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

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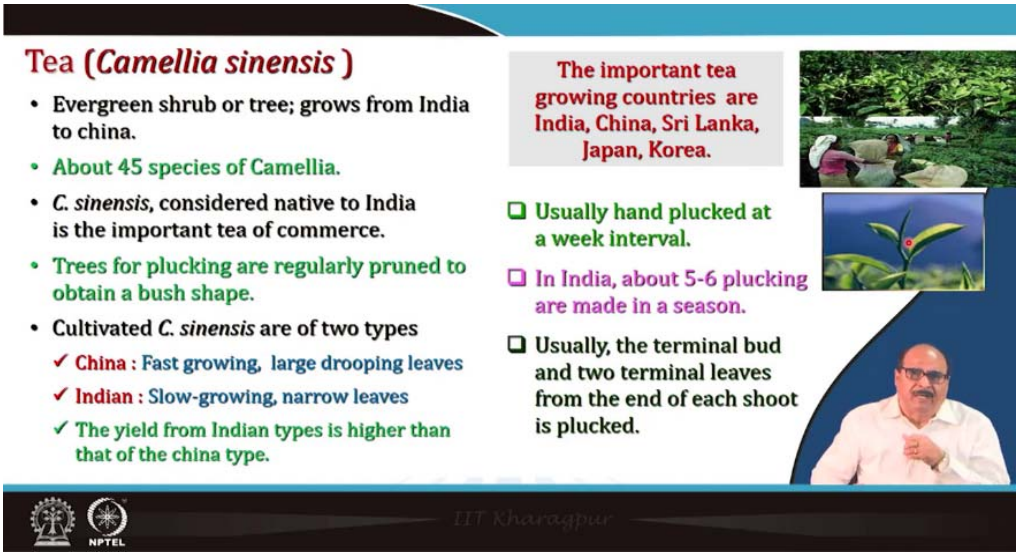
Lecture 36

Tea and Tea Products

Hello, everybody, Namaskar. In this lecture 36 today, we will discuss tea and tea products.

The concept which will be covered in this lecture includes tea chemistry and processing, classification of teas, unit operations involved in tea processing, major machinery used in the tea

processing industry, and finally, we will also discuss some of the novel tea products available in the market.

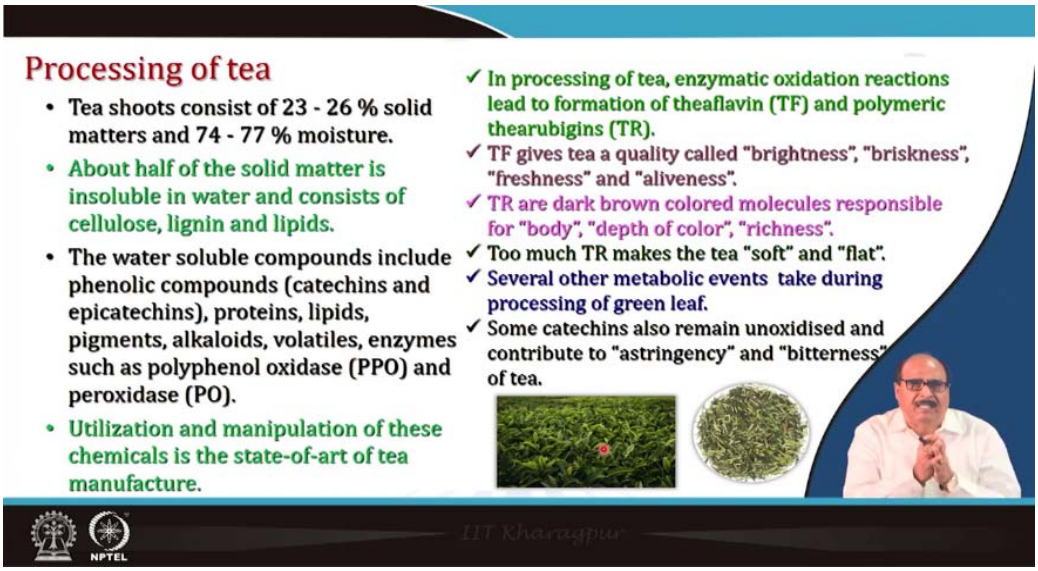


Tea (*Camelia Sinensis*)

So, let us see what is the tea. Its botanical name is *Camellia sinensis*. It is an evergreen shrub or tree, which grows wide from India to China. About 45 species of *Camellia* are known among which the *Camellia sinensis* is considered native to India and is important tea of commerce.

