Organic Farming for Sustainable Agricultural Production

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Lecture - 35
Antioxidant Capacity of Fruits and Vegetables

So, welcome to the lecture 35, Antioxidant Capacity of Fruits and Vegetables. So, previous lecture we have discussed about the antioxidants and the role of antioxidants in neutralizing the free radicals and what are the free radical formations takes place in human body; either due to the food habit or due to the environmental pollutions or the work pressure intense work pressures. So, there is a formation of free radicals and the role of antioxidants how to neutralize the free radicals and keep the human being healthy and to avoid from any chronic diseases.

So, this lecture will be discussing about the antioxidant capacity of different fruits and vegetables and also discuss how high the organic foods have the higher anti oxidant capacity has compared to conventional or the chemically produced food. So, that so having the organic foods it can have a better health benefits. So, if we can avoid many diseases the regular intake of the organic foods.

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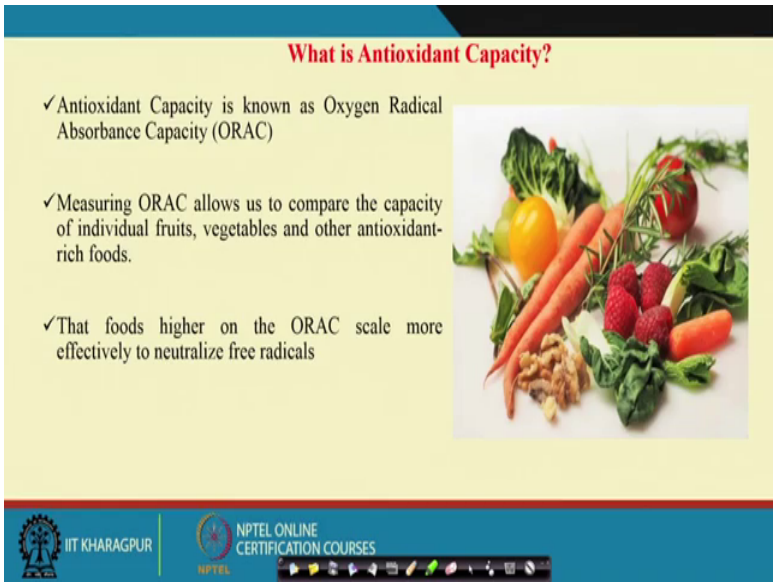

So, coming to this let us have this; what is a the antioxidant capacity. So, usually the antioxidant capacity is known as the oxygen radical absorbance capacity; that means,

there is a free radical formation takes place like the superoxides or the groups. So, how, this means oxygen radical absorbance antioxidant capacity by the antioxidants. So, that is known as antioxidant capacity that is oxygen radical absorbance capacity.

So, measuring the ORAC allows us to compare the capacity of individual fruits vegetables and other antioxidant rich foods by knowing the ORAC value. We can compare different fruits also you can compare with the organic foods with the conventional foods based on the ORAC value. That is Oxygen Radical Absorbance Capacity how to scavenge the free radicals and free radicals absorbance capacity by the antioxidants; that is the antioxidant capacity.

So, the foods that are higher on the ORAC value are the more effectively to neutralize the free radicals means, there is a free radical formations in the human body. So, if you can take the natural sources of the anti oxidants, so those are the higher ORAC value that is oxygen radical absorbance capacity. So, that can better neutralize the free radicals formations in the human body.

So, now we will discuss what is the function of antioxidants, how the antioxidants can neutralize the formation of free radicals.

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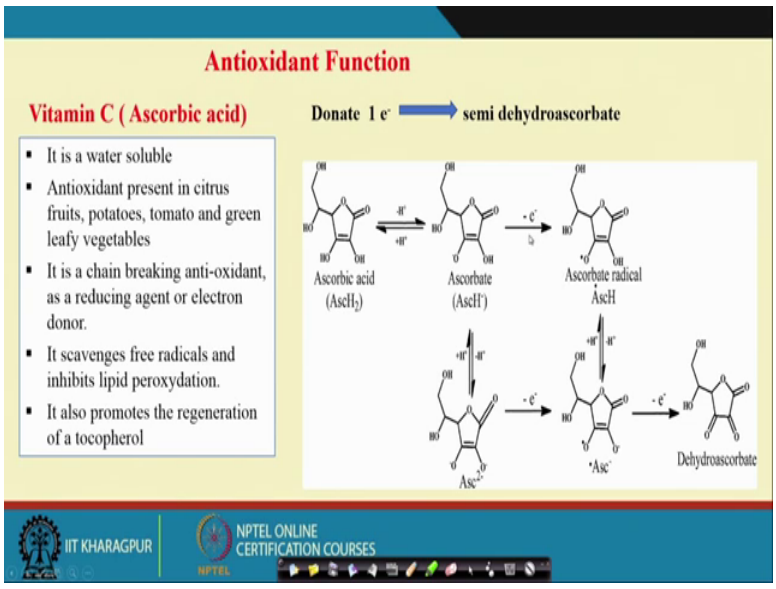

So, this is for example, one of the antioxidants that say vitamin C is ascorbic acids. So, this is a water solubles and this is the antioxidant represent in citrus fruits, say potato,

tomato and green leafy vegetables they are the ascorbic acids. It is chain breaking antioxidants as a reducing agent or this act as a electron donor because, it can donate electron and that electron can neutralize the free radical formation in the human body.

