut produce is frozen and converted into ice and then this frozen is appropriately packed and after that it is stored at minus 18 or minus 23°C.

So, this freezing technology will discuss with the cold technology of freezing module. So, that is an important aspect frozen material and it keeps for the longer period of time. So, the different packaging material for these frozen products are recommended like shrink film, cardboard packaging, IQF polyethylene, wax coated cardboard, flexible bags and so on.

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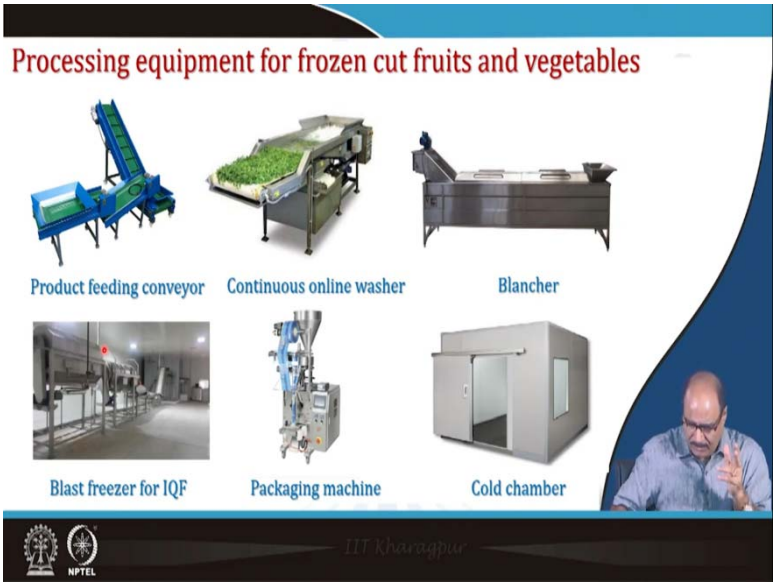

These are the equipment, possible processing equipment for frozen cut fruits and vegetables. In the continual line, these are the minimum equipment we are suggesting. They are very standard. It is being easily available like feeding conveyor, continuous on-line washing machine, then appropriate branching system.

And after that the material can be directly converted to the blast freezer for IQF individual cook freezing or any other suitable freezing system can be used that from this freezer it comes with a packaging, which is again done in the low temperature environment. And then the cool chamber that is where the minus 18 degree or minus 23 degree celsius temperature is maintained and the commodity is preserved stored in that.

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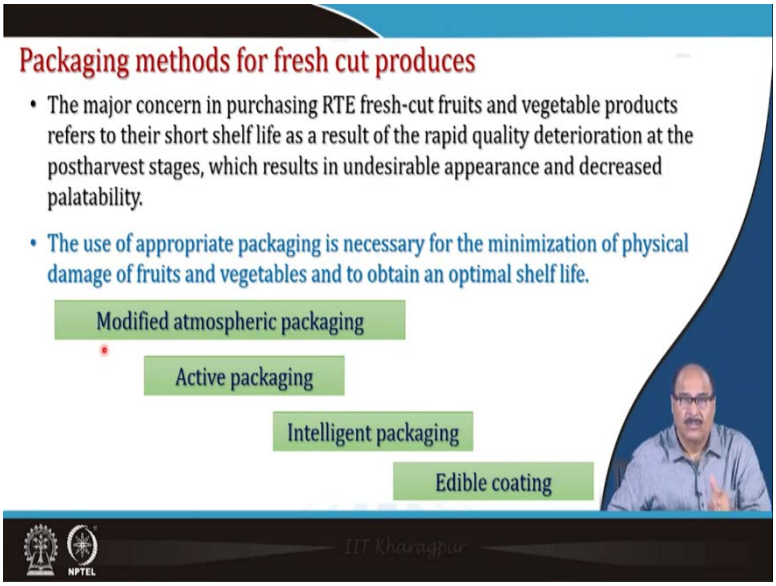

The packaging is very important aspect of the packaging method, packaging of fresh cut produces. Because as I told you in the earlier lecture also we discussed that you are removing the natural protective covering to the fruits and vegetables, at the same time you are increasing the surface area, more area is getting exposed to the environment. So, here rate of deterioration, it will increase sharply.