The trees, as you can see here in the figure, are regularly pruned in order to encourage more and more leaf production to obtain a bush shape. The cultivated *Camellia sinensis* are of two types, China type and Indian type. China's type is a fast-growing, large drooping leaves, whereas the Indian type is a slow-growing variety, it has narrow leaves. But the yield from the Indian type is higher than that of the China type.

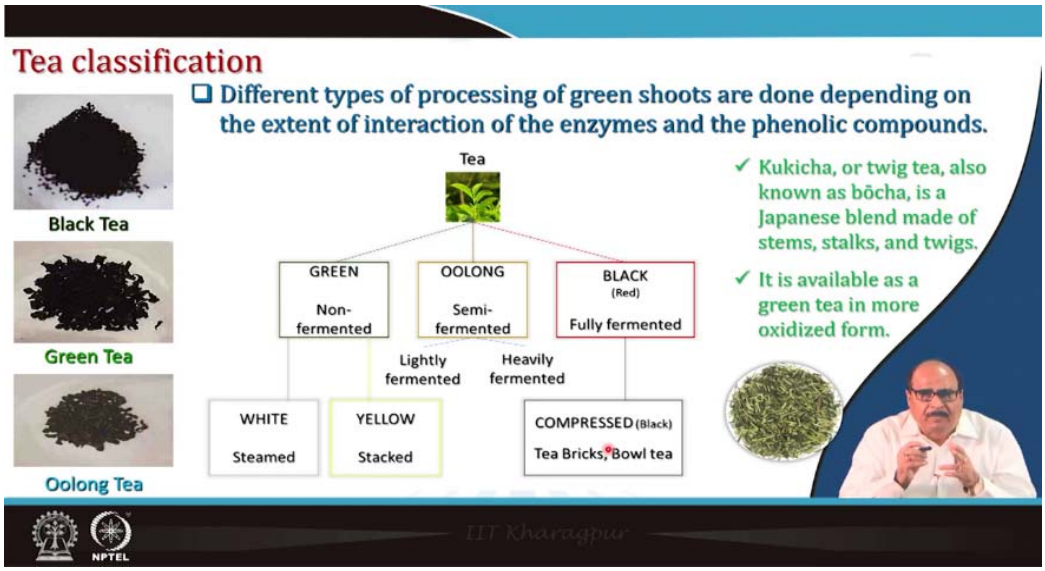
The leaves are usually plucked at a week interval in India about five, six pluckings are made in a season. Usually, you can see the terminal top and terminal bud. The top terminal two leaves from the end of each shoot are plucked. The important tea-growing countries in the world are India, China, Sri Lanka, Japan, Korea, etc.