It scavenges radicals and inhibits the lipid peroxydations. It also promotes the regeneration of a tocopherols vitamin E. So, let us say so, it gives example how it can donate electron and it can neutralize draw free radical formation, as you see the chain of actions here is. So, donate one electron that becomes semi dehydroascorbate, the final the stable protocols as a by donating electron. So, this is what the ascorbic acids compounds the AscH 2. So, by releasing hydrogen this becomes the O negative that becomes asorbate Ass minus s minus and this what you can do so, this can donate 1 electron and this becomes O dot, that is the ascorbate radical. And this ascorbate radical of course, it can release this OH that can release hydrogen ion that become again the O minus and this also this can release the 1 electron. So, that becomes the dehydroascorbate.

And from here also chain of action here AscH minus, this also this hydrogen iron can be they can take away hydrogen ion that becomes also O minus. And here, it can be donate the electron 1 electron from this O minus that becomes the O O dot AscH minus. So, by this chain of action so, this ascorbic acid it becomes a stable product dehydroascorbate. And in this process this ascorbic acid that donates many electrons and these electrons are utilized for neutralizing the free radicals, as we discussed the earlier class there is a formation of free radicals either the superoxide OH radicals RO radicals, so those radicals can be neutralized so, having electron from these antioxidants like the ascorbic acids.

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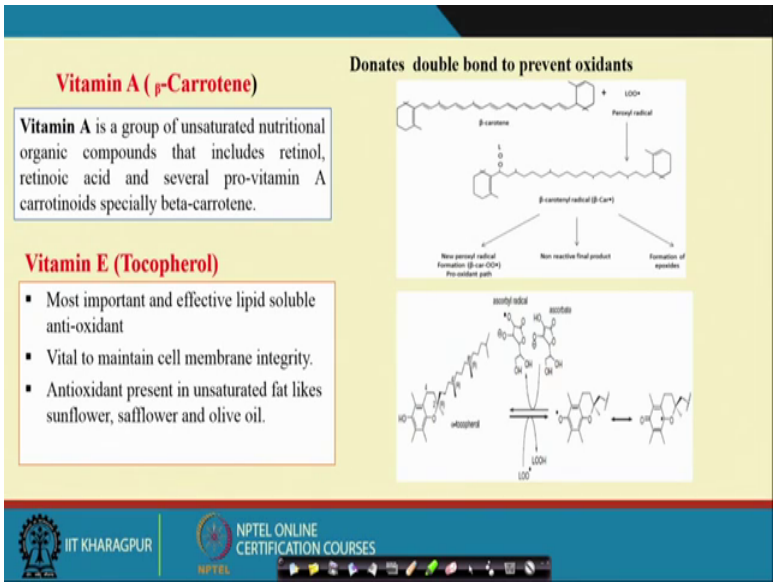

Similarly, we have the vitamin A, that is a B-carrotene and also vitamin E tocopherols. So, they donate the electrons, that electron is utilized to neutralize the free radical formations in the human body. Vitamin A is a group of unsaturated nutritional organic compounds that includes retinols, retionic acids and several pro vitamins A carrotinoids, especially beta-carrotene.

So, this as the structure of this ones, so double bonds are there so, they can donate electrons and these electrons can be utilized for neutralizing the free radicals. Similarly, the vitamin E that is a tocopherols, that is a most important and effective lipid soluble antioxidants, so vital to maintain the cell membrane integrity. So, antioxidant present in unsaturated fats like sunflower, safflower and olive oils that vitamin E tocopherols and this also donates electrons, release electrons, those electrons can be utilized by the or the free radicals are they can scavenging activity. So, they can neutralize the free radicals by donating electrons.

This is how the antioxidants they can donate the electrons in this process. So, electrons can be utilized to neutralize the free radicals formations in the plant body. So, that you can so build the free radicals they cause cell damage. So, they can about the cell damage having regular intake of the antioxidants.

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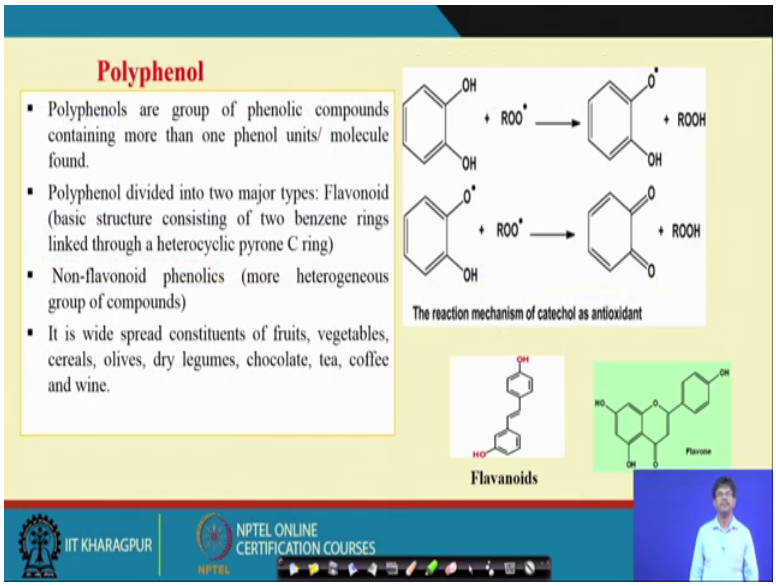

So, similarly, the polyphenols like these are the reaction mechanism of the catechols as at the poly antioxidants. Polyphenols are group of a phenolic compounds containing more than 1 phenol units are molecules are founds.

And the polyphenol divided into two major types: One is a flavonoid the basic structure consisting of 2 benzene rings linked through heterocyclic the pyrone C ring and also non flavonoids phenolic groups more heterogeneous group of compounds. And it is a widespread constituents of fruits, vegetables, cereals, olives, dry legumes, chocolates, tea, coffee and wines.