The rate of respiration, even, the contamination with the microorganism, contamination with oxidation reaction, very other biological reaction, physiological reaction. So, very important step is that these cut produces should be properly packed with proper packaging material.

They should have appropriate properties particularly their barrier properties, barrier to oxygen, barrier to carbon dioxide, barrier to moisture vapor, barrier to light and they should have proper strength, all these things. So that, the properties like color, flavor, texture and shelf life of the commodity can be properly maintained.

So, modified atmosphere packaging, active packaging, intelligent packaging, edible coating, in earlier lectures we have discussed details about and even methodology and equipment for all these things. So, the same is applied here but with little more care. Because here you are having more surface area and so and the material is already cut. It is tender; the soft, so proper care has to be taken during this packaging.

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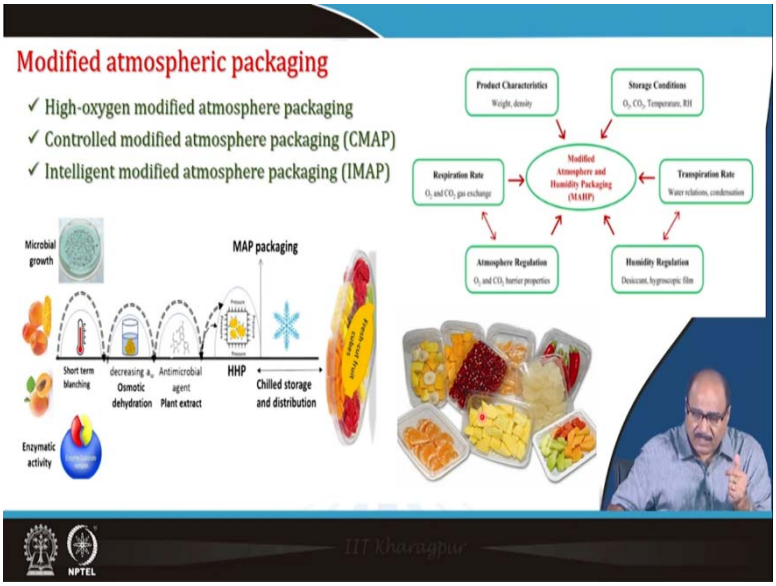

So, the modified atmosphere packaging that is high oxygen modified atmosphere packaging or control atmosphere modified atmosphere packaging, intelligent modified atmosphere packaging may be done. The main thing is that around the produce, we control the environment like O_2 and CO_2, so that, the deteriorative reactions are stopped.

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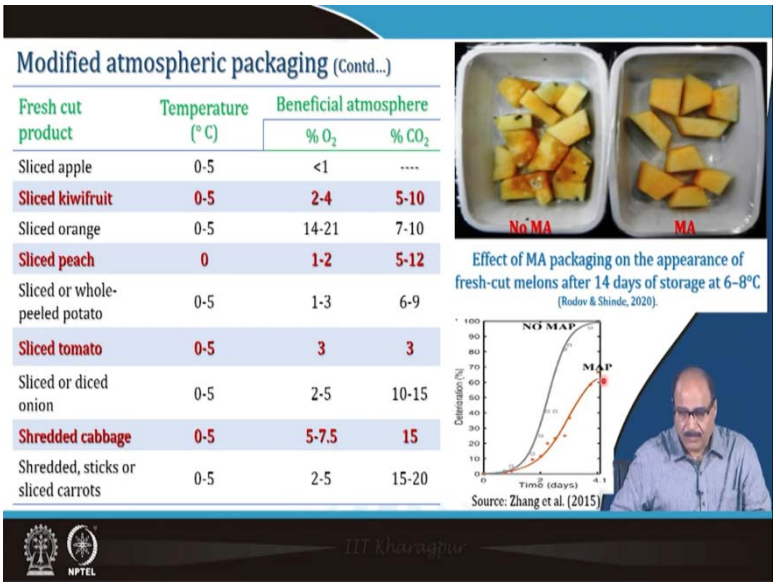

In modified atmosphere packaging, the various produces like for sliced apple, the temperature may be 0 to 5°C and O_2 less than 1 percent and CO_2 is a accordingly adjusted so this is recommended for the better proper shelf life and better quality.