Processing of Tea

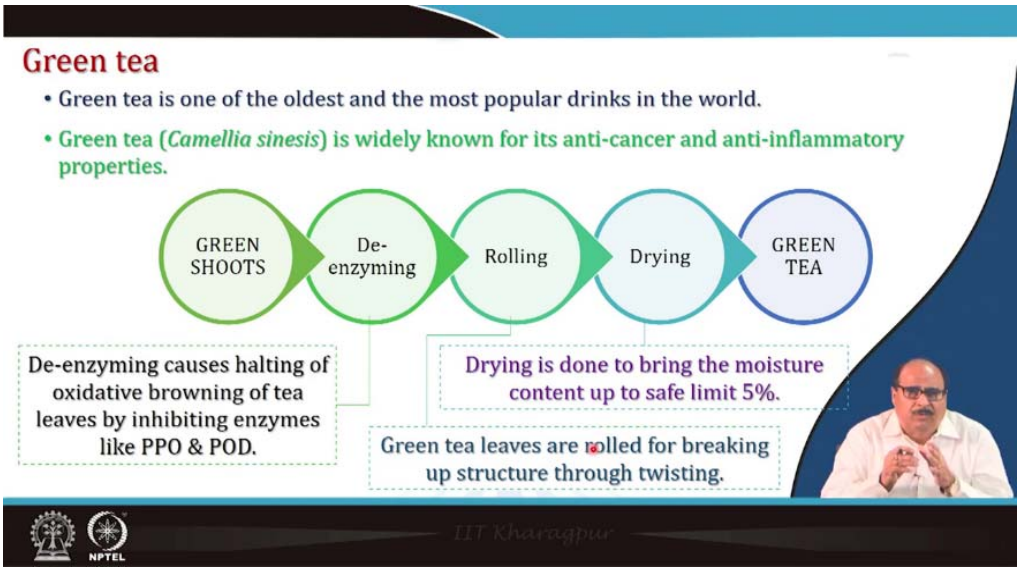
Let us discuss the processing of tea. These green tea shoots consist of about 23 to 26 percent solid, as well as about 74 to 77 percent moisture. So, whatever solid is present, half of that solid is insoluble. Half of the insoluble compounds consist of cellulose, lignin, lipids, etc. and the remaining half consists of water-soluble compounds like phenolic compounds, catechins, epicatechins, proteins, lipids, pigments, alkaloids and the enzymes like polyphenol oxidase, peroxidase and so on.

So, this utilization and manipulation of these chemicals, both water-soluble compounds as well as water-insoluble compounds present in the leaves is a state of the art of tea manufacture. In the processing of tea basically, enzymatic oxidation occurs. In tea leaves, the enzymes and substrates are present in different compartments i.e. in the plastids and vacuoles. So, when the leaves are macerated these cells get broken and then these enzymes and substrates get released from their position and in the presence of atmospheric oxygen, an instant oxidation reaction takes place. There is a formation of theaflavin and polymeric thearubigins. Theaflavin gives the tea its quality called brightness, briskness, freshness and aliveness. Thearubigins are dark brown coloured molecules responsible for body depth of colour and richness of the brew. Too much thearubigins make the tea soft and flat. Several other metabolic events take during the processing of green leaf and some catechins also get oxidized and some remain unoxidized which contributes to the astringency and bitterness of the tea and that is particularly true in the case of green tea.



Tea classification

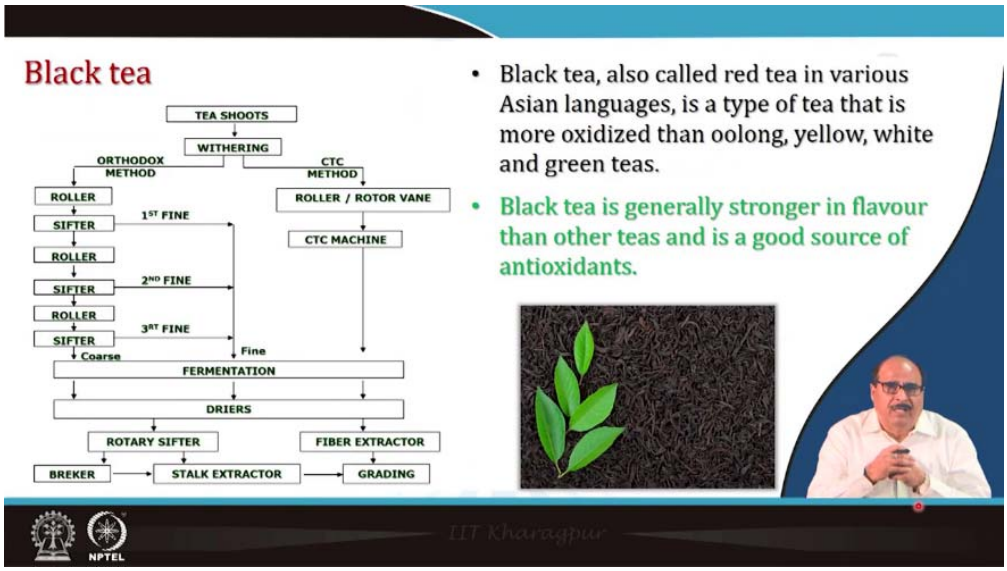
So, the classification of tea, you can see here, depending upon the type of processing of green shoots, i.e. extent of interaction of the enzymes and the phenolic compound, different types of teas are available like black tea, green tea, oolong tea. Green tea is basically non-fermented tea. Oolong tea is semi-fermented and black tea is fully fermented. It is also in some countries, known as red tea. There are also green tea, white tea, yellow tea or even compressed black tea bricks or bowl tea, etc. So, various types of tea are produced in India. In fact, if India is known for one single product, so, it is Indian tea. Worldwide, it has found very good acceptability.