So, the polyphenols they also as the group of antioxidants are so regular intake of polyphenols. They can release the yes so, this by this polyphenols the OH and HH, so the H can be released from here they can neutralize the ROO then neutral ROOH. So, by this way we can neutralize this is the free radicals R double O, radical this radical can be neutralized having these poly phenolic compounds.

So, by this either the antioxidants or the poly phenyl compounds so, they release the by having the electrons from this compounds. So, we can have a neutralizations of the free radicals there is a formation in the human body and we can avoid the cell damage or damage of the DNA structure.

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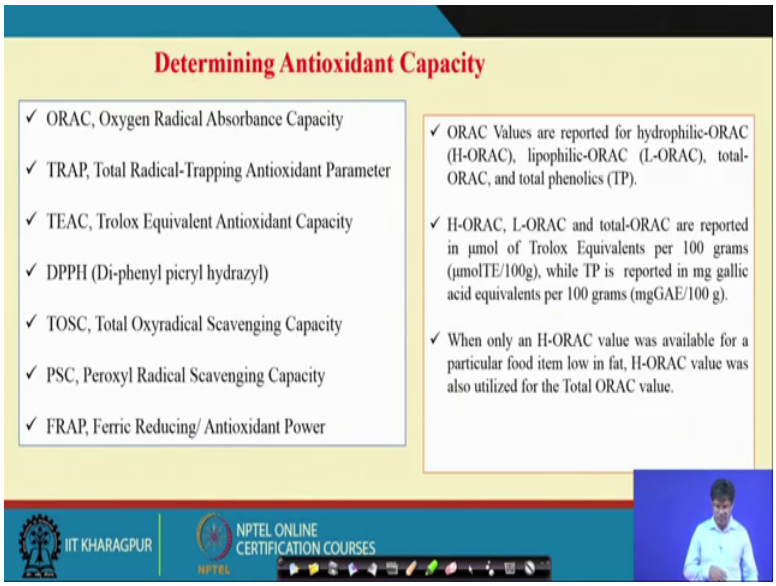

How can determine the antioxidant capacity? So, that is say the different methods how can you calculate or the estimate the antioxidant capacity of any fruits and vegetables.

Let us say ORAC, as we discussed oxygen radical absorbance capacity or the TRAP as a Total Radical Trapping Antioxidant Parameters, TEAC, Trolox Trolox Equivalent Antioxidant Capacity and DPPH, Di-phenyl picryl hydrazyl TOSC, Total Oxyradical Scavenging Capacity, PSC Peroxyl Radical Scavenging Capacity, FRAP, Ferric Reducing Antioxidant Power. So, these are the some of the methods we used for determining antioxidant capacity of fruits or vegetables.

So, ORAC that is a oxygen radical absorbance capacity, they reported as a hydrophilic ORAC or the lipophilic ORAC and the total ORAC and total phenolics as a TP. So, if there is a hydrophilic or a ORAC or the lipophilic ORAC or the total ORAC they reported as a in micro mole Trolox equivalent for a 100 gram about the fruit of the fresh fruits or the vegetables; that means, the Trolox is a standard that is as usual antioxidant standards the chemical standards Trolox.

So, this H ORAC or the L ORAC or the total ORAC are (Refer Time: 09:40) as a presented in terms of a Trolox equivalent for 100 gram of the produce. As a micro mole, TE micro mole Trolox equivalent per 100 gram of the materials or the fruits or vegetables, that you say the H ORAC value. If there is a total phenolics, so that is

estimated as presented in terms of milligram, gallic acid equivalent for 100 grams of the fruit fruits or vegetables as a materials.

So, these are the standards are the gallic acids or the Trolox so though as standards used. And this ORAC value are the are the total phenolics are repented in terms of the Trolox equivalent and all the milligram gallic acid equivalent. And one only the hydrophilic ORAC value was available for the particular food items low in fat then, H ORAC value was also utilized for the total over as you see, when there is a hydrophilic ORAC and there is low in very low in fat content. So, H ORAC is as good as is equal to your the total ORAC present in their fruits and vegetables

This is how we can determine the antioxidant capacity of different fruits and vegetable.

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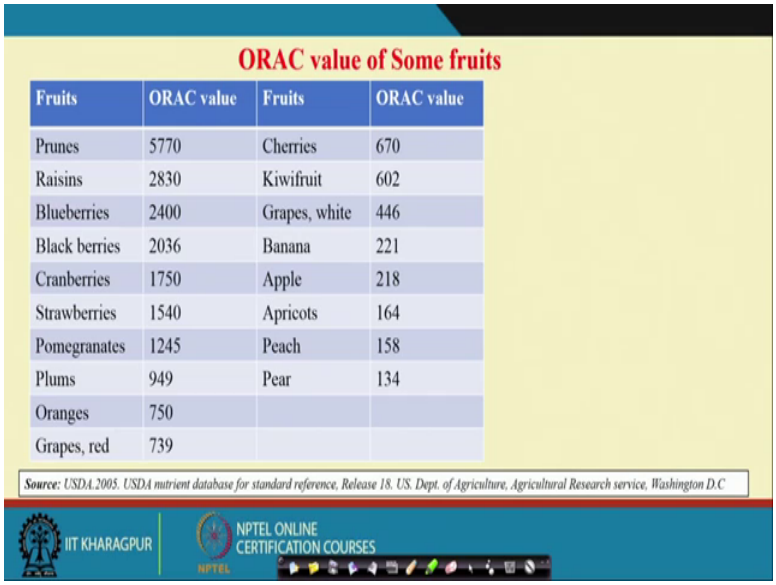

Now we will be so what are the ORAC value that is oxygen, radical absorbance capacity or of the free radicals, oxygen radicals absorbance capacity of some fruits and vegetables.