In the sliced kiwi food, 0 to 5°C temperature, 2 to 4 percent O_2 and 5 to 10 percent CO_2 are maintained. So, in the most of these fruits' commodity, you can see here, whether it is shredded tomatoes, shredded cabbage, shredded sticks or that carrots, the 0 to 5°C temperature is important and in many cases 1 to 3 percent in exceptional cases, some cases 5 percent O_2 or in sliced oranges may be 14 to 21 percent O_2.

And in other cases, mostly that 10 to 15 percent CO_2. In some cases, sliced tomato 3 percent CO_2. In the sliced peach, 5 to 12 percent CO_2. So, this oxygen, carbon dioxide level and temperature should be maintained. The packaging material should be appropriate enough and system equipment, so that the desired quality is obtained. And here you can see, the effect of modified atmosphere packaging on the appearance of fresh cut melons. There is no modified atmosphere and here in the modified atmosphere, that is 14 days of storage at 6 to 8°C and you see the appearance here. Even rate of deterioration when there is no modified atmosphere, the rate of deterioration is high. In the case of modified atmosphere rate of deterioration is much less even after 14 days of storage.

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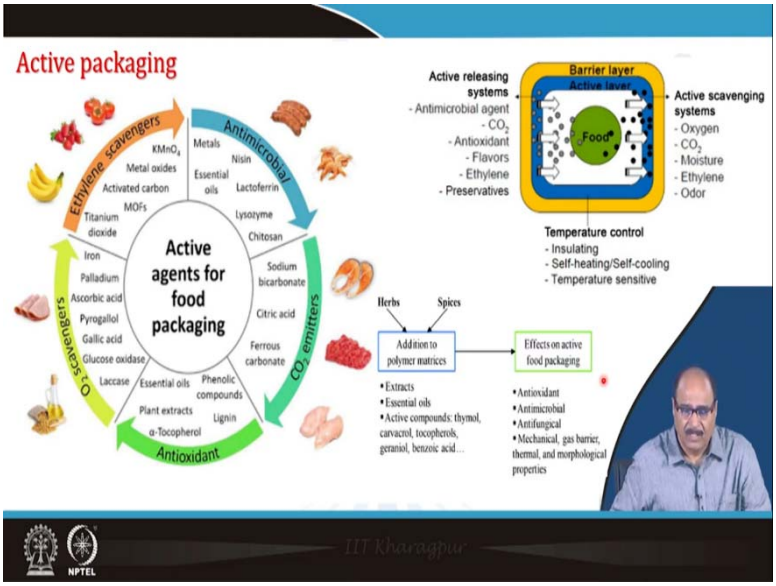

Active packaging, again, the same concept. There are agents like antimicrobial, anti-browning and all those things in details; we have discussed earlier.

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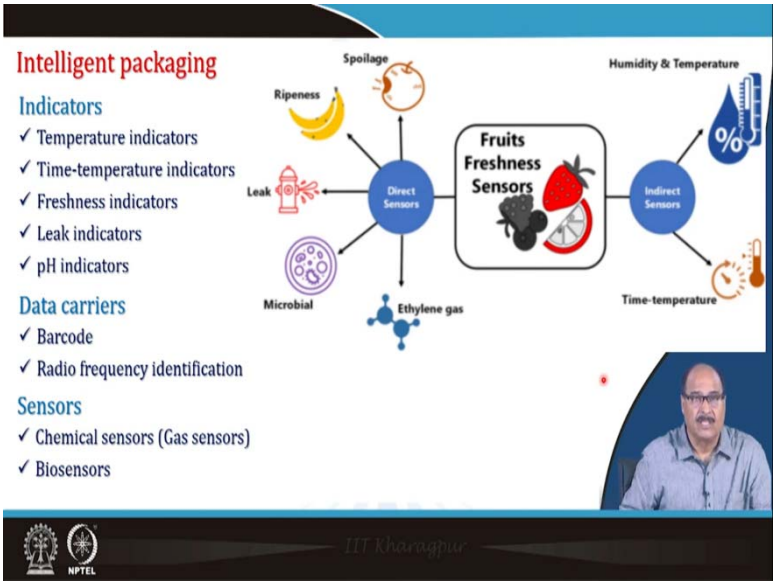

Similarly, intelligent packaging. This fresh produce are the appropriate packaging technologies which should be used to increase their shelf life. The indicators are very important like temperature indicators, time-temperature indicators, freshness indicator, leakage indicators, pH indicators, etc. Because the material inside is very active and change very fast.

