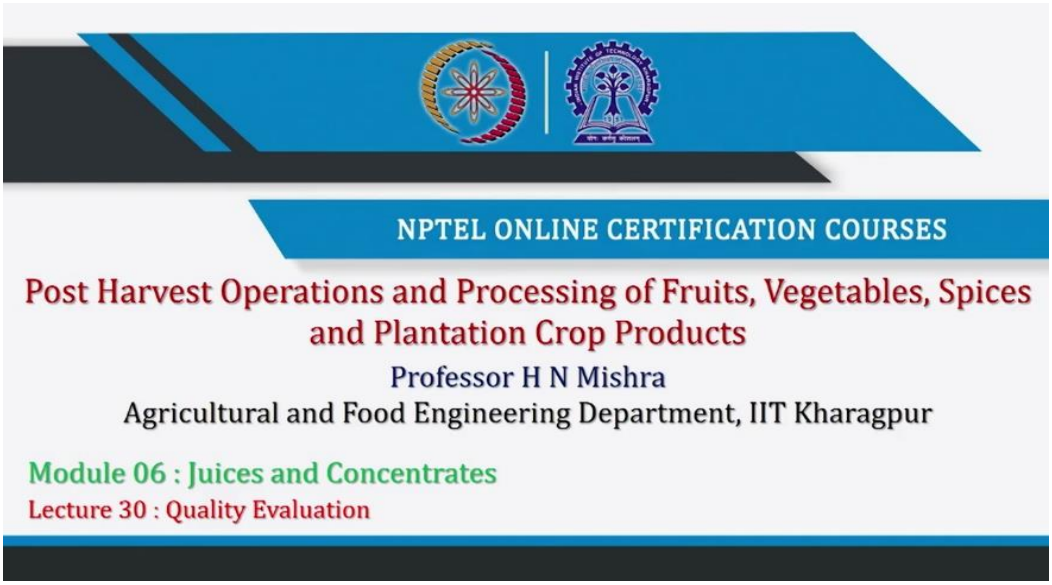
Post-Harvest Operations and Processing of Fruits, Vegetables, Spices and Plantation Crop Products

Professor H N Mishra
Agricultural and Food Engineering Department
Indian Institute of Technology, Kharagpur

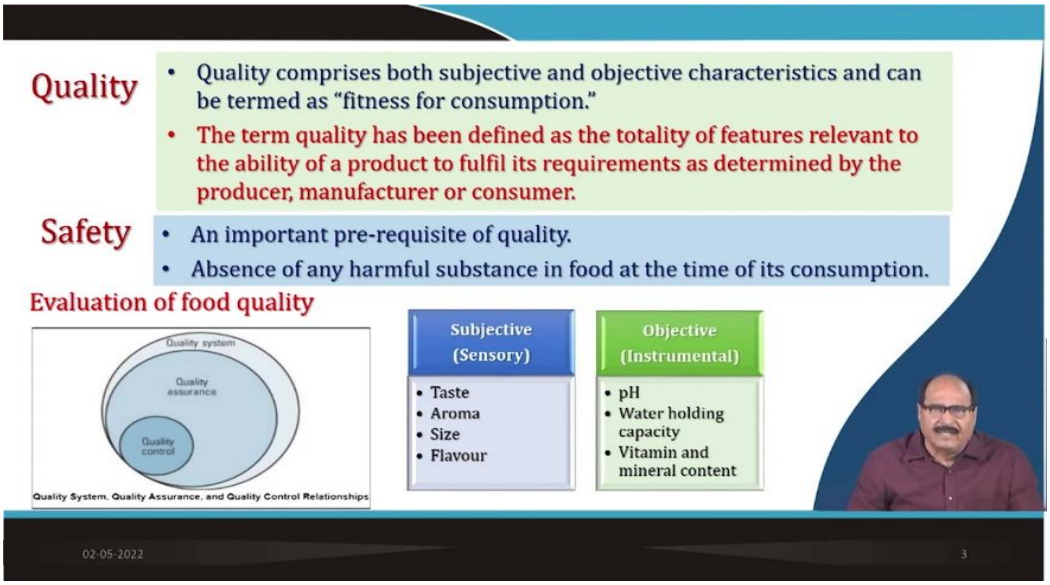
Lecture 30
Quality and Safety Aspects

Quality Evaluation



Hello everyone, namaskar, today in this thirtieth lecture of the course, we will discuss about various quality and safety aspects of juices and concentrates. Particularly we will discuss about the evaluation of quality attributes. The quality attributes; physical, chemical, rheological and microbiological quality; how they are determined in various fruits and vegetables, juices and concentrate, we will discuss in the next half an hour or so.

Quality and Safety



So, let us see first: what do you mean by quality? Quality comprises both subjective and objective characteristics and can be termed as fitness for consumption. A good quality material is good for consumption. It is fit for consumption. So, the term quality has been defined as the totality of features relative to the ability of a produce to fulfill its requirements as determined by the producer, manufacturer or consumers. So, whatever the quality standards are set by either regulators or industry or producer or manufacturer, a product should meet those standards. And, how do we know that the product meets to the standard? We go to analyze it either in laboratory or in some other way (that is the standard protocols are there).

So, along with the quality, another very important attribute is safety. A food may be good in quality, but it may be unsafe for consumption. So, the safety is a very (very) important prerequisite of quality of any food. So, what does safety mean? Its absence of any harmful substance in the food at the time of its consumption. When it has been consumed, it should not contain any harmful or any toxic component whether it is microbiological, chemical or any other aspect (any other toxic agents). So, the evaluation. Now we will talk about evaluation of food quality. Basically, it is a quality system as I told you that these are the various attributes (earlier classes also we discussed).

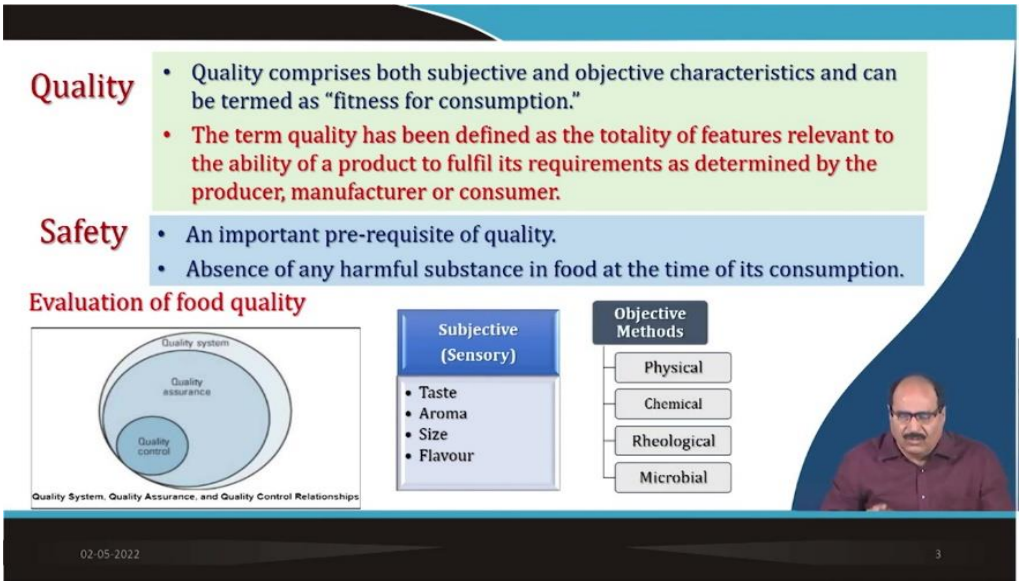
So, those attributes make the quality system. The quality assurance and quality control are the two important aspects of this quality system. Quality system is a bigger umbrella and within this are the quality assurance and quality control. So, the quality is evaluated in two ways, one is the subjective method of evaluation; other is the objective or instrumental method of the evaluation. In the subjective method (like) sensory characteristics like taste, aroma, flavor, even

sometime size et cetera, color, all those things; we evaluate subjective devices, sensory (using our sensory attributes) and for this, there again are the standard protocols, that is, the trained panel of judges are selected, that is, those judges panelist, they are first trained about the product which is to be evaluated (that is for example suppose tomato, tomato paste, tomato juice color is or its taste).

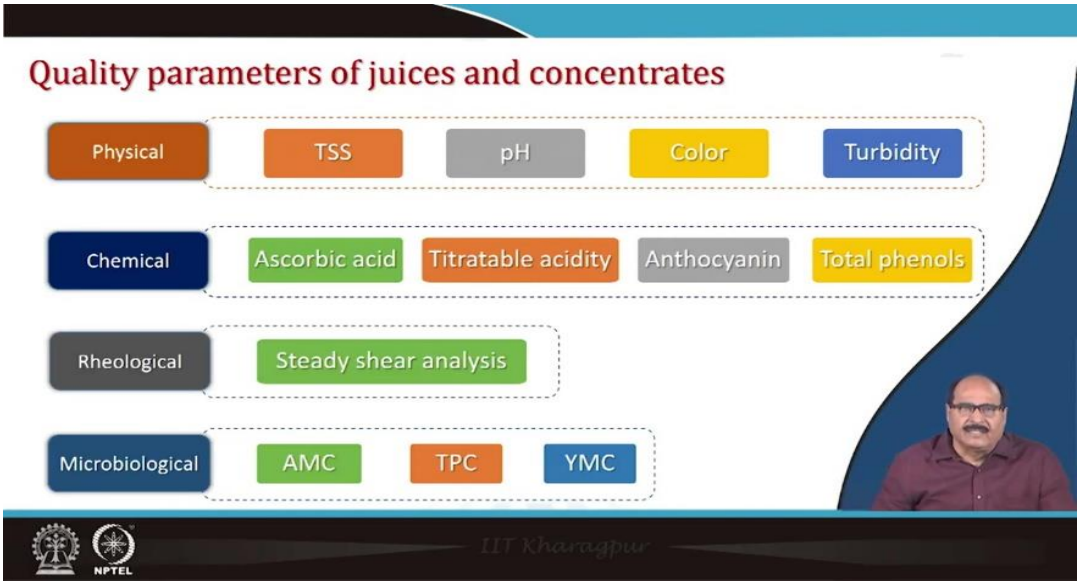
So, the panelist who is evaluating it, he or she must know what actually a good color of the tomato is; what a good color of tomato concentrate, tomato paste is; (what) a (good) flavor (is). So, they are the consumers panelists. They are trained and there are some sensory record. Data record sheets are prepared using the standard protocol. The judges are given the sample and they are asked to record their impression about the sample, various attributes and the data records it and then those data are analyzed using various methods (so, that is how that) may be nine point hedonic scale rating or other such statistical methods are used to analyze the data; sometime logic evaluation is also used to analyze the sensory data and to find out the goodness of a sample.

So, that is in the instrumental method or of the objective method like pH, water holding capacity, vitamins and mineral content that such other attributes are determined.

Quality Parameters of Juices and Concentrates



So, basically, that in the next slides, we will discuss about what are the various physical, chemical, rheological and microbiological quality attributes for juices and concentrates and their determination methods.

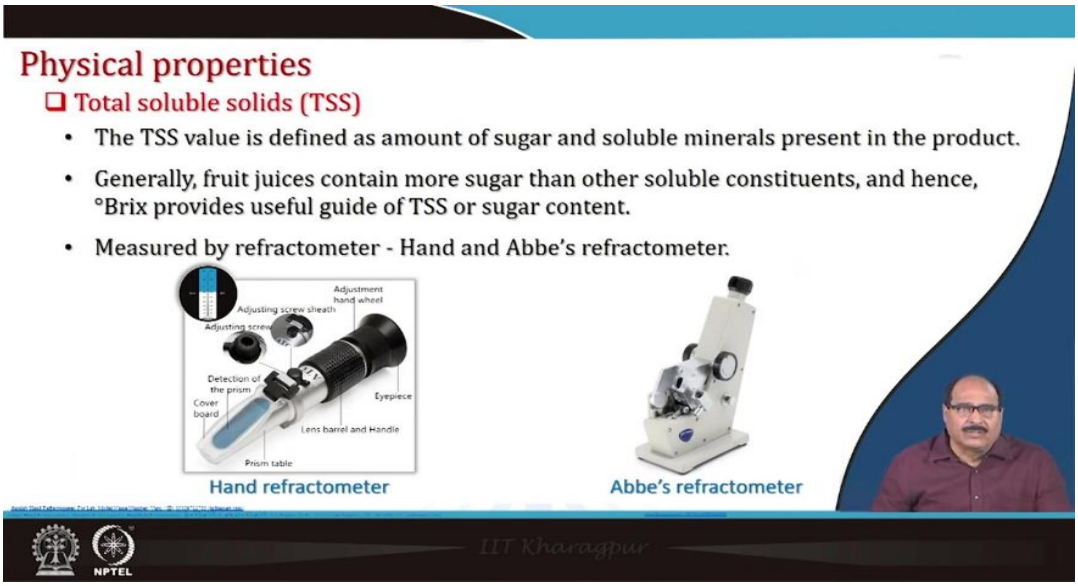


So, in the physical quality when we talk about the juices, mostly the TSS, pH, color, turbidity become the important attribute among the others. In the chemical components (chemical characteristic) it is the vitamin C because the fruits are good sources of vitamin C. So, that is considered to be one major component. Vitamin C (ascorbic acid), titratable acidity, anthocyanin content, total phenolic content which also gives the idea about antioxidant capacity (that what is the antioxidant value of this particular fruit or vegetable juice or concentrate).

In the rheological characteristics, normally steady shear analysis is done. How the viscosity, another rheological attributes are determined and these rheological attribute (basically they) help in designing the food processing equipments et cetera. Then finally, in the safety attribute which you are talking about that the microbiological quality. Microbiological quality that is a what is aerobic mesophilic counts, total plate count, coliform count, yeast and mold count: these are some standard method which every laboratory and in the depending upon the type of product all has to use. There are also methods for determining specific toxic that is what is the toxicity value or LD50 value of microorganisms et cetera and toxic contaminants and all those things can be evaluated.