If you see the fruits, among the fruits, prunes has the maximum ORAC value that is 5770 that is the micro mole as micro mole t equivalent for 100 gram of the fruits. The prunes has the maximum 5770 ORAC value, followed by the raisin there is a dried grapes; that are the also very good value of the ORAC value 2830

Then, blueberries 2400, blackberries 2036, cranberries 1750, strawberries 1540, pomegranate followed by plums, orange then grapes, red grapes then cherries, kiwifruit that is around 600 the ORAC value grapes, white grapes then banana, apple, apricot, peach and pear.

There are also several other fruits have has the ORAC value. So, these are the some of the fruits have the high ORAC value; that means, so, if daily intake of the foods we can include some of the fruits having the high ORAC value. So, there is a natural sources of antioxidants and the also resources of antioxidants, so natural sources and resources. So, regular intake of these fruits so, they can fight against many chronic diseases and we can keep your body the fit or the healthy for the good work.

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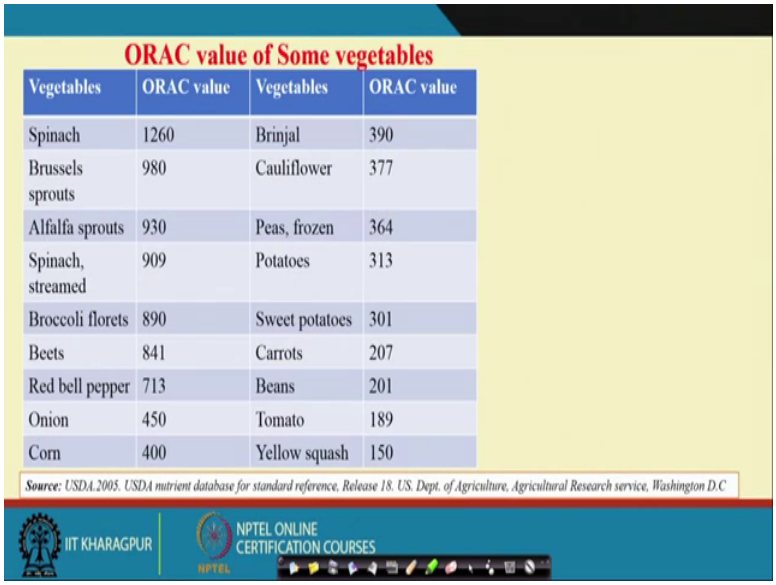

And then some vegetables among the vegetables you can see spinach; say raw spinach so, that has the very big as compared to the fruits, vegetables have lower ORAC value. You can see the fruits the ORAC value of fruits is around 5770, the maximum case of prunes and here among the vegetables if you see the spinach it has 1260 ORAC value. That is that means, the fruits have the much higher ORAC value, as compared to vegetable So, regular intake of fruits is really very very essential to have a natural source of antioxidants to keep your healthy body.

So, among the vegetables as you see spinach and that has the 1260 ORAC value, that is a raw spinach and the brussels sprout this is a this is a family of the either the cabbage

groups or the crucifer groups, so those krauts also have the high ORAC value 980. Alfalfa sprouts is used as a salad and salad also it take the alfalfa sprouts that has the 930 ORAC value, spinach esteemed that has 909 ORAC value, broccoli florets there is a good ORAC value that is 890.

Then the beets 841, red bell pepper 713, onion 450, corn say 400; 400 verses is the if the vegetable corns usually the sweet corns we get take this the vegetable corn, sweet corns that have the high ORAC value. Then the brinjals 390, cauliflower also 370 because in cauliflower or the broccoli we get the anti oxidants as a glucosinolate so that is a very good powerful antioxidants to neutralize the free radicals and the peas the frozen peas 364, potato 313, sweet potato 301, carrots 207, beans 201, tomato 189, and yellow squash like the cucumber family 150.

So, these are the ORAC value of some vegetable so, that means, when you so the daily intake of these are the fruits and the combination of the vegetables we can get the natural source of antioxidants as a balanced diet for human health.

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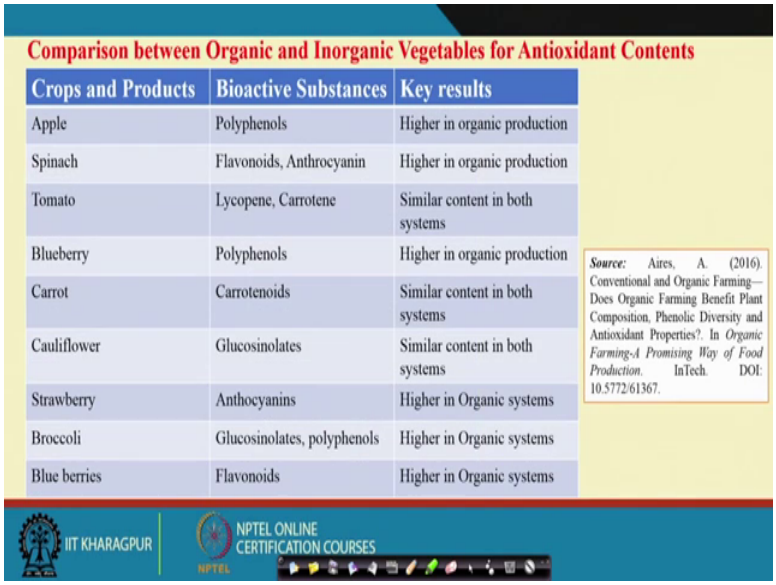