So, these various indicators may be put on the packages packets, so that by this indicators will indicate where the produce is edible or not, it is safe to consume or not, it is good or it is spoiled. Because you cannot take a chance by eating this and testing this on yourself. So, intelligent packaging becomes very important. Even data carrier barcode or RF identification, chemical sensors, biosensors, etc can be used.

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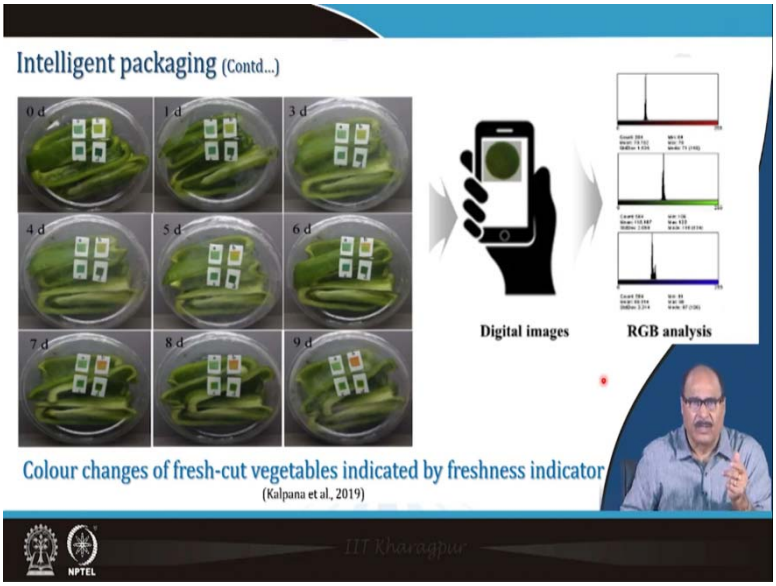

Some experimental result reported by some researchers. That is how the color change in the fresh cut vegetables is indicated by freshness indicators. You can see different color changes in the labels are there. So, they can, these are digital image and then RGB analysis is there. That is 1 example. Similarly, various TTI level indicators or freshness indicator, spoilage indicators or other color indicators, one can design any type of thing.

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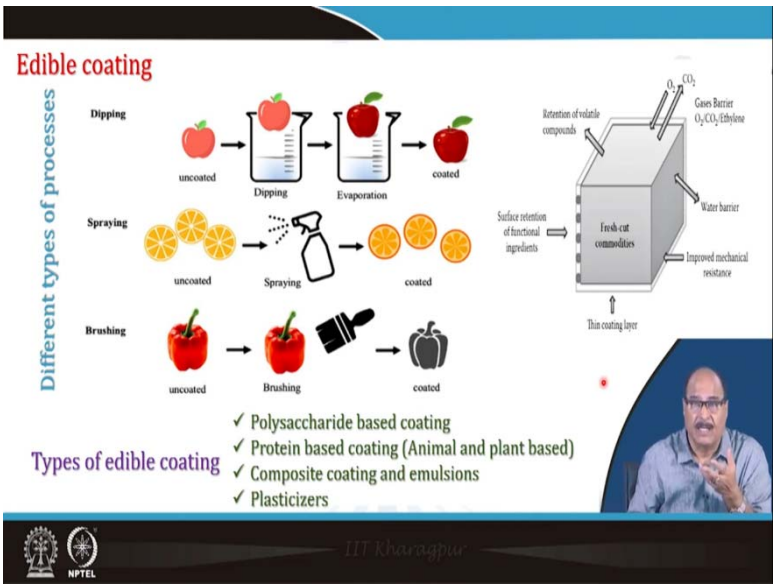

Similarly, edible coating is also important. It can be applied and then by using a dipping method or a spraying method or brushing method but in nutshell that a thin layer of the polymer is

applied on the commodity i.e. either polysaccharide based coating, protein based coating or composite coating emulsion or plasticizer.

But the coating material, it should be appropriate to properly regulate the gaseous composition and because it is very delicate and another thing is that because it is edible coating, the coating material which you are using, it should not interfere. It should match with the color and flavor and texture of the eating quality, sensory quality of the produce. So, these are some of the challenges in the case of edible coating applications.