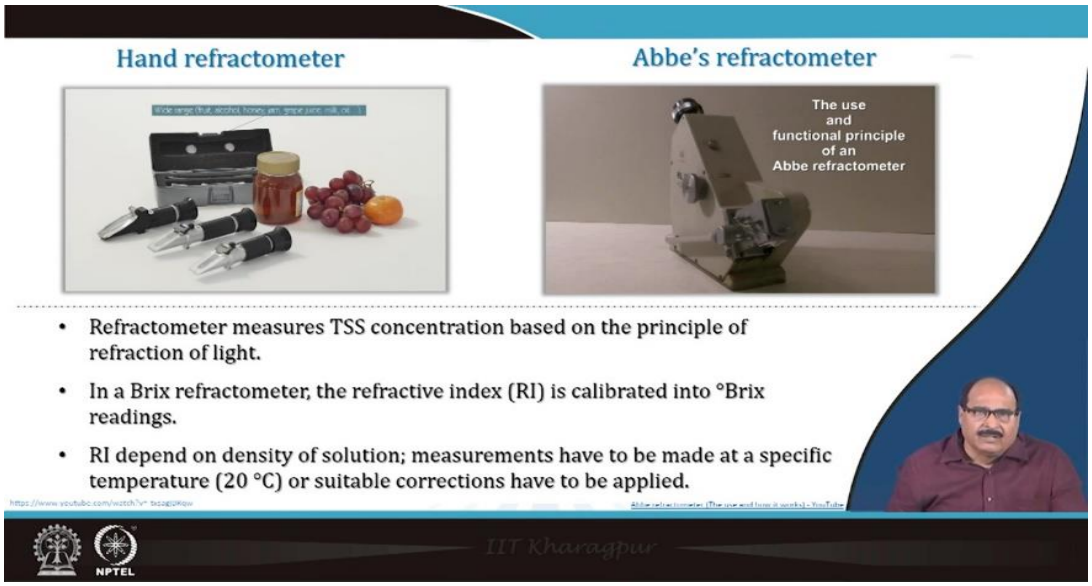
Physical Properties

Total Soluble Solids (TSS)



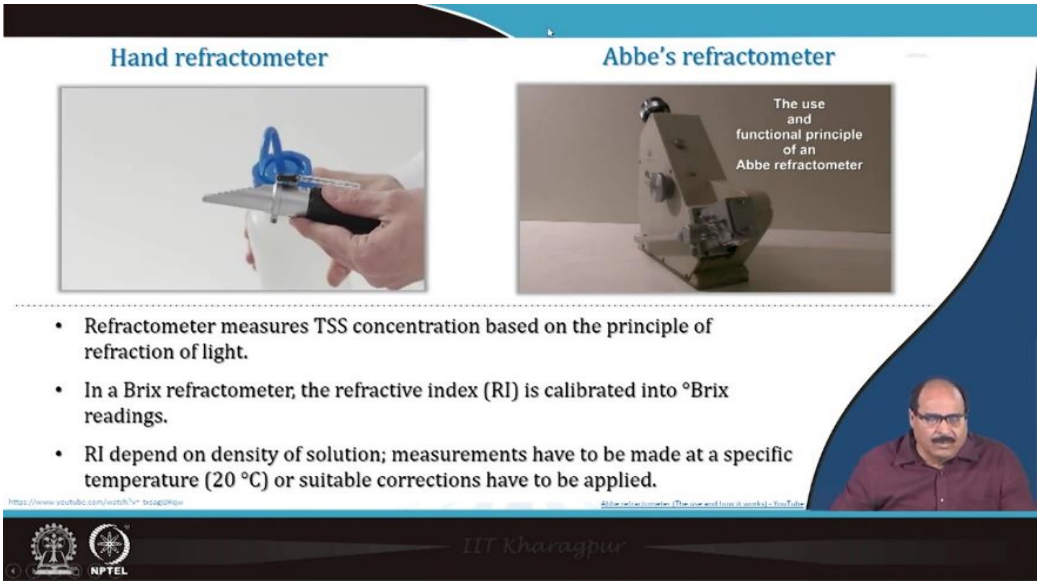
So, let us see first, we go for the physical property determination: total soluble solids. The total soluble solid value is defined as the amount of the sugar and soluble materials present in the product. Generally, fruits and vegetables contain more sugar particularly fruits they contain more sugar than the other solid constituent or soluble constituents and hence, the degree Brix provides the useful guide of the TSS or sugar content. The TSS is reported in degree Brix and the measure it is measured by as a refractometer, as a hand refractometer or abbe refractometer.

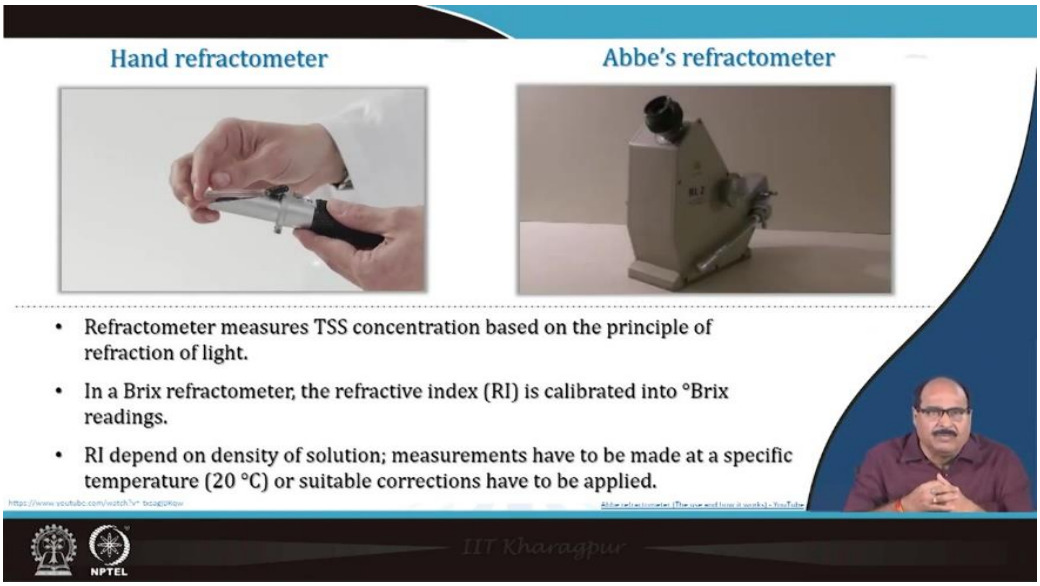
Hand refractometer and Abbe's refractometer



So, a refractometer measures the TSS concentration based on the principle of refraction of light. In a Brix refractometer, the refractive index is calibrated into degree Brix readings. The

refractive index depends on density of solution. Measurements have to be made at a specific temperature particularly normally it is done at 20 degrees Celsius temperature and then a suitable concentration is applied if the temperature is high or low then (some) it is multiplied by some factor and accordingly the actual value is determined.





Hand refractometer

Abbe's refractometer

- Refractometer measures TSS concentration based on the principle of refraction of light.
- In a Brix refractometer, the refractive index (RI) is calibrated into °Brix readings.
- RI depend on density of solution; measurements have to be made at a specific temperature (20 °C) or suitable corrections have to be applied.

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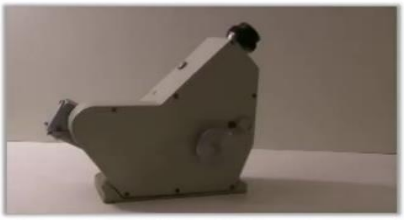
Hand refractometer

Abbe's refractometer



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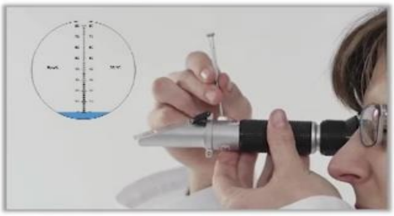

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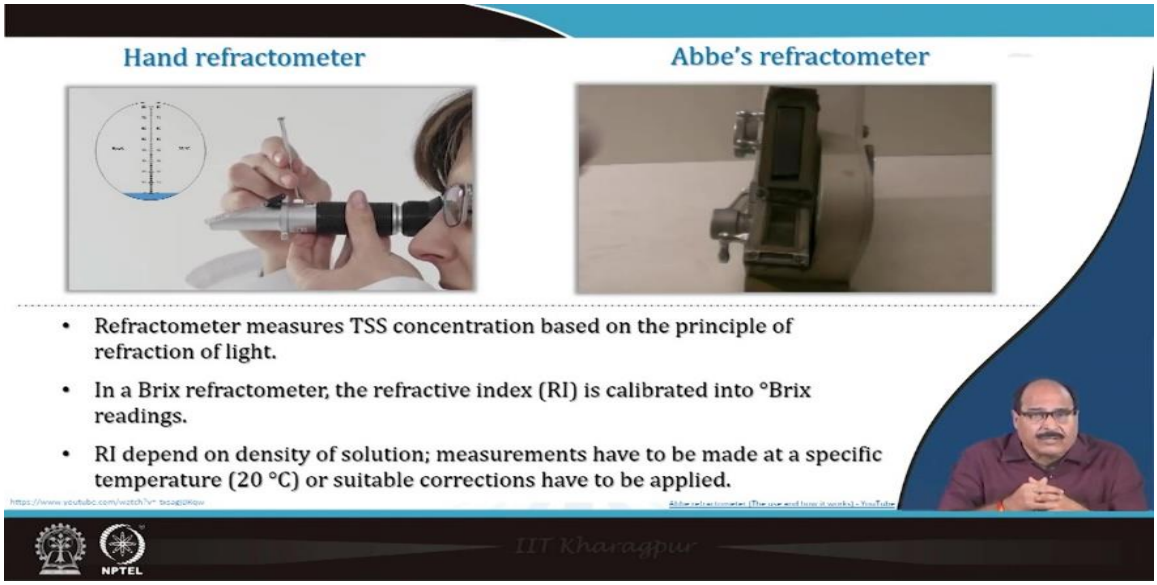
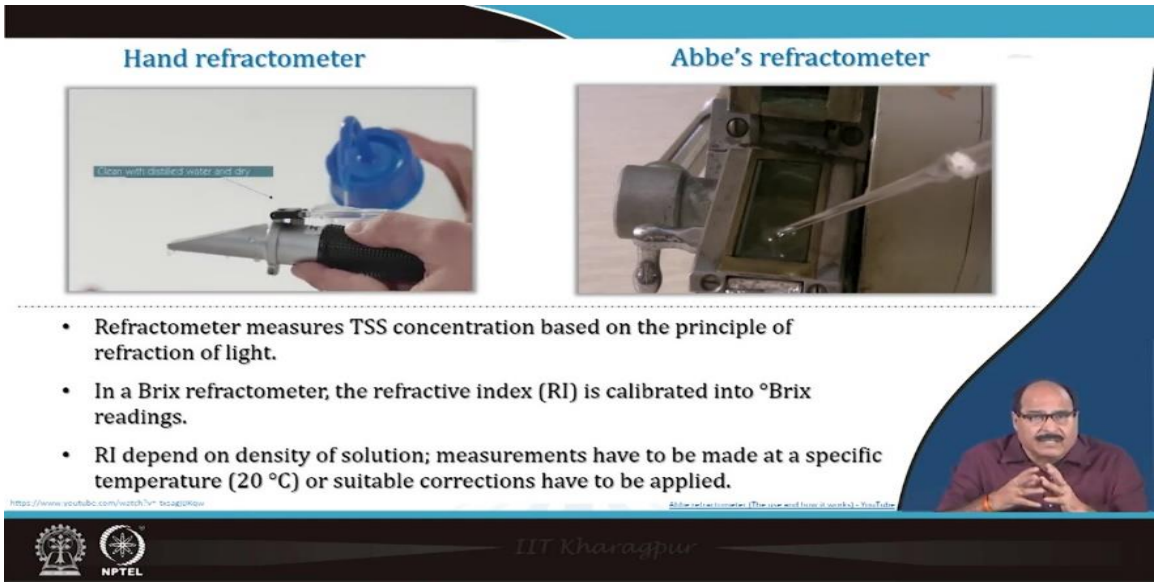
So, you can see that in the figure how that the hand refractometer is being used as it is being sample, it is cleaned and then the data is that is the standard scale in the hand refractometer.