So, now let us see why organic foods are or what is of the contents of the organic foods. So, the organic foods have the higher ORAC value as compared to the many cases we have seen organic foods has give the high ORAC value as compared to conventionally grown or the chemically produced foods. So, there is a comparison between the organic

and inorganic vegetables per antioxidants contents because, a high an antioxidants; that means, it had the high ORAC value

If you see the apple, so the bioactive substance is a compound is the polyphenols as a antioxidants in apple polyphenols and this polyphenol is found to be higher in the apple is produced organically. That means the organic apples have the higher antioxidants as compared to the apple from the chemical farming. Similarly for spinach the compounds is a flavonoids or the anthocyanin these are the antioxidants. So, those three streams to be higher in organic can be produced peanuts as compared to the conventionally or the chemical were chemically produced spinach.

And tomato is a lycopene or the carotene. So, those are higher though those seems to be similar contents in both systems; either the chemical farming or this conventional farming or the organic farming, there is not much difference in the lycopene content or the carotene content of tomato. So, this is as for the source is the Irish the conventional and organic farming. .

So, does organic farming benefit plan compositions phenolic diversity and anti aging properties in organic farming a promising way of food production intake intakes. So, this so this is a publications, where we have found that in some cases the there is no difference in the ORAC value of the produce from organic or the conventionals and in many cases you can find that organic produce have the very higher ORAC value as compared to the chemically produced fruits or vegetables.

And you can see the similarly, the blueberry that contains polyphenols that is higher in the blueberry, when organically produced, but as a carrot, so this carotenoids as the tomato carrot is a carotenoids, the similar contents in both systems either go for the organic or inorganic so, there is not much change in the ORAC value. Cauliflowers the glucosinolate as you are discussing the glucosinolate is the powerful antioxidant.

So, this is a so that is also similar contents in both the systems whereas, the strawberry the anthocyanin so there is a higher in organic systems, the broccoli that is a glucosinolate or the polyphenols that is higher in organic system. So, here you have the cauliflower, so there is no chance in the glucosinolate contents either in the organic or conventional systems whereas, in broccoli though grow in organically has the higher content of glucosinolates as a polyphenols as compared to the conventional systems. And

the blueberries also flavonoids that is higher in organic systems as compared to the conventional system.

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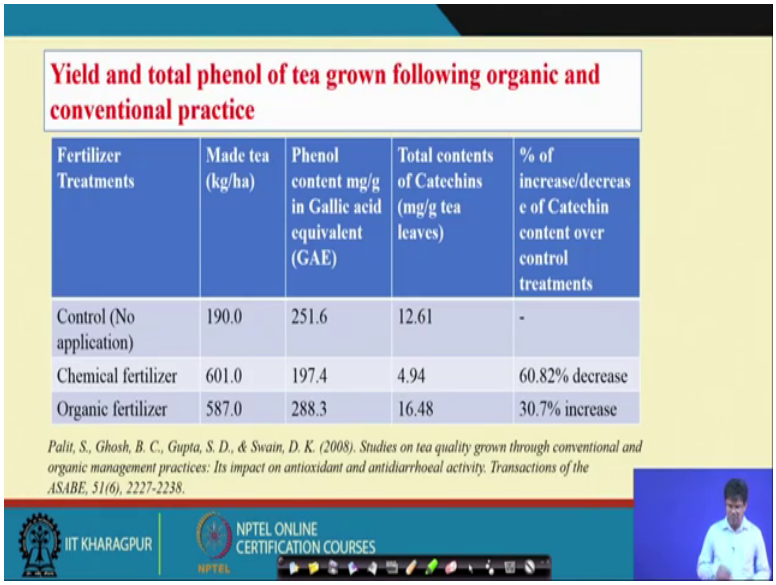

So, from one of our experiments, so what we did here in our institute experimental farm was as a tea garden yield and total phenols of tea grown following organic and conventional practice. So, this is a as a beginning of the; we can say the experiment. So, this is this tea garden was closely 3 to 5; 3 years old garden, where we have the treatments we can say that there is a control where no fertilizer is applied as a field of the native need native soil fertility without the application of any chemical fertilizer pesticide, but only initially probably it was given only the for initial establishment of the (Refer Time: 18:20).

And in the main field we do not apply anything, the annual appliques after 1 year. Then the chemical fertilizer splat where only chemical fertilizer applied as per the recommended dose and organic fertilizer also the organic fertilizer like vermicompost, it was applied to meet the requirement of the nitrogen demand of the crop throughout the year.

So, in this case if you see the yield of med tea in kg per hectare per year, where there is a in case of control as you should apply any fertilizers or as a grown as a native soil fertility the yield was very very low, it was 190 kg per hectare per year. The yield was

maximum yield we got from the chemical fertilizer treated plot around 601 kg per hectare per years.

And if you see for the organic fertilizer yield was in between the either no applications or the chemical fertilizer. And we can say as good as the chemical fertilizer it was yield is around 587 kg per hectare per year; that means, the yield wise the chemical fertilizer is giving the higher yield as compared to the organic fertilizer the med tea productions, but I can say those are quite comparable. But if you say phenol contents there is a content phenol content in milli milligram per gram in gallic acid equivalent as we discussed in gallic acid equivalent.