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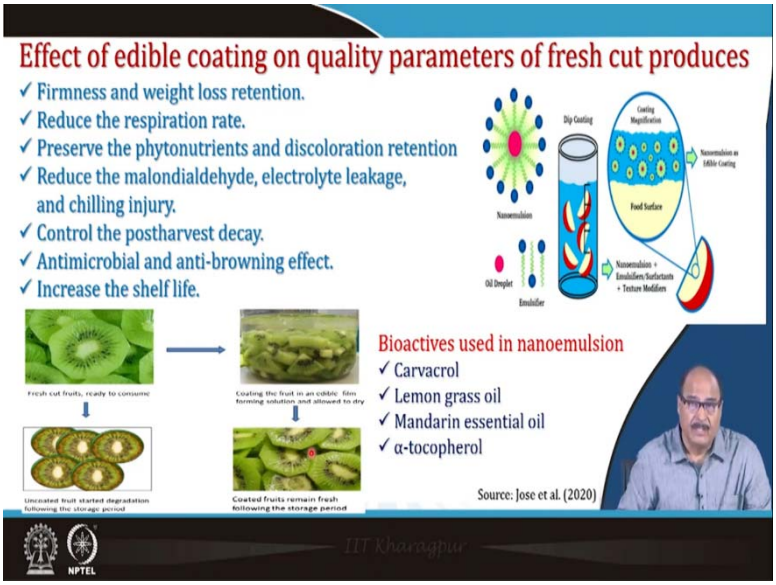

So, effect of edible coating on fresh cut produces, it may affect the firmness and weight loss retention. It reduces the respiration rate. It preserves the phytonutrients and discoloration retention or reduction of the discoloration. It reduces the malondialdehyde, electrolyte leakage and chilling injury.

It controls the post-harvest decay; antimicrobial and anti-browning effects are there and it increases the shelf life. So, edible coating has been found effective in all these aspects. Here you can see that how a fresh cut ready to consume cucumber, it is uncut fruit started degradation following the storage, whereas the coating of the fruit is applied and then it is kept even further for storage also you can see that fresh cut after storage how it is and the coated material how it improves the appearance.

So, the bioactives, even the nano-based emulsions like carvacrol, lemon grass oil, mandarin essential oils, alpha tocopherol, etc can be used for the application of the coating. But in the

coating, the type of the coating material, thickness of the materials and the gas exchange permeability, permeable properties, etc are some of the challenges which needs to be resolved.

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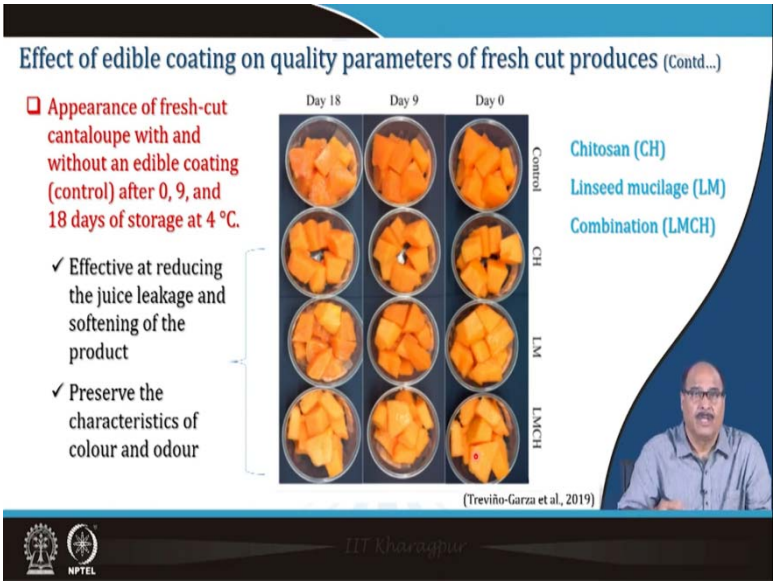

Effect of coating on the appearance of fresh cut cantaloupe, with and without the edible coating. That is after 0, 9 and 18 days of storage at 4°C. At 0 day, the first top 3 is the control sample. Then the bottom 3 is the chitosan coating, then other is the linseed mucilage coating and the combination, bottom one is the LMCH, combination of linseed mucilage and the chitosan coating. And it has been found effective in reducing the juice leakage and softening of the product and it preserves the characteristics of the colour and order. And it is even visible you can see, it has been found very effective that combination treatment, the color is almost similar to that of the natural fresh one.