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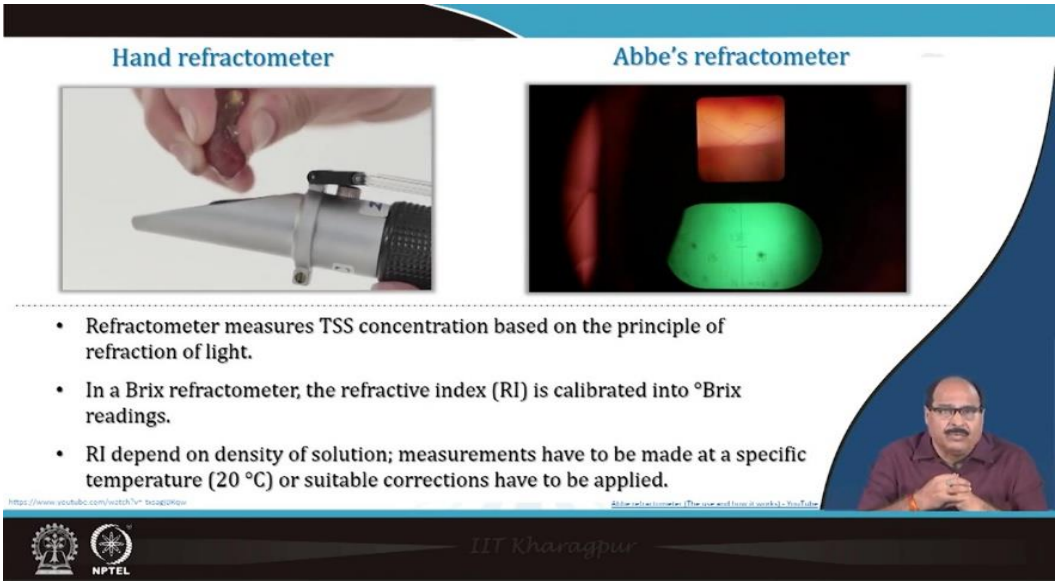
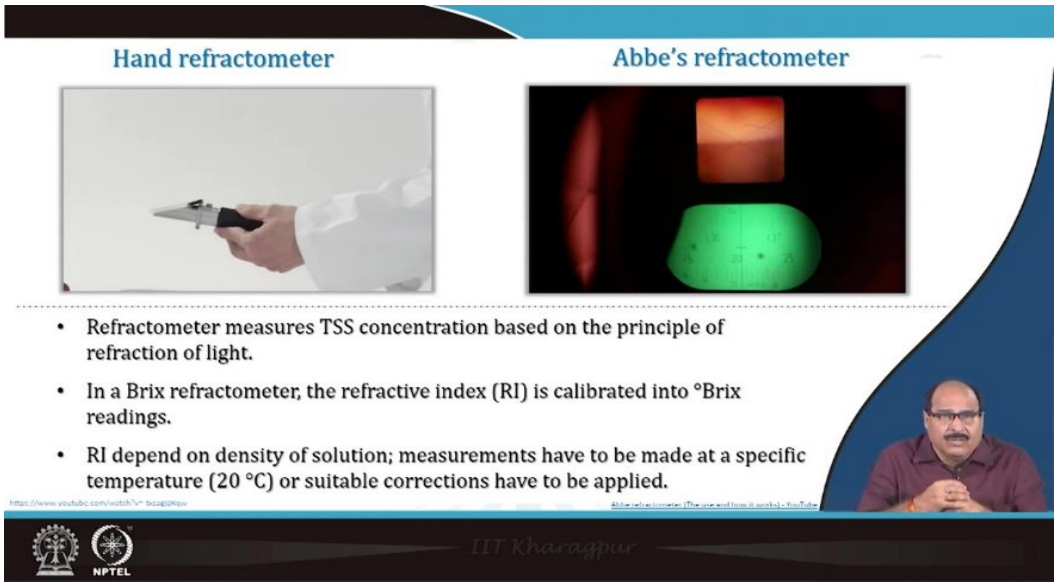
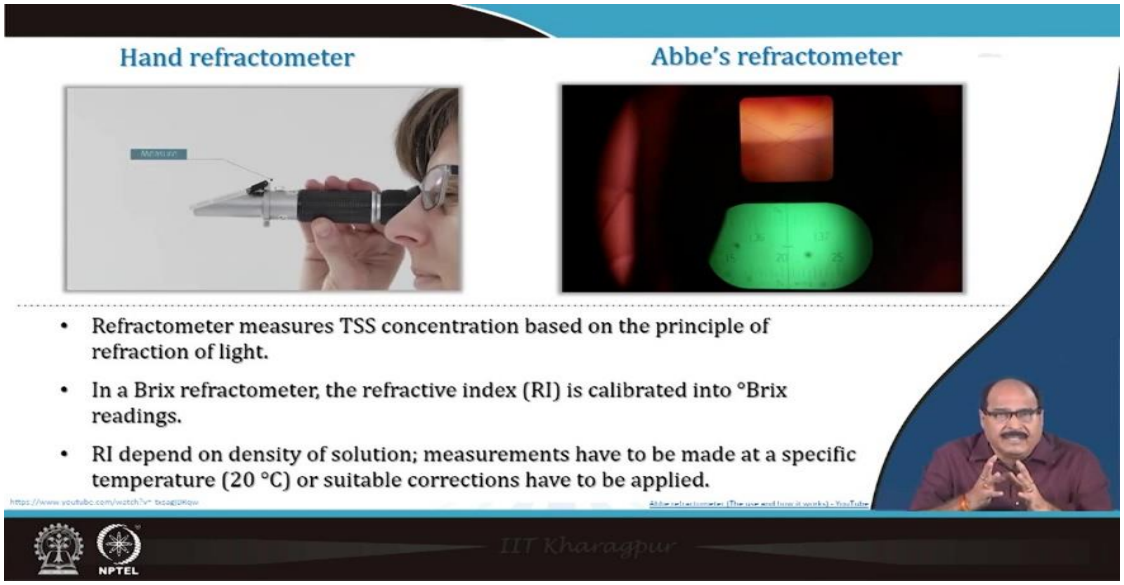
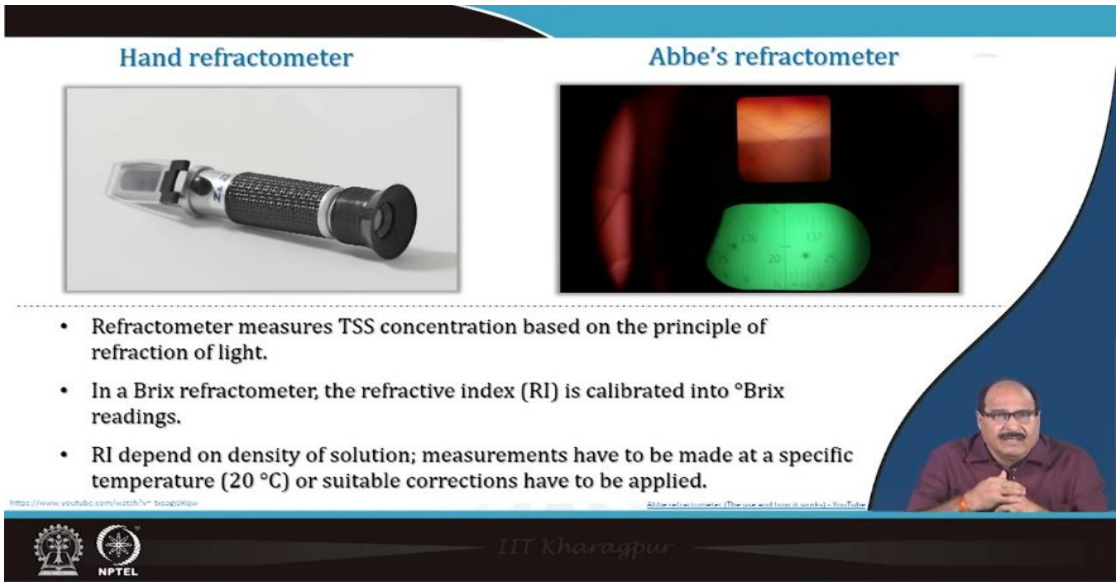
So, the scale is standardized and now the person, after that, is using (that some) proper glass distilled water (your water is being rubbed while it is being cleaned).



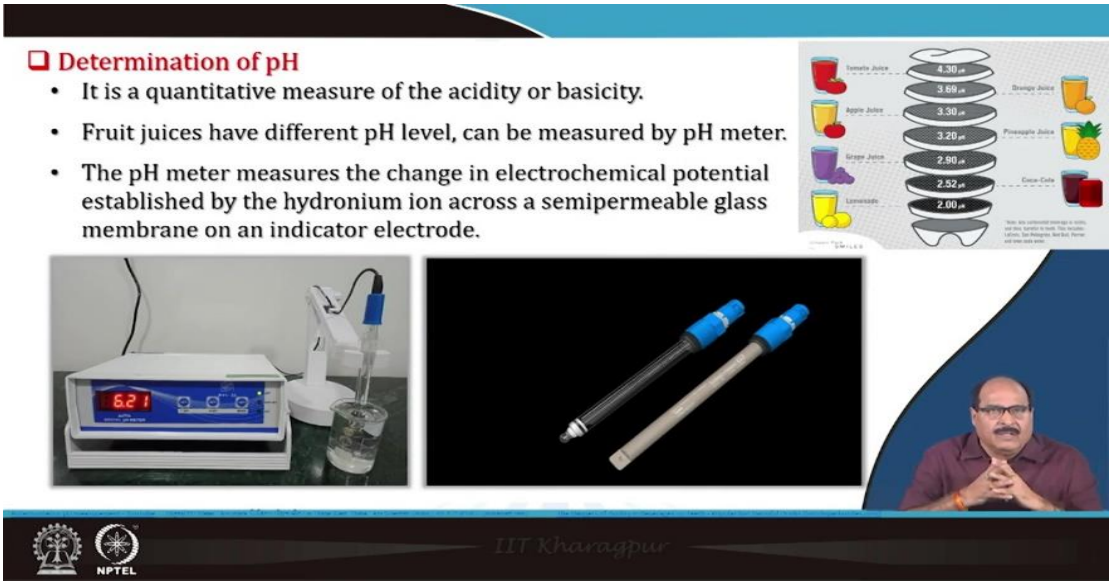




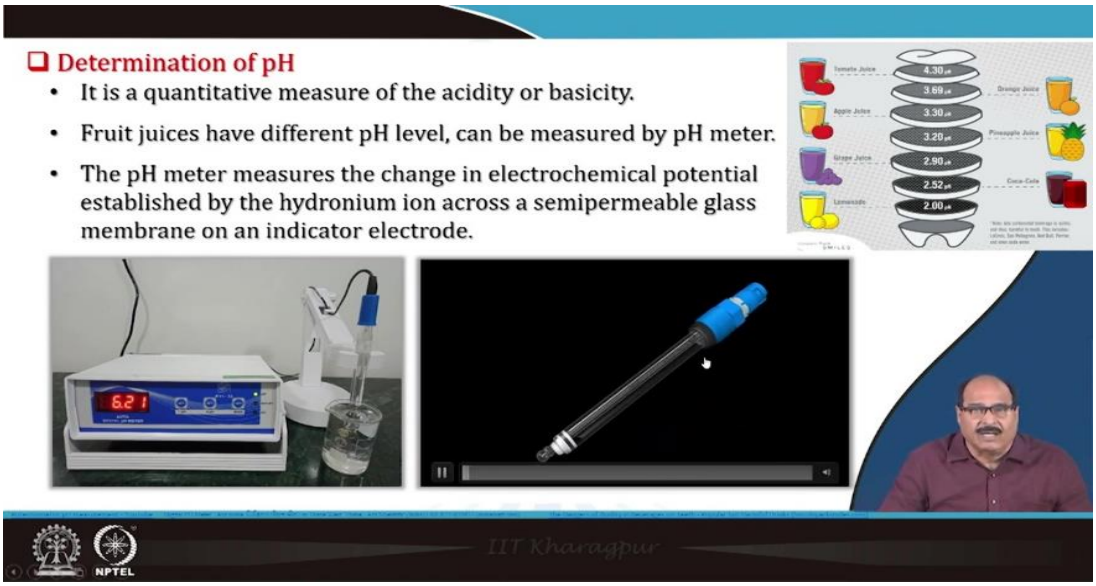


And after cleaning, now the sample that is used (sample or consulted sample) is put (as) a drop of that. It put the cover is closed after that the lady adjust it is the head that is the scale there is inside it will give directly the degree Brix reading. That is about how the hand refractometer works.

Determination of pH



Now let us see the determination of pH. It is a quantitative measure of the acidity or basicity of the sample. Fruit juices have different pH levels. They can be measured by the pH meter. In the slide here I have shown that what are the various: that tomato juice, it has a pH of around 4.3, apple juice, maybe it has pH of 3.3 and so on. So, the pH is a quantitative measure of the acidity or basicity. The pH meter measures the change in the electrochemical potential established by the hydronium ion concentration across a semi permeable glass membrane or an indicator electrode.



Determination of pH

- It is a quantitative measure of the acidity or basicity.
- Fruit juices have different pH level, can be measured by pH meter.
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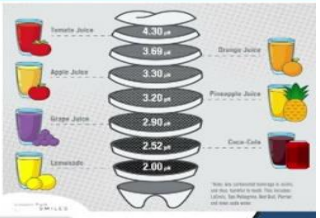

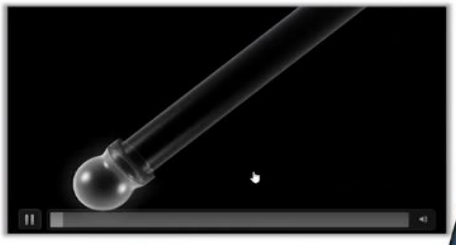

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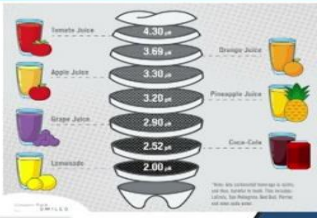