In that case the chemical fertilizer that report was very lowest the lowest content of the phenols in the tea grown chemical fertilizer, that is 197.4 milligram per gram of tea milligram gallic acid equivalent per gram of tea. Whereas, we have the organic fertilizer, it was higher phenol that say 288 very significantly consisting higher phenol contents and the control also that has a very good phenol content as compared to chemical fertilizer.

Where you have applied chemical fertilizer the content is very low whereas, in case of the control there is no application it has the high content of the phenols; that means application of chemical fertilizer that reduces the further the compounds like the secondary metabolites formation is inhibited if you are going for the application of the chemical fertilizer that seen from the experiment that with chemical fertilizer the content is very low.

Similarly, the total catechinic content say it was very low in case of chemical fertilizers, that is 4.9 per milligram per gram of tea leaves whereas, the control has quite good 12.61 per gram of tea leaves and the organic fertilizer 16.48. But if you see because, we can say in control though the content is as much higher as compared to the chemical fertilizer, but the production is very low.

So, if you see the yield of the total catechin will be also low in case of control whereas, in case of the organic fertilizer as the content is very high is 4 times almost four times higher, as compared to chemical fertilizer the content of the total catechinics organics. So, if you see the yield of the catechins from the from the organic tea will be though the production level almost same or slightly lower, but you see the yield of the or the

production of the secondary metabolites are significantly higher in case of the organic tea as compared to conventional tea.

And here you can see the percentage of increase or decrease of catechinic content over the control treatment if you see control with no application of the fertilizers. And the chemical fertilizer, if you apply chemical fertilizer that the decrease in the catechinic contents around 60 percent and go for the organic fertilizers applications that increases the catechinic content by 30.7 percent.

So, that mean you say that with this is a 3 years tea garden. So, initially we planted the tea in a barren land was a mid cultivables and the tea was grown, so this is 3rd year, we we took these observations for the tea productions and the categonic contents with regular applications of the chemical fertilizers or the or the organic fertilizers and the cases, where there is no fertilizer applications.

So, in this case we can see so, this is clear cut indication that with application of the organic fertilizer, so there is the better formations higher formations of the secondary metabolites, as compared to the chemical fertilizer where, chemical fertilizer decreases the formations of the secondary metabolites.

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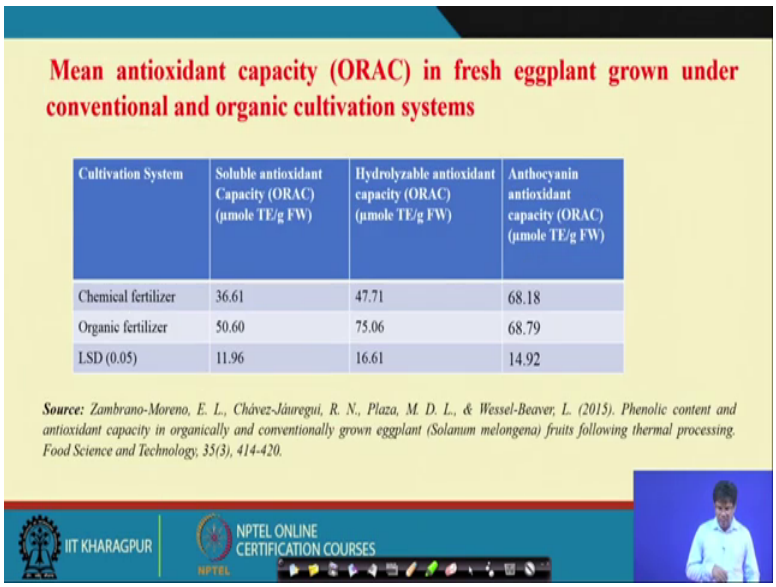

And another experiment from the other researchers they have also indicated the mean antioxidant capacity. In case, eggplant grown under conventional and the organic

cultivation systems, so you can see there is a chemical fertilizer, organic fertilizer, the soluble antioxidants capacity, the ORAC value, the micro mole Trolox equivalent per gram of a phase weight. In case of chemical fertilizer at 36.61 and the organic fertilizer 50.60 and it is also highly significant.

There significant increase in the soluble antioxidants capacity ORAC value of the organic produced a plant as compared to chemically produced plant. Similarly you can see other anti oxidants, hydrolyzable antioxidants here also, there is a significant increase in the in case of organic fertilizers as compared to chemical fertilizer it is 47.71, here it is 75.06. Though would not see any there is no difference in case of the anthocyanin pigments, there is a anthocyanin anti oxidants, so, there is no much difference between the organic and the chemical fertilizer they are almost similar because, they are statistically at power there is no change.

So, whereas, the ORAC value or the soluble antioxidants or the hydrolyzable antioxidants. So, they are much higher in case of the organic curry produced to the eggplant, as compared to the chemically produced plant. So, that is clear indication that, so having the growing the crops organically. So, you can have the more and more the secondary metabolites.

There is a anti oxidants either the phenols or the vitamin C, vitamin A those and secondary metabolites formations as much higher. If the produce the fruits or vegetables grown organically as compared to the inorganic or the chemical farming.