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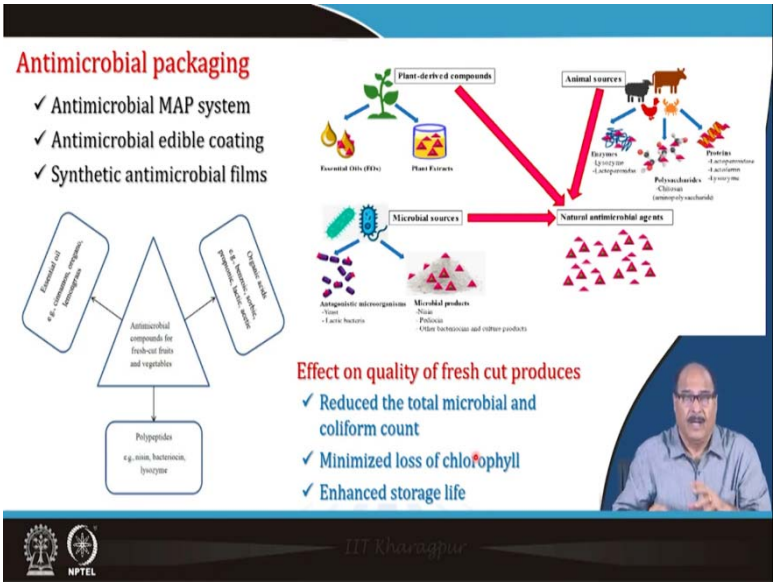

Then antimicrobial packaging, again, it is very important. In the edible coating, the antimicrobial or antioxidants can be added, even in natural antimicrobial film and in synthetic antimicrobial films.

The various natural antimicrobials are there. That is either from the animal products or from the fruits origin sector; they can be infused either in the packaging material or the edible coating material. So, the antimicrobial and antioxidant packaging system becomes very important for fresh cut produces. So, it reduces the total microbial and coliform count, minimizes the loss of chlorophyll and enhance the storage life of the produce.

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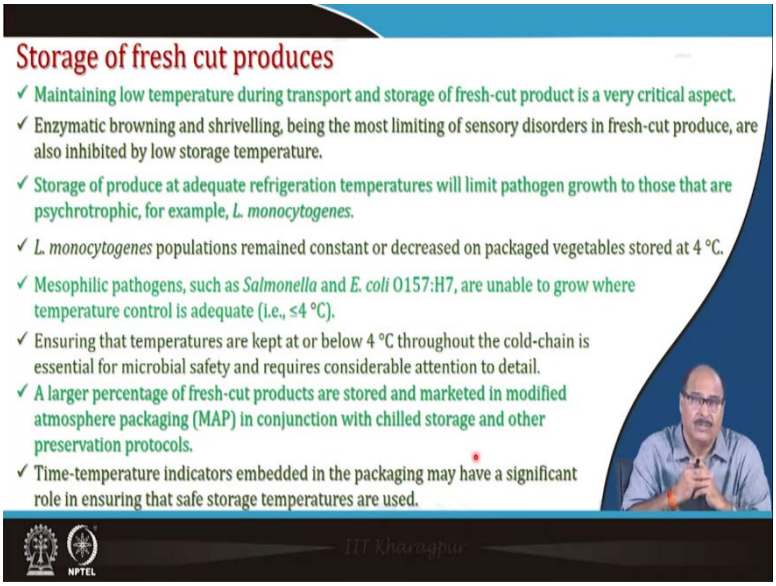

So, after the packaging, obviously, the storage of the fresh cut produces is very important. And in whole, probably in storage, in the packaging, as far as possible less than 4°C refrigerated storage, cool temperature, maintaining low temperature during transport and storage of fresh cut produce is a very critical aspect. Because by this it will able to control enzymatic browning, it will able to control shriveling or most of the sensory disorders in the fresh cut produce. They are slowed down by low temperature storage. Storage of produce at adequate refrigeration temperature even are reported to limit pathogenic microbial growth also, that is particularly those, which are of course, psychotropic.