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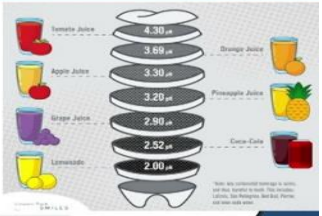
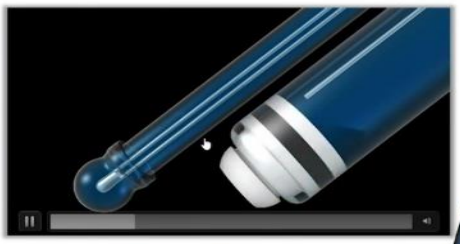
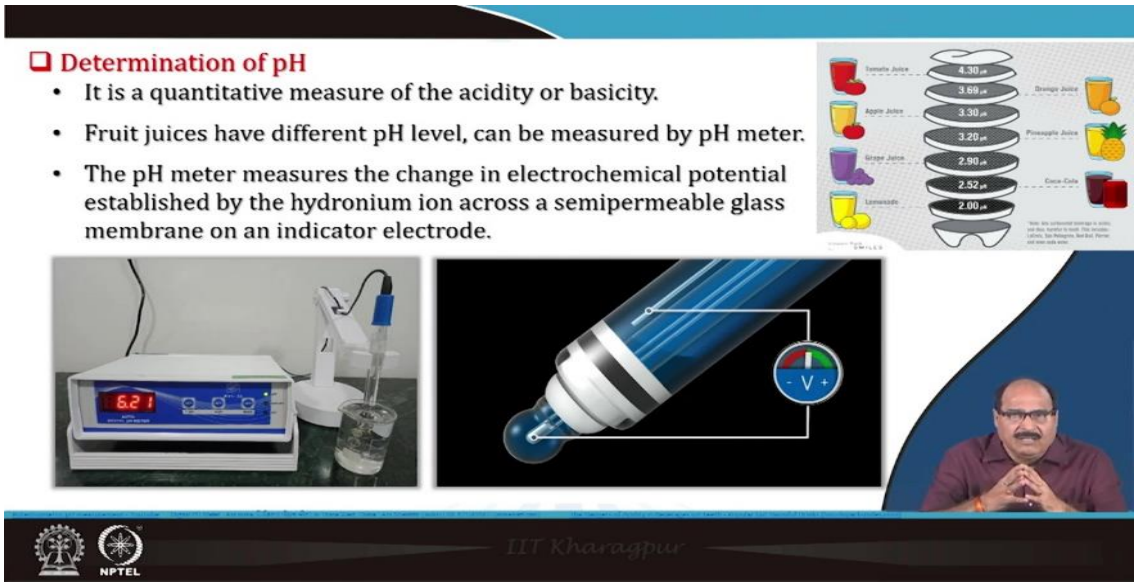
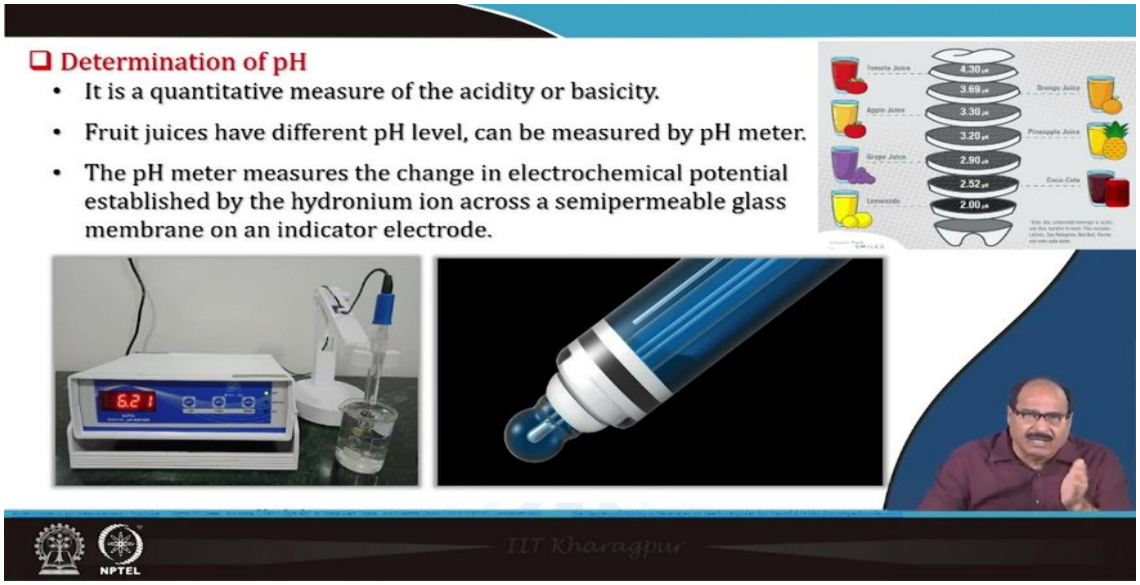
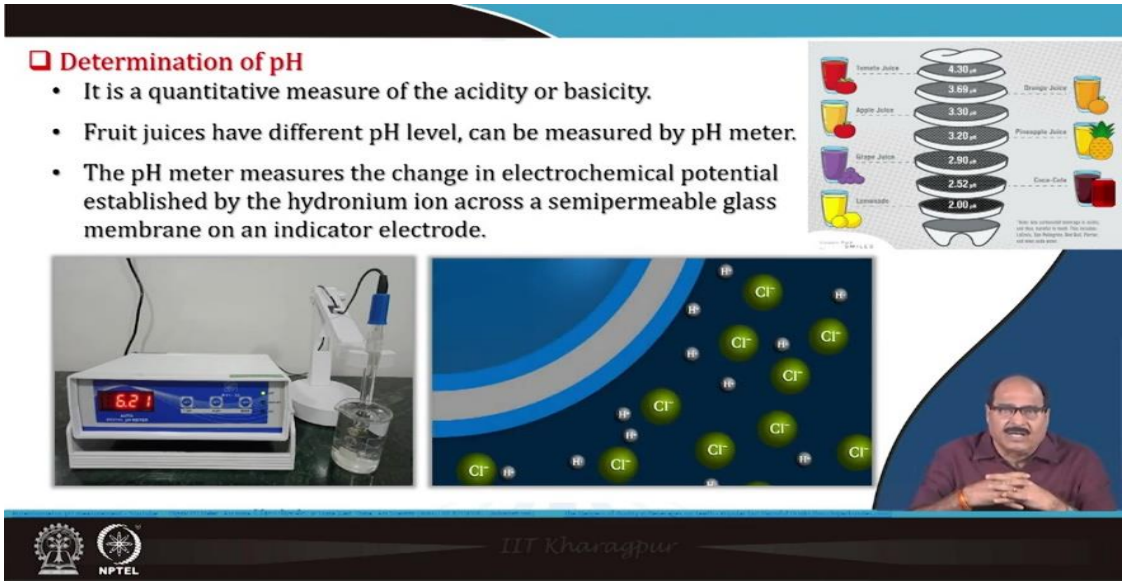


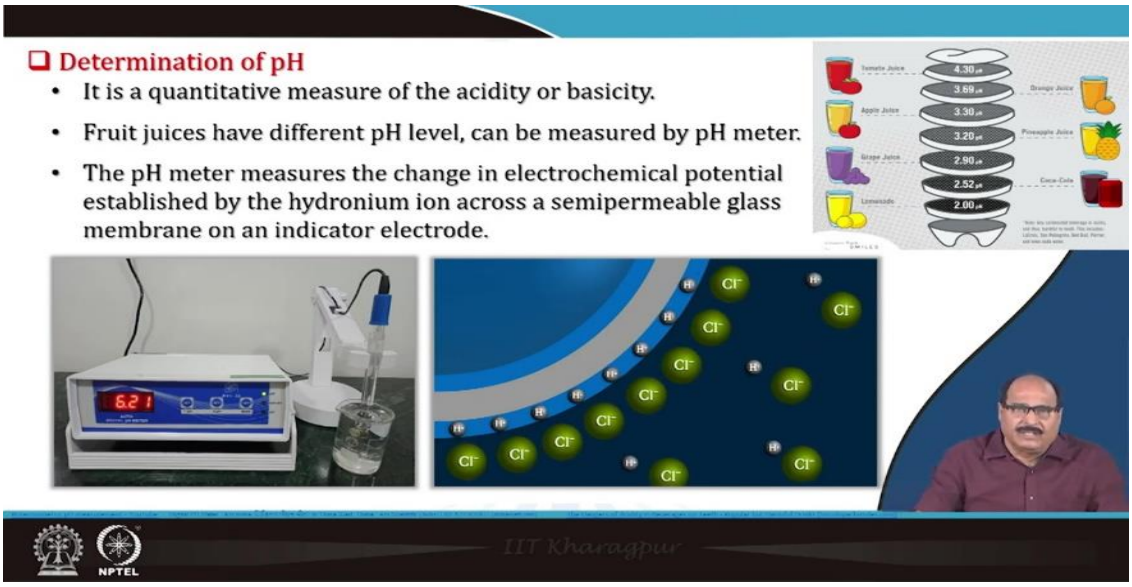


You can see in this electrode, how these are the electrodes: first the equipment is calibrated, pH meter is calibrated using some base that is buffer solution of a lower buffer maybe in the buffer four rather than buffer nine and reading it once after the pH meter is calibrated.



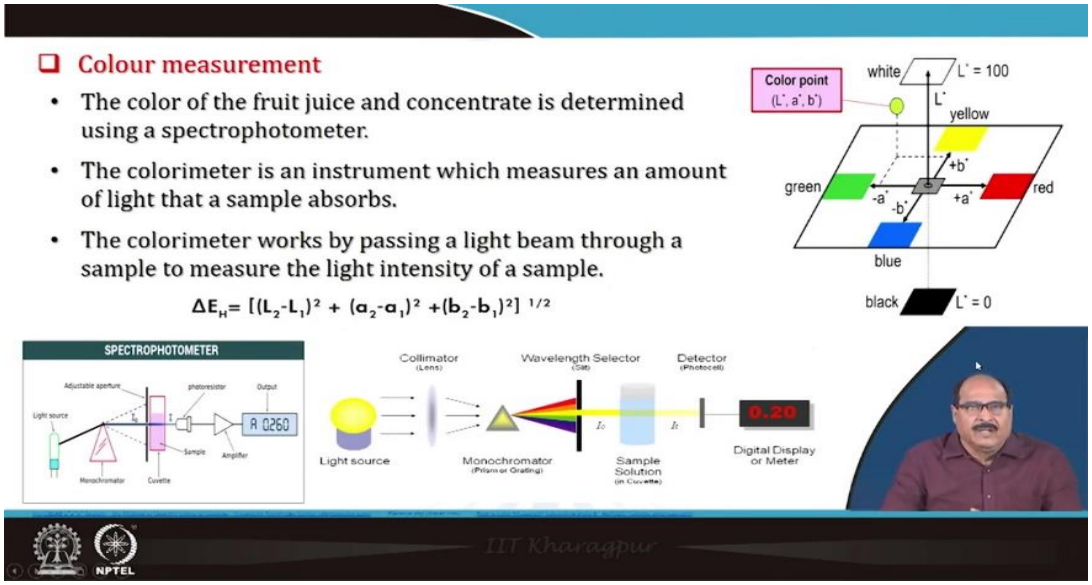






Then the sample is taken into the beaker and then this electrode is put there. The electrode measures the potential that is hydrogen ion concentration there is a glass and the gradient difference in the hydrogen ion concentration inside the electrode and the outside in the environment. If the difference is that it is negative or positive on the basis of that, that is, what are the hydrogen ion gradient, it is determined, and then it is represented in the form of pH in the indicator, so, accordingly that actual pH of the commodity.

Colour Measurement



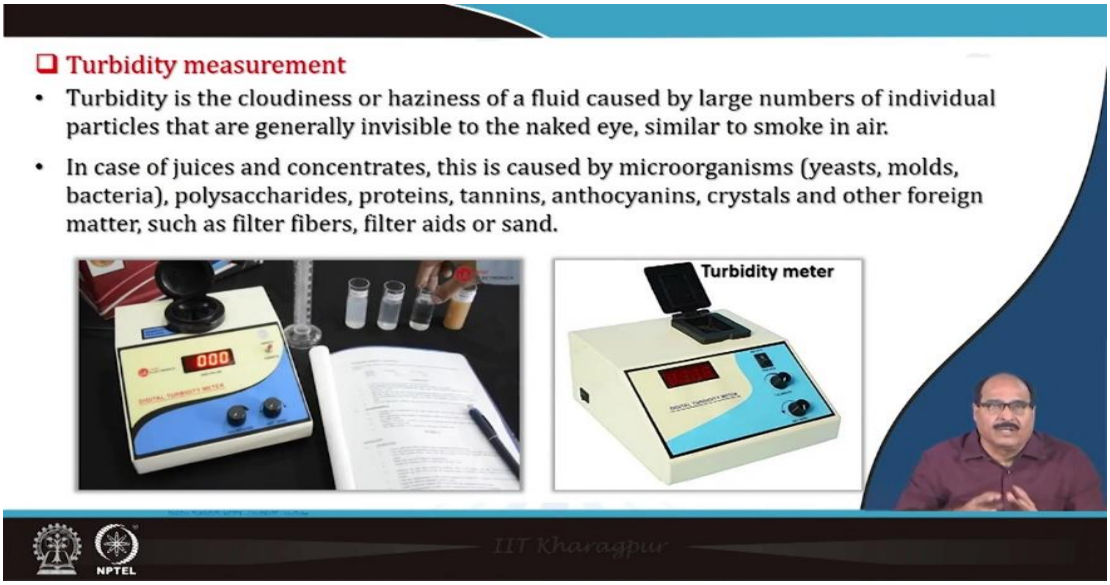
Next with the color of measurement, the color of the fruit juice and concentrate is determined using a spectrophotometer. In the spectrophotometer, there is a light source and this light is a, that is, monochromatic light which passes through the, that is, the cuvette what is used and this light that is absorbance what is the light absorbed that is absorbance is read in the spectrophotometer. The colorimeter is an instrument which measures an amount of light that is sample absorb basically.

The colorimeter works by passing a light beam through a sample to measure the light intensity of the sample and this equation one can use.