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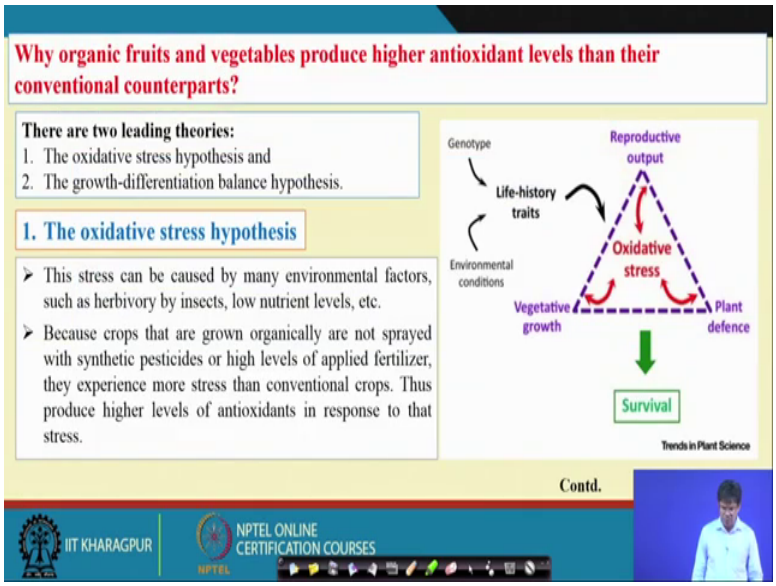

So, the question comes then, why the organic fruits and vegetables produce higher antioxidants levels than their conventional the counterparts. So, for; what is the reasons why the organic farming or the produce of organic farming have the higher antioxidants, as compared to conventional farming.

So, there are the 2 leading higher the theories I can say the one is the oxidative space hypothesis and the other one is the growth differentiation balance hypothesis. So, there two hypothesis say why the organic produced, the producer of the organic farming of the higher antioxidant capacity or you can say, ORAC capacity oxygen radical absorbance capacity as compared to the produce of the chemical farming.

The oxidative stress hypothesis says that, this stress can be caused the stress hypothesis, stress can be caused by many environmental factors that such as the herbivore by insects or the low neutron levels. As we are not applying any pesticides or any fertilizer as chemical fertilizer, only you are going for the organic farming or the organic management. So, there is a release pattern of nutrients very very slow as for the demand of the crops are the slow and steady release. So, that causes some nutritional stress in the plant body and also there may be some the herbivore insects.

So, by this the stress may be there; there may be oxidative stress in the plant body. And that that may cause the imbalance the growth imbalance either to talk vegetative growth

or the reproduce growth or the plant depends. When there is an oxidative stress so, there is a plant defense mechanism it trigger.

So, there is so that means, because crops are grown organically are not sprayed with synthetic pesticides or high levels of applied fertilizers, they experience more stress than conventional crops. So, thus produce a higher level of antioxidants in response to that stress, so if there is the oxidative stress in the plant body because of the low level of nutrients or the less use of the pesticides or no use of pesticides. So, there is a stress, so there is a situation of phytohormones, those antioxidants. So, there is more formation anti antioxidants. So, this is a plant defense mechanism so, that way that can, so as we discussed earlier classes, so we are by growing crops as a natural are the organic systems. So, there is a natural defense mechanism of plants because of this oxidative stress.

So, there is phytohormones or the secondary metabolites formation takes place. And that is a less infested by the pests and diseases, but what happens in that process, so there is a once there is a stress either due to the nutrient deficiency or this the less pesticide or the herbivore insect herbivore insects. So, there is a stress, so that causes the formations of the antioxidants in the plant body. This is one of the oxidative stress hypothesis

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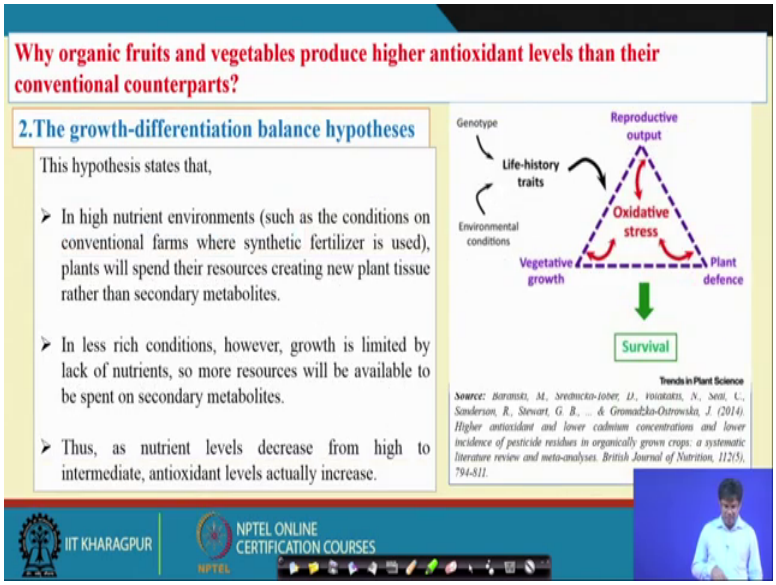

The other the second one is say the growth difference balance hypothesis; that means, as you see the what this hypothesis says, in high nutrient environments such as the

conditions on the conventional farms where synthetic fertilizers used, plant will spend their resources creating new plant tissue rather than secondary metabolites this also we have discussed in the previous classes.

So, if you are supplying the nutrients as per the requirement the crops sufficient nutrients available for the crops. So, the crops looks for the more of the growth, more of the biomass formation, that is more of the vegetative growths and also the reproductive growth if there is the ample or the sufficient supply of nutrients. So, the crop does not bother to formation of these secondary metabolites. So, there is more and more the plant tissue formations for the better growth and yield.