For example, *L monocytogenes* growth will suppress, if the temperature is less than 4°C. In fact, *L monocytogenes* populations in some experiment remained constant or decreased and packaged vegetable when it is stored at less than 4°C.

Mesophilic pathogens like *salmonella* and *E coli* are unable to grow where the temperature control is adequate that is less than 4°C. Ensuring the temperatures are kept at or below 4°C throughout the cold chain is essential for microbial safety and it requires considerable attention to detail.

A larger percentage of fresh cut produce are stored and marketed in modified atmosphere packaging in conjunction with chilled storage and other prevention protocols. Time-temperature indicators embedded in the packaging may have a significant role in ensuring the safe storage temperature are used.

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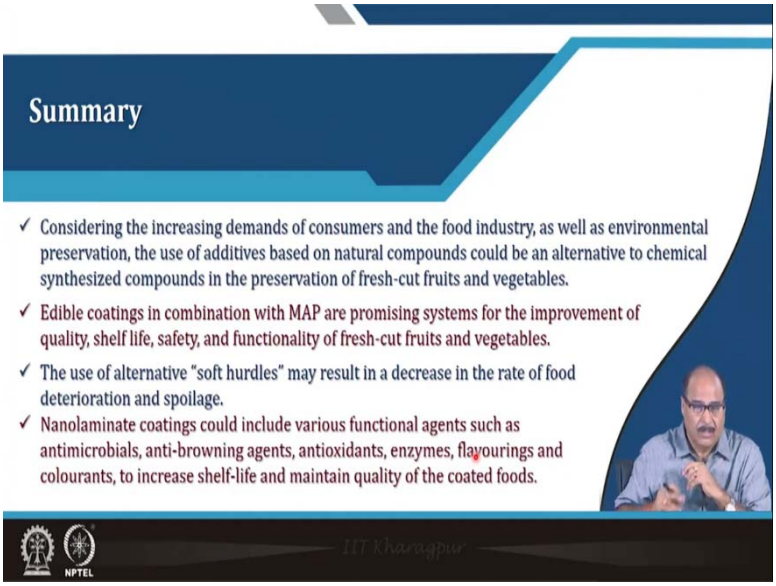

So, with this I now will summarize this lecture that considering the increasing demand of consumers and food industry as well as environmental preservation. The use of additive-based natural compound could be an alternative to chemical synthesized compound in the preservation of fresh cut fruits and vegetables. Edible coating, modified atmosphere packaging or such other system are effective and they should be followed.

And even the soft hurdle technology concept which we considered earlier, so, this should be applied a combination of coating, a combination of thermal treatment like mild heat treatment, blanching, adjustment of the pH and proper packaging and storage at low temperature, this will help in maintaining the quality of the fresh cut fruits and vegetables as well as its marketability and safety.

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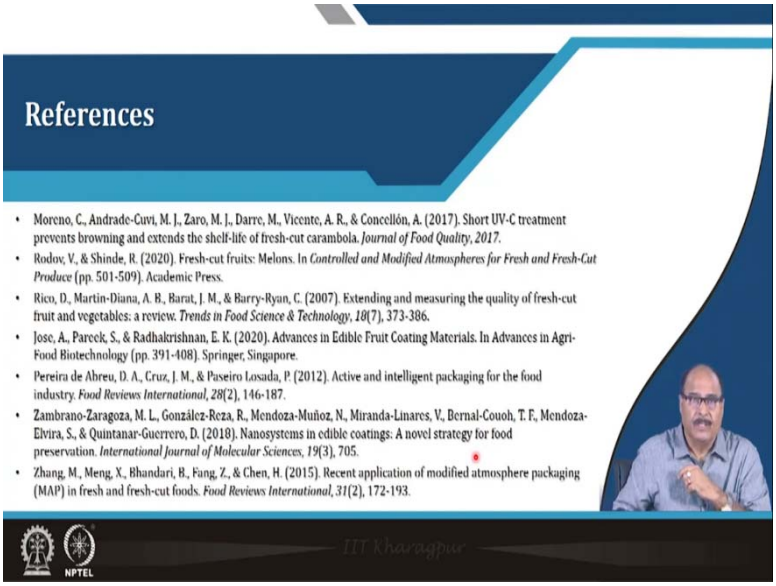

So, these are the references in this lecture. Thank you very much for your patience and hearing. Thank you.