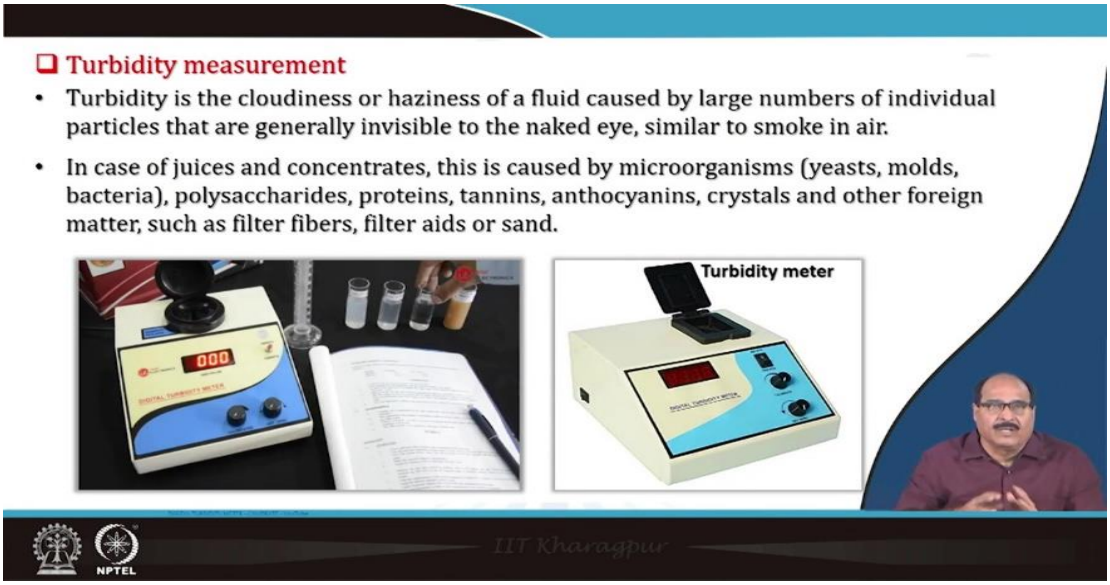
$$\Delta E=\sqrt{(L_2-L_1)^2 + (a_2-a_1)^2+(b_2-b_1)^2}$$

And these are normally told as L, a, b value you can see in the color scale that is a value is when it is minus it is considered to be green when it plus it is considered to be a red. Then similarly, b value in the positive side is considered yellow or negative side it is considered blue, when L is equal to zero it is black or when L is equal to 100 it is white. This was, these are the color scale accordingly L, a, b value are determined using the colorimeter and then this in delta E that is color value is calculated using this equation. The principle is shown here also in the schematic diagram.

Turbidity Measurement



Then turbidity measurement is another. Turbidity is the cloudiness or heaviness of a fluid caused by a large number of individual particles that are generally invisible to the naked eye. It is they are similar to smoke in air. In case of juices and concentrates, this is caused by microorganisms, yeast, molds, bacteria, their presence or even polysaccharide particles, protein, tannins, anthocyanins are sub crystals of other foreign matters such as filter fibers, filter aids or sand. So, other things might be present in the smaller quantity: the colliders suspended part or these particles may be, so they may give the juice turbidity. So that turbidity of the juices is determined using turbidity meter.



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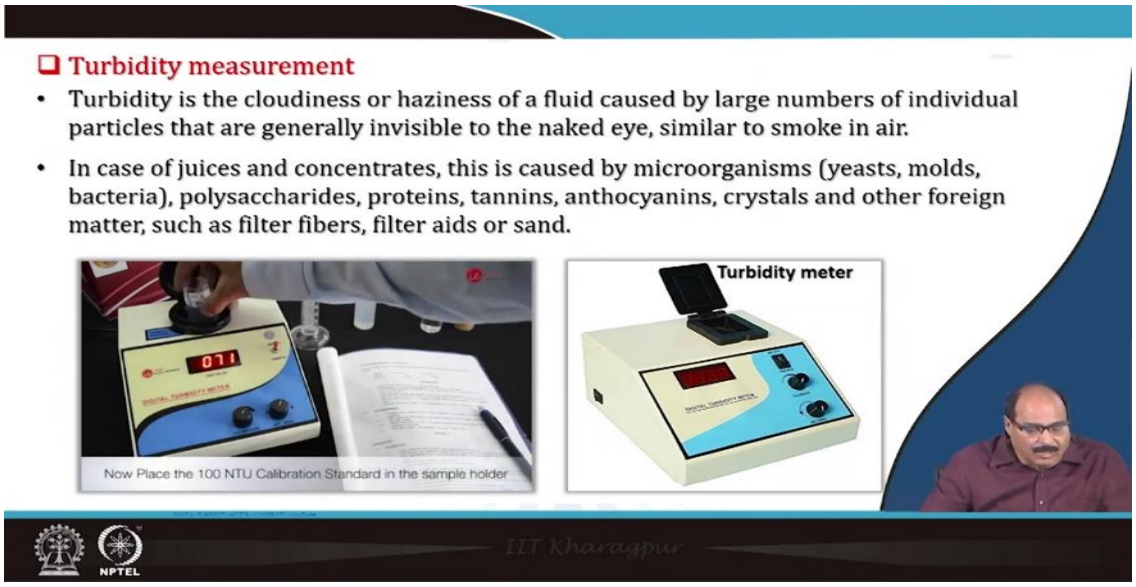
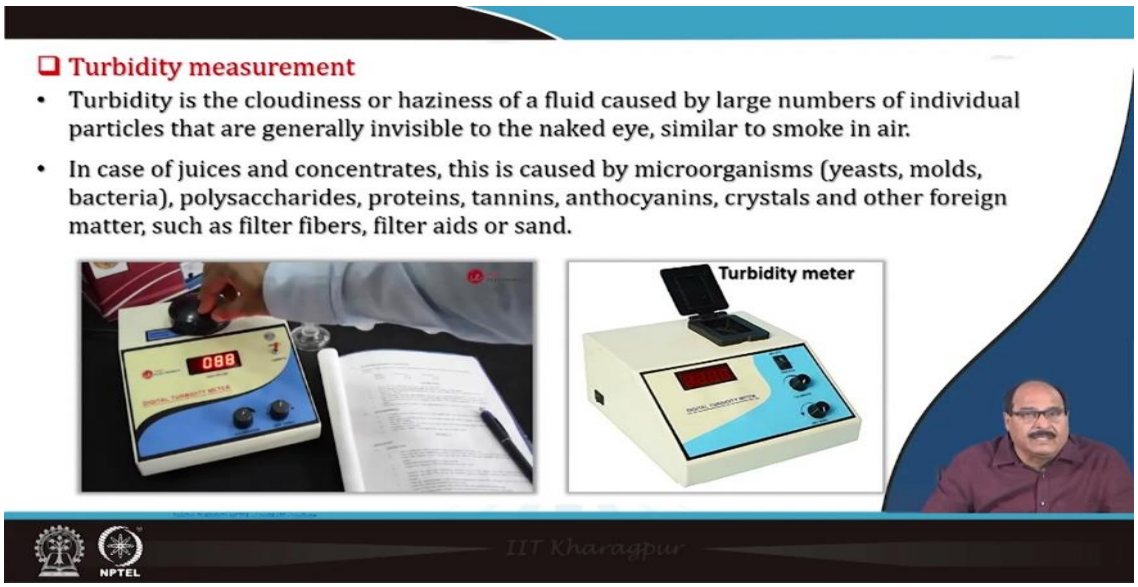
Consider the principle of how it is turbidity meter works past the equipment is calibrated. Again that is this reading put the zone and the reading is brought zero then rotate the calibration knob to the next to the center position. Adjust the zero knob, so that they now it is showing zero.





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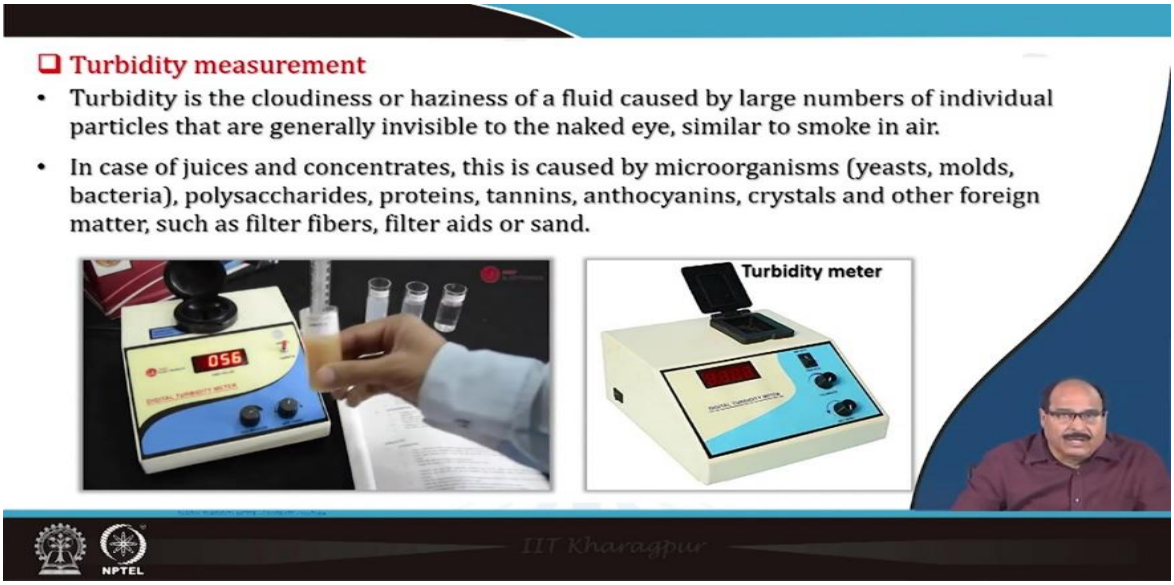
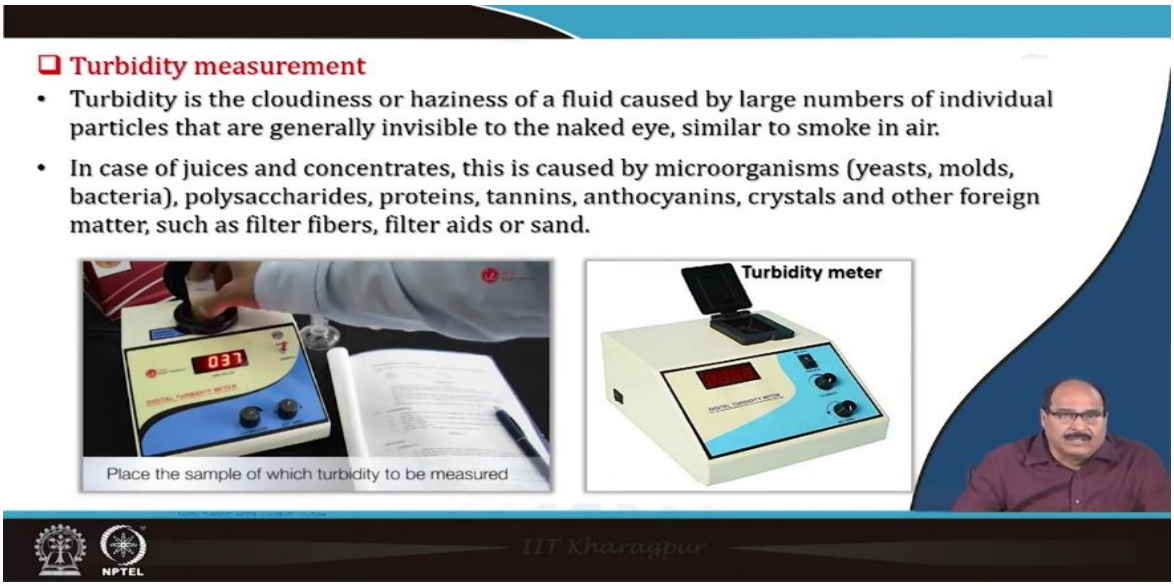
Then now place the 100 NTU calibration solution and again now is adjust the knob rotate the knob adjust to 100. So, the first it was calibrated to zero then it is calibrated to 100.





Turbidity measurement

- Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air.
- In case of juices and concentrates, this is caused by microorganisms (yeasts, molds, bacteria), polysaccharides, proteins, tannins, anthocyanins, crystals and other foreign matter, such as filter fibers, filter aids or sand.

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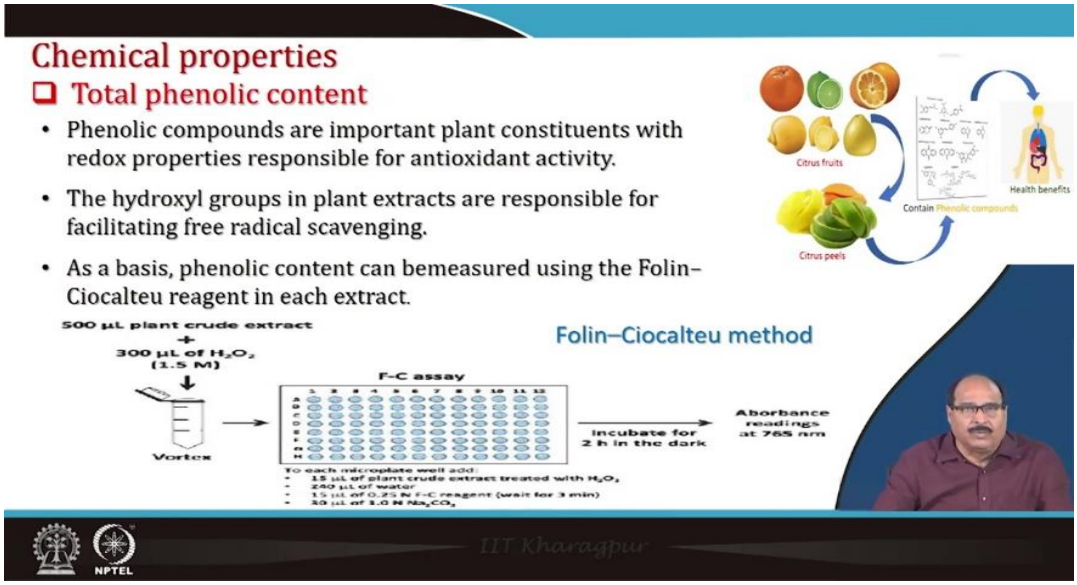
So, now actual solution is put into the juice or concentrate and it will give directly the reading it will give. Now, this has the 126 NTU is the turbidity of this sample. So, this way one can find out the turbidity sample.