And whereas in case have the in less risk conditions however the growth is limited by lack of nutrients so, more resource will be available to be spend on secondary metabolites. So, when there is a limitation of nutrients, so there is a stress. In ultimately, there is oxidative stress because of stress, so plant does not to spend its energy for the formation of the new cells or the biomass because, it is a limited available nutrients rather expensive energy for the formation of secondary metabolites or the antioxidant formations are triggered or the enhanced by the stress mechanism. Thus as nutrient level decreases from high to intermediate anti oxygen levels may actually in.

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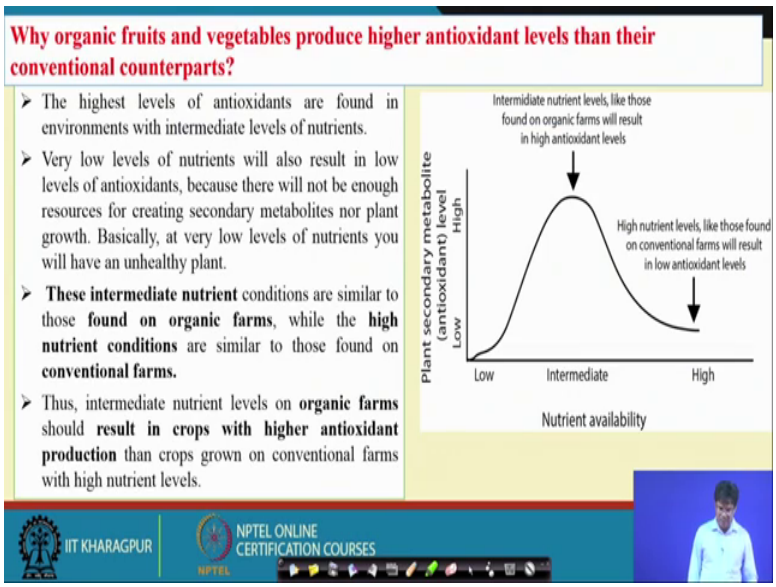

So, that is what why organic farming So, they have the so from this slide last slide can show you the why organic fruits and vegetables that produce the higher anti oxidant,

because in case of organic you can see this figure this is a nutrient availability from low to high. In case of low; that means, you are not applying any fertilizer, this grown as a native soil fertility or no external fertilizer application or there is a inherent soil fertility is very low. And the high means, here we are applying high neutron levels like those found in conventional farms like chemical farming, where you have the surface the optimum supply of sufficient supply nutrients as needed the crops.

In that case if there is a nutrient high nutrient available and intermediate nutrient available in case of the organic farming. So, where we go for organic farming though we are not able to supply the nutrients in the rapidly or in the sufficient amount as per the requirement the crops for there is a the slow mineralizations and the steady release of nutrients; that means, there is a the nutrient the availabilities intermediate not exactly excessive or not low as of the control or the non use of the fertilizers. But it is with organic farming or the organic nutrients so, the nutrient availabilities intermediate; that means, the not high or not excessively low. So, as being intermediate, so this favors the formation of the secondary metabolites.

So, here because in this because as organic farming we are here, here we are there the nutrient availability is intermediate not exactly high as of the chemical farming, not low because you do not apply any fertilizer pesticides, but the intermediate levels. So, that helps the formation of the more formation of the higher formation of the anti oxidants.

So, this you say the highest level of antioxidants are found in environments with intermediate level of nutrients, not excessive nutrients are not exactly very low or deficit nutrients. Very low level of nutrients will also result in low levels of antioxidant, because there will be not enough resources for catering or creating the secondary metabolites not plant growth. Basically, at very low levels nutrients you will have an unhealthy plants. So, plant depends the plant will be on early plants with less nutrient.

So, in that case in case of the low chemical low fertilizers or low soil fertility, so the plant may not have the higher secondary metabolites. Those intermediate levels where there is a nutrient available is there, so considers are similar to those found in organic farms. So, while the high nutrient condition are similar to those found in the conventional pound. So, intermediate nutrient levels as organic farming.

So, there these are more formation of the secondary metabolites. Thus the intermediate nutrient levels of organic farms should result in crops with the higher anti oxidant productions then crops grown conventional farms. So, this say that if you are work for organic farming in the earlier report we have shown in our tea garden. See control fertilizer without application in fertilizer that gives a higher level of the catechins as compared to chemical fertilizers. Though that is a very low fertilizer levels, but still we are finding a contracting these results this hypothesis that we are getting the more of the catechins as compared to chemical fertilizer. Reason I can say that, so that crop was the starting phase.

So, we have started only three years old tea garden So, if you go for the long run maybe after maybe 5 6 years 7 years or 8 years 9 years, we can find that still control will not give the higher secondary metabolites, because all the nutrients that might because tea is a perennial crop that might have any existed a by their by the time.

So, that means, your part to have a higher metabolites or the secondary metabolites are the higher level of antioxidants. Organic farming is the best suited that we can undoubtedly, we can say though having organic produce though yield is lower or as good as chemical fertilizer, but having the more of more of secondary metabolites. So, if you are going for the quality of the products high antioxidants then organic farming can produce more of antioxidants from a particular area as compared to chemical forming.

So, having the organic produce we can minimize your food intake also is in view of the quality. So, if you take the high the volume of the chemical your produce from chemical fertilizers, we can take less volume of produce from organic fertilizer to provide the same level of antioxidants as in of the chemical fertilizers chemical farming.

Moreover this having organic fruits and vegetables, so having the high antioxidants and also free from the pesticides or the residue that has a better health many benefits and we can avert the risk of many diseases. So, what we can say the organic farming are the produce of organic farming that that from this research evidence we can be sure that the produce of organic farming have the higher level of anti oxidant, many cases we have seen as compared to conventional farming. With these I

Thank you all.