Chemical Properties

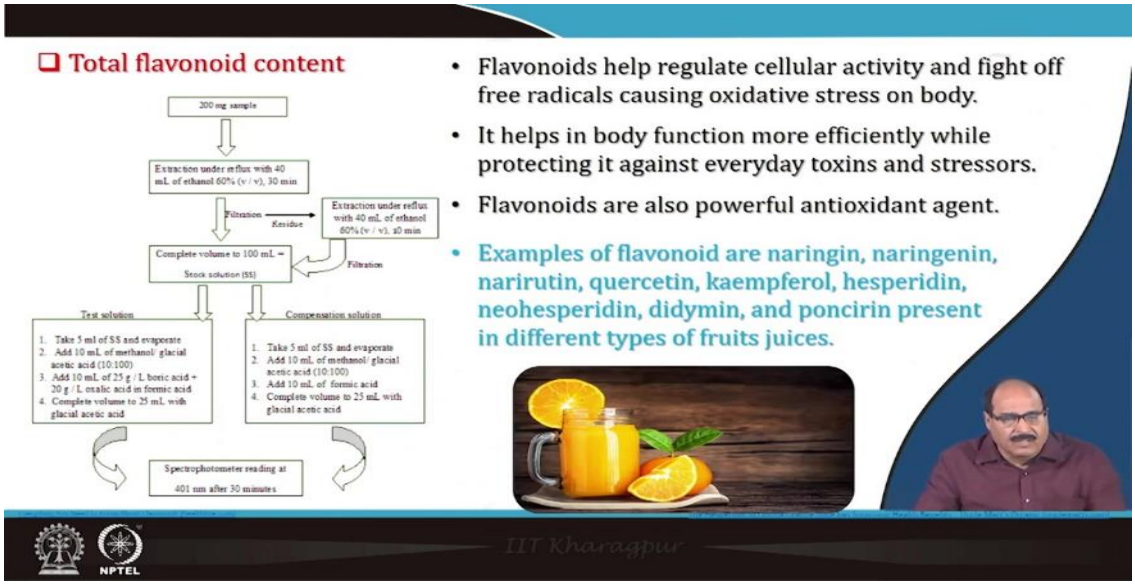
Total Phenolic Content



Now, we will discuss chemical properties. In the chemical properties total phenolic content is very very important. The fruit juices and concentrate vegetable juices concentrate et cetera: they are known for their antioxidant potential and these antioxidant value are due to the presence of various phenolic components. So, the total phenolic total phenol content of the sample is analyzed and it gives an idea about the antioxidant capacity of the component.

Phenolic compounds are important plant constituents. So, the hydroxyl group in the plant extracts are responsible for facilitating the free radical scavenging as a basis phenolic content can be measured using Folin-Ciocalteu reagent in the extract. So, that is about 500 microliter plant a crude extract is taken and in this 300 microliter of hydrogen peroxide maybe 1.5 molar is used and it is properly what extent mixed uniformly and after that it is put on the FC assay. Then FC assay, you can see that to each of the microslit will add about 1.5 µL of the plant crude extract treated with H_2O_2 or 240 µL of water, 15 microlitre of 0.25 N F-C agent, wait for 3 minute and then add 30 microliter of 1 N Na_2CO_3. Incubate it for 2 hours in the dark and then read the absorbance spectrophotometer at 760 nm and these absorbance readings are then matched with the standard curve one can then find out the total phenolic contents.

Total Flavonoid Content

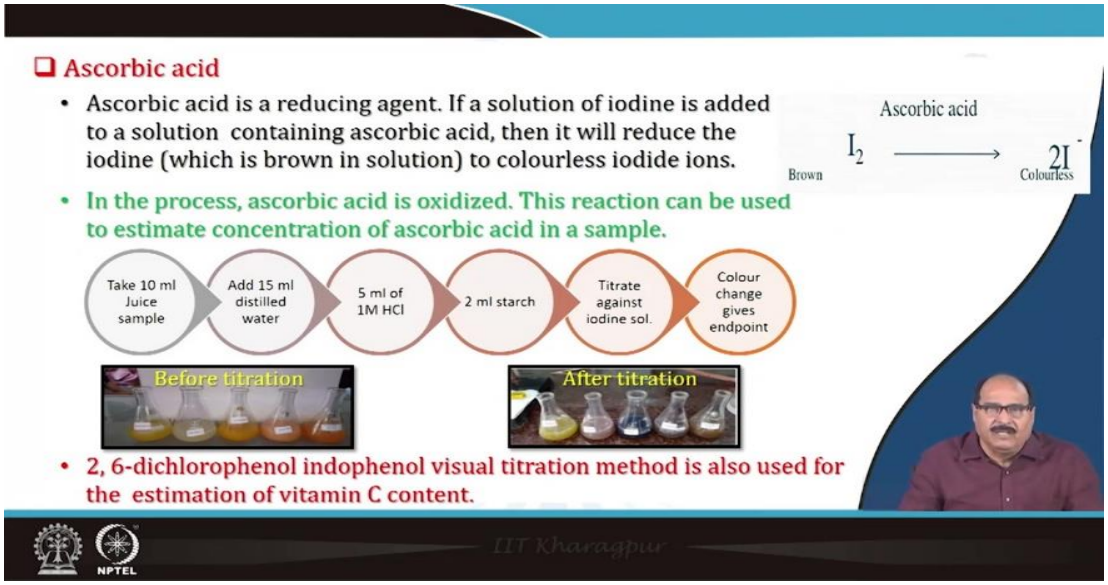


And total flavonoid content accordingly. Flavonoid help regulate cellular activity and fight off free radicals causing oxidative stress on the body. It helps in body functions more efficiently while protecting it against everyday toxins and stressors. Flavonoids are also powerful antioxidant agents. Examples of flavonoids are naringin, quercetin, kaempferol, hesperidin, neohesperidin and poncirin present in the different types of fruit juices et cetera. So, these are total flavonoid content, but their determination method is given briefly described here in the slide.

You can take 200 milligram of sample, extract it under reflux with 40 ml of ethanol, 60 percent volume by volume and filter it that you get the whatever that extracted there again it is reflux with 40 ml of ethanol, 60 percent value for 10 minutes and both are mixed you get the complete volume 100 ml and then this is tested. Test solution and compensation solution. Finally, the spectrophotometer reading is observed at 401 nanometer after 30 minutes using the either test solution method or compensation solution method that is the process is given here you can read.

So, this is absorbance spectrophotometer reading recorded and for always spectrophotometer reading one has to also prepare a standard curve and the data obtain if the sample is read compared with the standard curve.

Ascorbic Acid

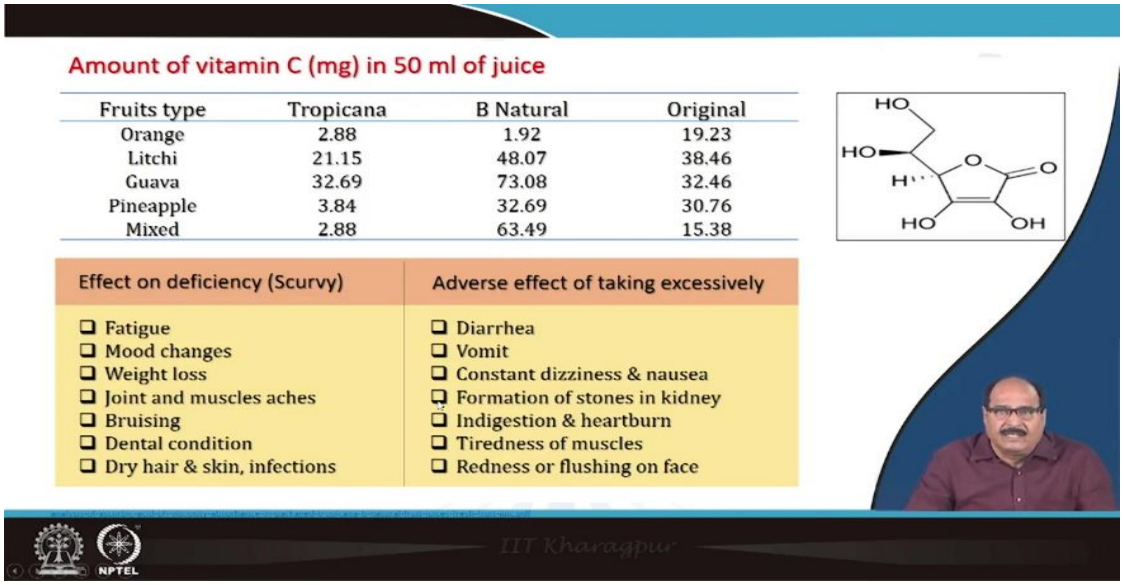


Then ascorbic acid determination. L-ascorbic acid is a reducing agent. If a solution of iodine is added to a solution containing ascorbic acid, then it will reduce the iodine which is brown in solution to colorless or the colorless iodide ions you can see here the equation that is iodine which is brown after reduction it becomes to iodide which is a colorless. So, in this process the ascorbic acid is oxidized and this reaction can be used to estimate concentration of ascorbic acid in a sample.

So, normally you take around 10 ml of the juice sample or concentrate sample which can be concentrated can be diluted, then add 15 ml of the distilled water, take 5 ml of 1 M hydrochloric acid, 2 ml starch and titrate against iodine solution. So, this is the starch iodine reaction and you get in color is gives the endpoint and then one can calculate how much this can be considered there. Alternatively, that 2, 6-dichlorophenol indophenol, visual titration method is also used for the estimation of the vitamin C content in fact, the more frequently used the method in the chemical laboratory in the food industry, which is the 2, 6-dichlorophenol indophenol.

So, this is also the principle of this is also that this dye is reduced by the ascorbic acid and once first one has to calculate the dye factor that is a dye solution of standard known concentration is titrated with the known concentration of ascorbic acid and the dye factor is calculated and then in the unknown sample, it is evaluated using the titrated using the dye and then one can find out calculate the vitamin C content or ascorbic acid content in the sample.

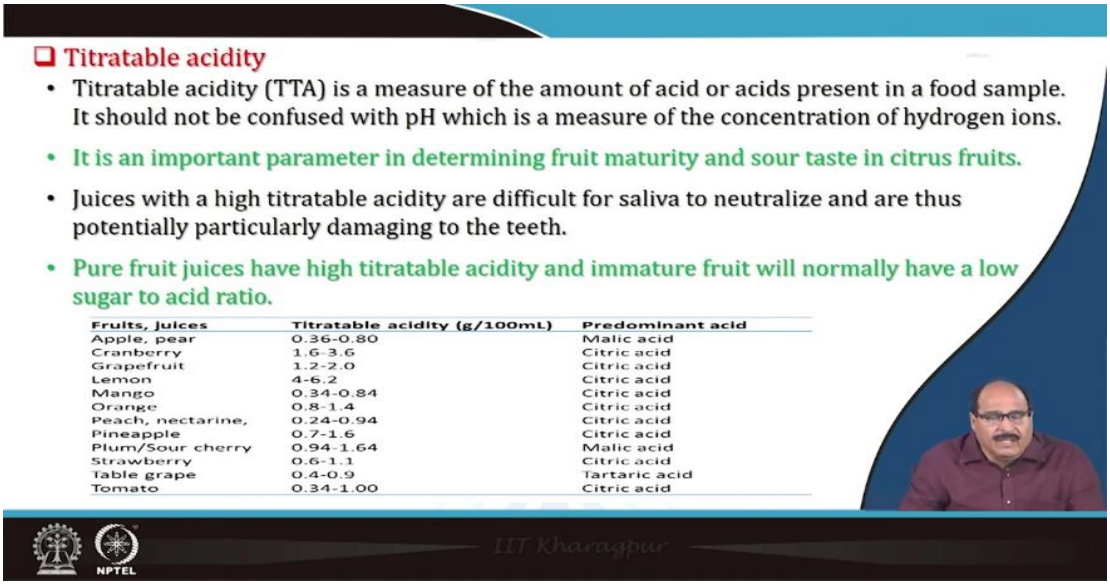
Amount of vitamin C (mg) in 50 mL of juice



So, in this slide I have given this is the figure that is the formula of ascorbic acid and normal vitamin C content in the common fruit juices like orange, litchi, guava, pineapple are that is mixes fruit juices. It may range from around 15.38 milligram to about 38 or 40 milligram like litchi juice contains around 38.46 milligram and that the pineapple juice may contain 30 milligram or so. The ascorbic acid is a very important component, if it is a deficient in our diet, it causes various problems like scurvy, the major disease caused by the deficiency of ascorbic acid, it's symptom may be fatigue, mood change, weight loss, joint and muscle ache, bruising, dental conditions, may be wet or dry hair and skin infections et cetera. These might be the latter problems.

Similarly, sometimes if you take excessively more amount of ascorbic acid that may also sometime cause some problem like redness or the flossing and face that formation of stones in kidney, indigestion and heatburn et cetera and so on.

Titratable acidity

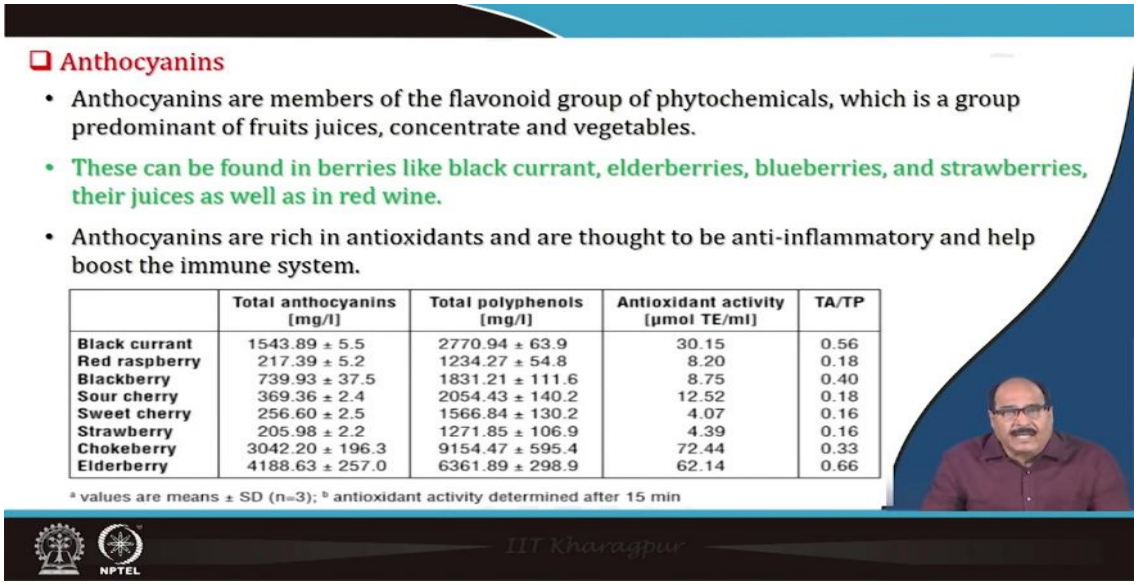


Then the titratable acidity is another important quality attributes. It is a measure of the amount of acid or acids present in the food sample. It should not be confused with pH which is the measure of the concentration of hydrogen and pH is the measure of concentration of hydrogen ion whereas titratable acidity gives an idea about the amount of acid present. It is an important parameter in determining fruit maturity and sour taste in the citrus foods. Juices with a high titratable acidity are difficult for saliva to neutralize and are thus potentially particularly damaging to the teeth.

So, pure fruit juices have high titratable acidity and immature fruit juices will normally have a low sugar to acid ratio. So, these are other fruits that is this is just standard that is the acidity is found out by normal titration with a standard sodium hydroxide solution and the acid value is calculated that is based on the particular acid like in the case of apple, pear it is the standard acid is used as a malic acid; in citrus fruit it is citric acid.

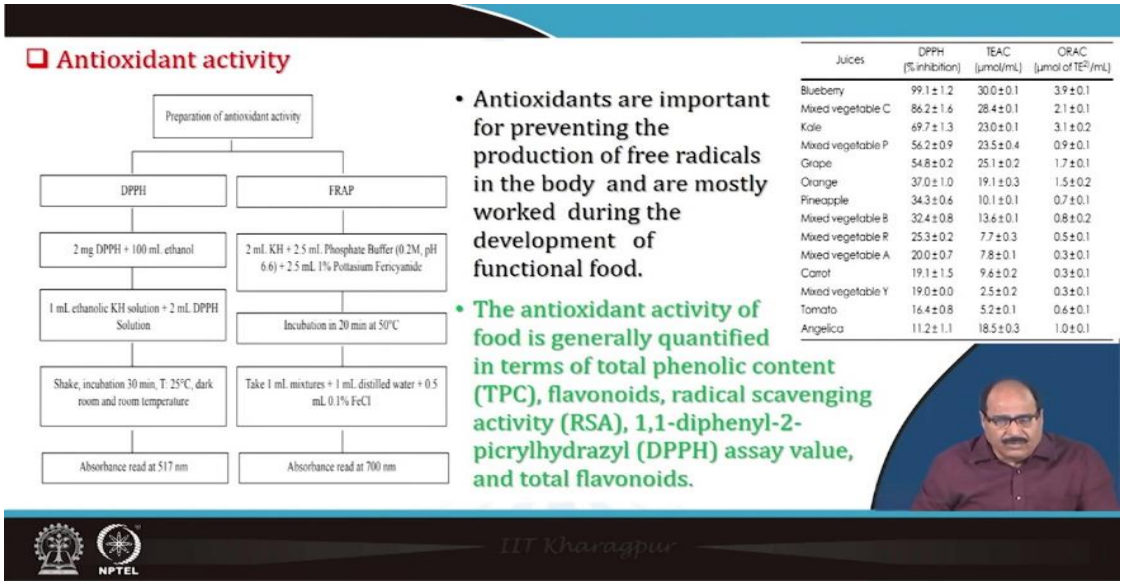
In this strawberry also citric acid, in the grape it is the tartaric acid, so their equivalent weight of these acids is used to calculate that is the tartaric acid will be good at reading to convert it into the percent acidity and the acidity of the fruits and vegetable juices, their concentrates are always expressed in terms of a particular acid that is as I told you in the grapes, it is percent tartaric acid, in the apple percent malic acid, in tomato percent citric acid and so on.

Anthocyanins



Then anthocyanin content. They are anthocyanins are member of flavonoid groups of phytochemicals, which is a group predominant fruit juices, concentrates and vegetables and this can be found in berries like black currant, elderberries, blueberries, strawberries et cetera and they are juices as well as in the red wine, anthocyanins are the positive component. So, these anthocyanins are rich in antioxidants and are thought to be anti inflammatory and help to boost the immune system.

Antioxidant activity

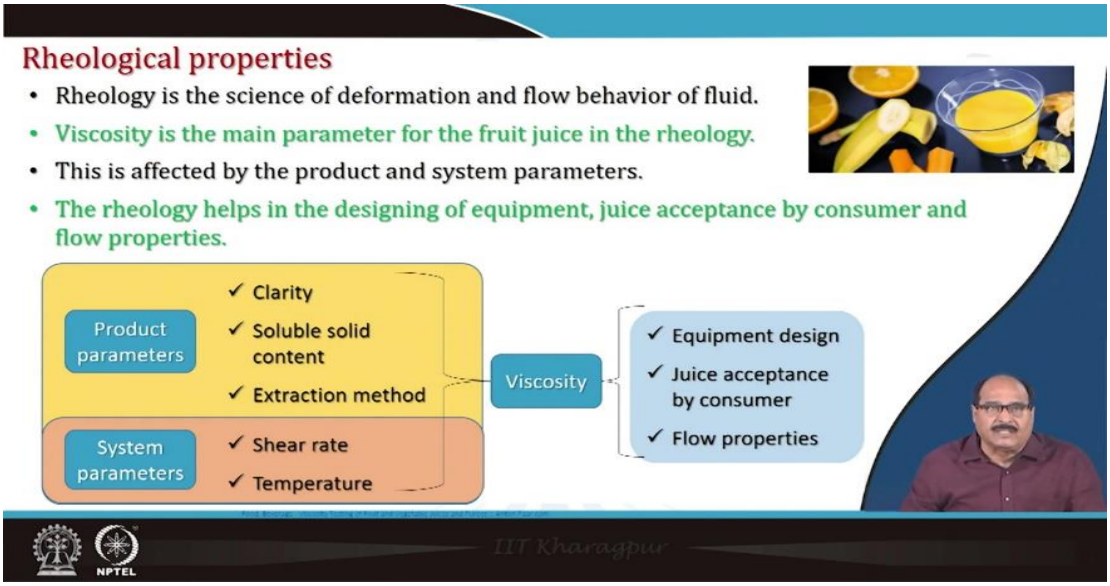


In the table, I have given certain subtotals anthocyanin, total polyphenol, then antioxidant activity and what is the how the TA, TP ratio influences the antioxidant activity in the commodity. So, for the determination of antioxidant activity there is a it is quantified generally in terms of total phenolic content like TPC or that flavonoid, radical scavenger activity that is

RSA or 1, 1-diphenyl-2-picryldrazyl that DPPH assay value and even total flavonoid content are also determined. And the method is given here either DPPH assay or FRP assay is used and in the case of DPPH assay using the standard protocol, one can go and read the absorbance at around 517 nm and in the FRAP method FRAP assay absorbance is read at 700 nm.

And these absorbance value then using the standard curve, the total antioxidant capacity is known and here in the some of the common foods like blueberry, vegetable juice et cetera. That is the percent antioxidant of DPPH assay or the TEAC value that is trolox equivalent absorbance capacity or what oxygen radical absorbance capacity, ORAC value is shown after different juices, which gives that a good fairly good idea of the antioxidant potential.

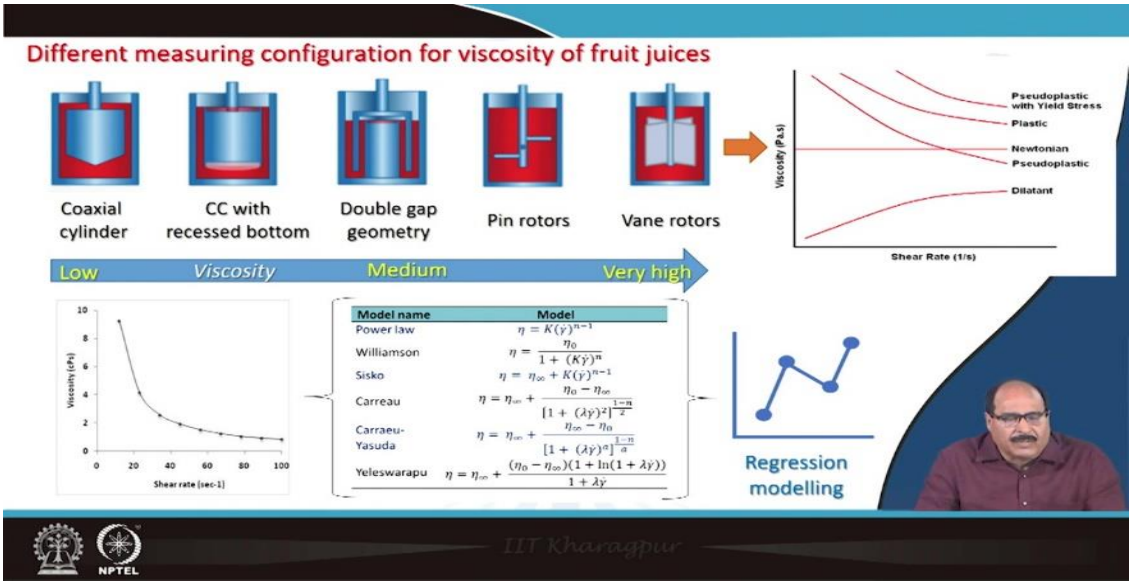
Rheological Properties



Now the rheological property. We will discuss that rheology the science of deformation of flow behavior of a fluid and particularly in the concentrate and juices is an important property discussed in the main parameter of the fruit juice in the rheology. This is affected by the produce and system parameters. The rheology helps in the designing of equipment, juice acceptance by the consumers and flow properties. So, they normally product parameters like clarity, soluble solid content and extraction methods are used as system parameters, shear rate and temperature and all these influence viscosity.

And this viscosity data helps in equipment design and as I told you is the other basis are this one can find out whether acceptability sometime viscosity of the material. It gives an important that is the consumers acceptance et cetera are flow property which is dedicated.

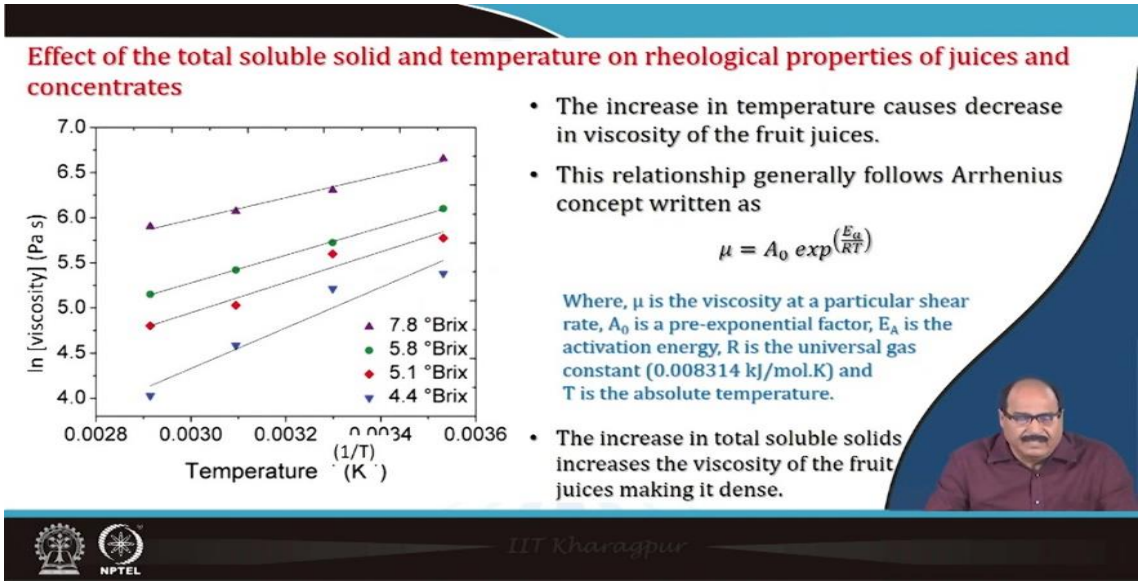
Different measuring configuration for viscosity of fruit juices



So, the different measuring configuration for viscosity of fruit juices is shown here that is the for the juices and concentrate starting from the low viscosity going towards high very high viscosity either coaxial cylinder or coaxial cylinder with recessed bottom, double gap geometry that is this device or pin rotors or vane rotor they can be used for to measure the rheology that is the system to measure this viscosity and then a curves was that is the viscosity and shear rate can be drawn you can see here in this figure that different solutions that the juices are concentrate which either they are dilatants or pseudoplastic. Newtonian that is Newtonian is just you see the parallel with the x is the or it may be plastic or pseudoplastic with yield stress so various behaviors and the data the viscometer one can use the various models are there like power law model, Williamson model, Sisko model, Carreau and so on.

There are various models and these data can be used and regression modeling then again graph can be generated and this gives the rheological various values can be calculated accordingly.

Effect of the total soluble solid and temperature on rheological properties of juices and concentrates



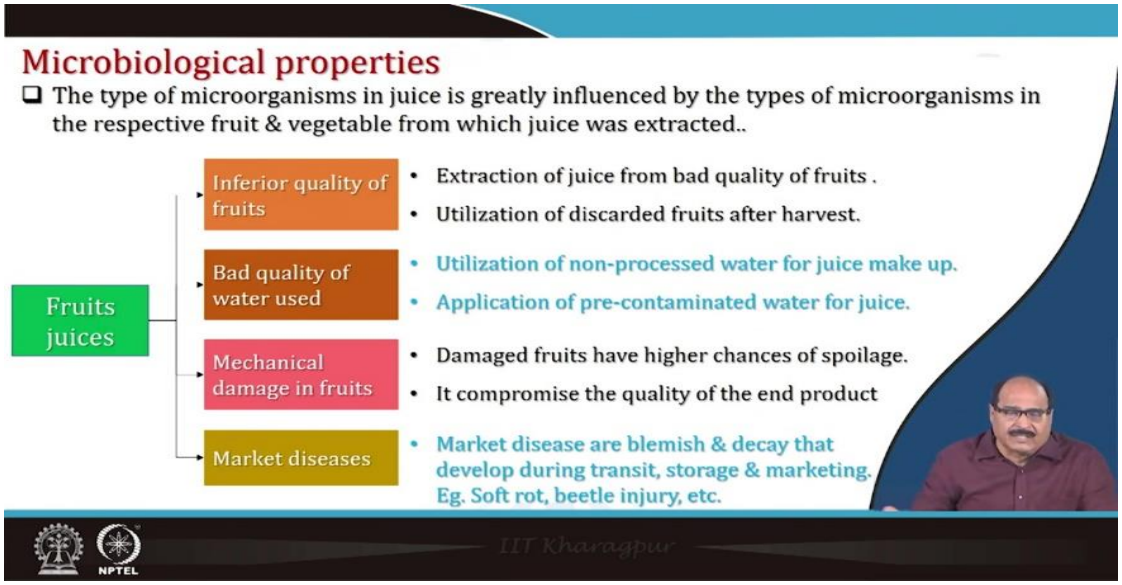
So, this is here the effect of total soluble solids and temperature on the rheological properties of the juices and concentrate is shown in this figure. The increase in the temperature as you can see in the figure it will causes the decrease in the viscosity of the fruit juices. And this relationship generally followed Arrhenius concept which written as:

$$\mu = A_0 exp(\frac{E_a}{RT})$$

Where, μ is the viscosity at a particular shear rate, A_0 is a pre exponential factor, E_a is the activation energy and R is the universal gas constant, T is the absolute temperature.

So, the increase in the total soluble solid increases the viscosity of the fruit juice and therefore, if the viscosity is more or total soluble salt content is more the fruits becomes more dense. So, the concentrates normally they have higher viscosity.

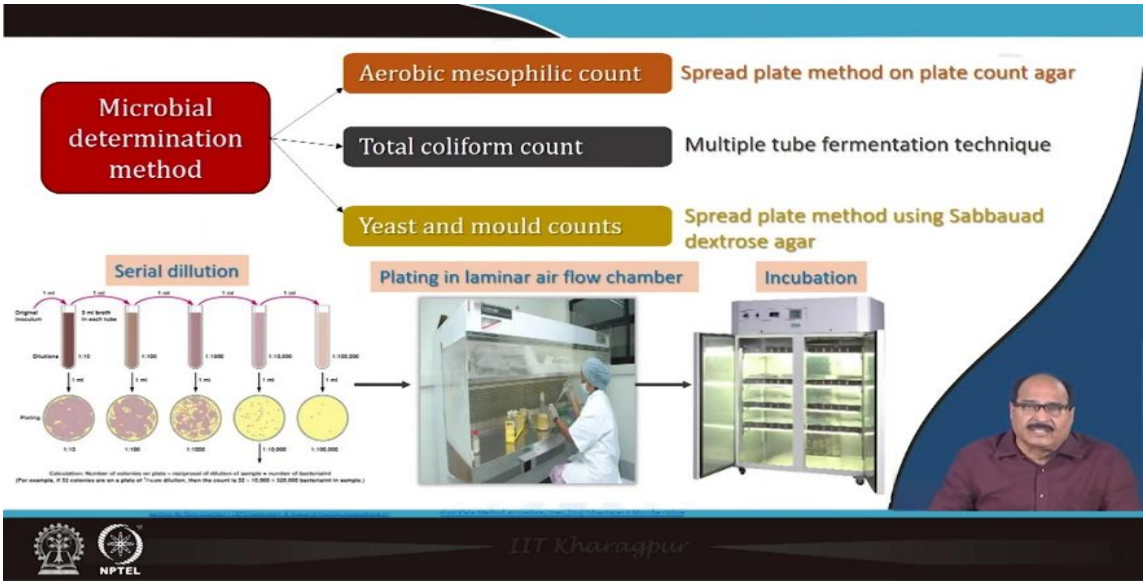
Microbiological Properties



Then you come to the microbiological properties. The type of microorganism in juice is generally influenced by the type of microorganisms in the respective fruit and vegetable from which juice was extracted and this there may be in the microbiological quantity is not good that it may be fruit maybe of, if the juice is prepared from the inferior quality of the fruits, then extraction of the juice from the bad quality of the fruit or utilization or discarded fruit after harvest.

If for the juicy extraction non-processed water is used to make up the juice or application or pre-contaminated water for the juice then also it may give that microbiological higher microbial count. So, these are there is the bad quality of water used maybe another factor then mechanical damage in the fruits also sometime there is the damaged fruits have higher chances of spoilage or it compromises the quality of the end product et cetera. Even market diseases, market diseases like blemish and decay that develop during the transit, storage and marketing like soft rot, beetle injury, et cetera, they also influence the microbiological properties, have more microbial count and then they may lead to the toxic metabolites generation.

Microbial determination method

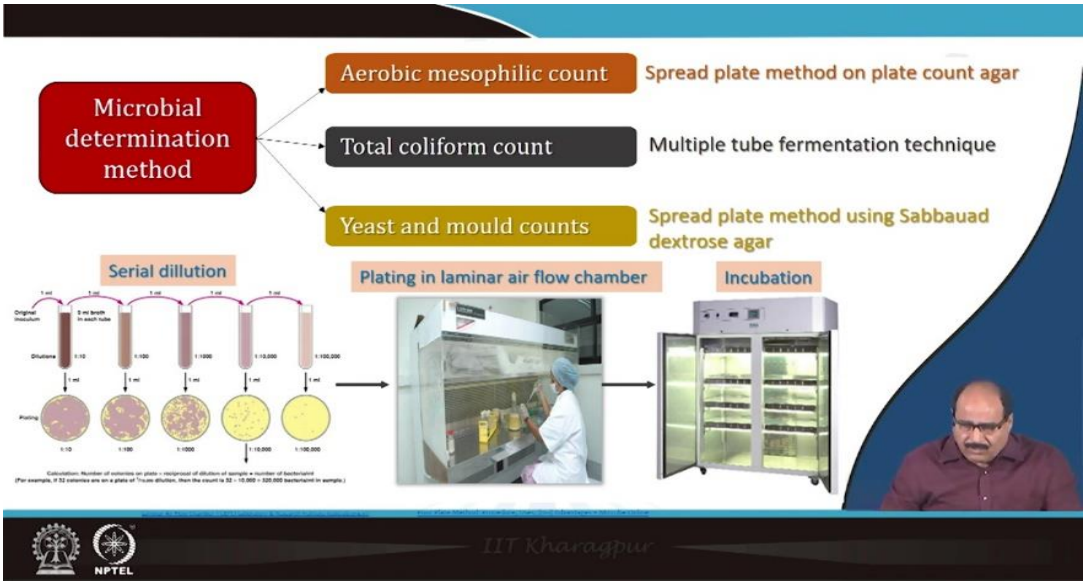


So, for the determination of the microbial number, in the laboratory, in the fruit cardinal such laboratory normally that is aerobic mesophilic count which we also can say that total plate count that is just spread plate methods on plate count agar media is used. So, then to total coliform count is also used by multiple tube fermentation techniques or a plate count method also is used for coliform count determination. But the media is a special, in this then yeast and mold count here also a spread plate method using Sabbauad Dextrose Agar. So, all these things that is split plate methods can be used, but using a specific media and even the same method can be used a similar technique can be used or getting measuring specific microorganisms also, pathogens, et cetera using standard media and standard incubation conditions.

So, a serial dilution method is normally used where that sample is taken and it is diluted easily, so, that you can get a statistically countable number in the plate. So, the plate in this region 10^4, 10^5, 10^6 dilution region that is the serial dilution is used. And then there is a category that 1 ml of these various diluted samples are used in the taken and the particulate in the particulates especially media use and then media that has some solidified agent like Agar-Agar are there.

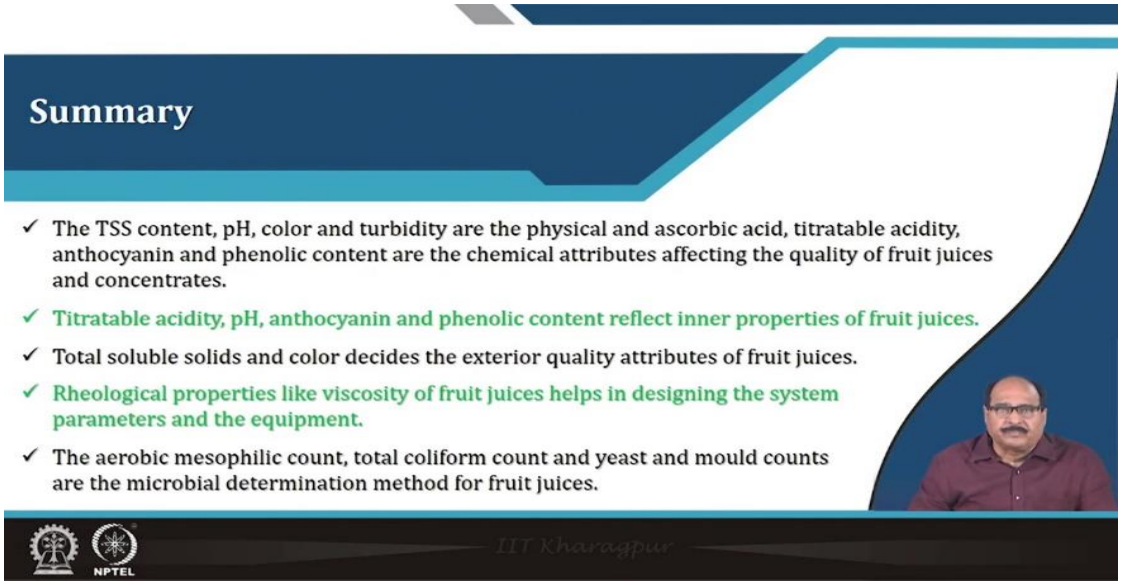
Then it is this once the sample is prepared in the laminar air flow chamber that is sample is poured or media is poured and then it is once the it is solidified it is put into the incubator for incubator which is set at particular temperature that is required for the micro organism like with a coliform count or total counter aerobic mesophilic count et cetera for aerobic media mesophilic count normally with a 35, 37 °C is there, for coliform maybe that at 28 to 30 degree, for yeast and mold count also same 25, 28 °C and for the required duration and after that.

So, basically we are taking a sample with unknown amount of these microorganisms and then it is given with the microbial media for the microorganisms to the food of the microorganisms put into the plate and the plate is kept in the incubator means in proper environmental condition is given for the growth of the, so, whatever that numbers are there in the solution sample, the each organism grows there as a individual colony and then these colonies are read by colony counter they are counted and then the data is expressed in number of colony forming unit per 100 ml or per 100 gram as the case may be.



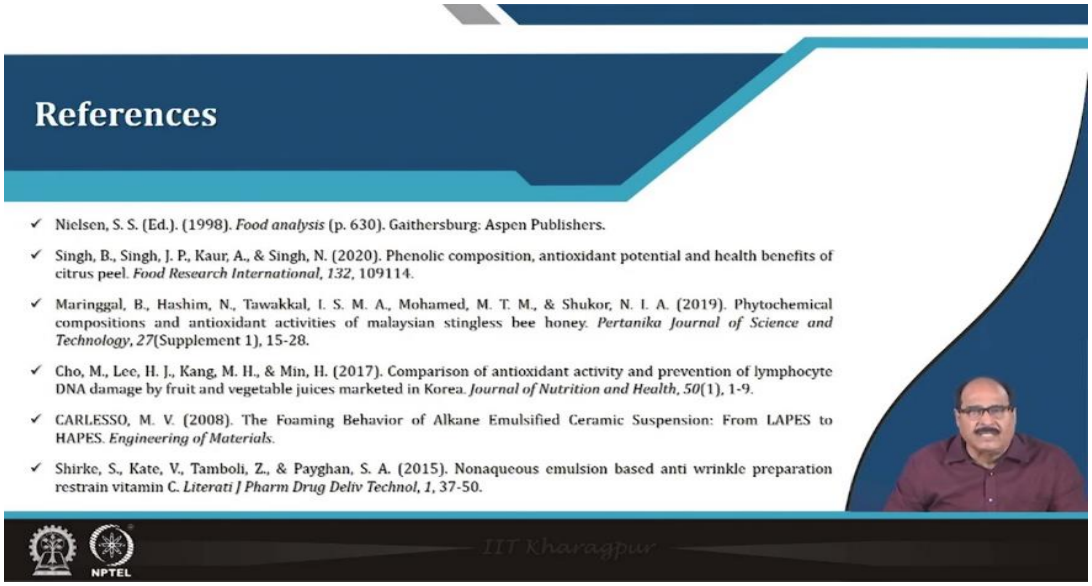
So, this gives that normally that the color values et cetera that it should not be every community there are given a specific number for this amount that as they should not have more than this much and under the regulatory agencies, they have specified normally like in the last class I told you that there should be nil coliform count. If the coliform count is found in any sample it indicates that the sanitary conditions are not properly maintained in the production processing and so on.

Summary



So, this gives now, the, I will summarize that is quality parameters are very very important aspects and this should be standard laboratory methods and protocols should be used to analyze the various quality attributes, both physical chemical, microbiological and then many a times either as a processing aid or these values are written on the label, how to meet the requirement of the regulatory agencies to have the more sale value this quality analysis is done and quality this data of these various attributes are used as per the requirement.

References



So, these are the references which I have used in this lecture. With this thank you very much for your attention.