Green tea

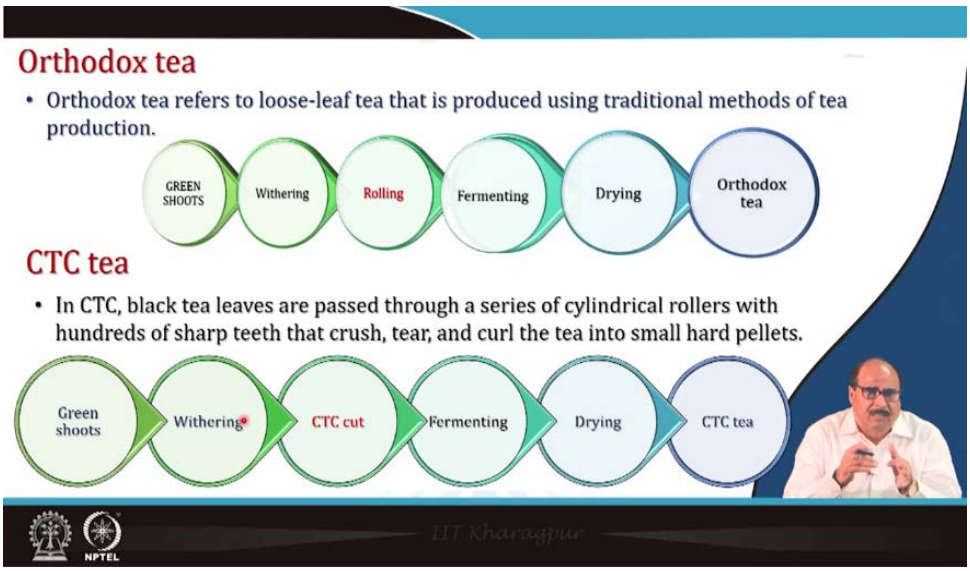
Green tea, as I told you, it is one of the oldest and the most popular drinks in the world. Green tea is widely known for its anti-cancer and anti-inflammatory properties. It has a very good health value. It has a grassy flavour and even grassy colour as well of a little greenish colour. So, what is done basically? These green shoots are taken immediately after harvesting, they are de-enzymed, i.e. they are given some sort of heat treatment either steaming or some other suitable heat treatment so that these enzymes, polyphenol oxidase is inactivated.

After that, it is rolled and dried and you get green tea. So, there is no oxidation here. So, de-enzyming causes the halting of the oxidative browning of tea leaves by inhibiting the PPO and peroxidase and polyphenolic enzymes. The drying is done to lower the moisture content to a safe limit and the rolling, we will see in the later part of the lecture also, green tea leaves are rolled for breaking up the structure through twisting etc. This facilitates further drying and then finally in the preparation of the brew.



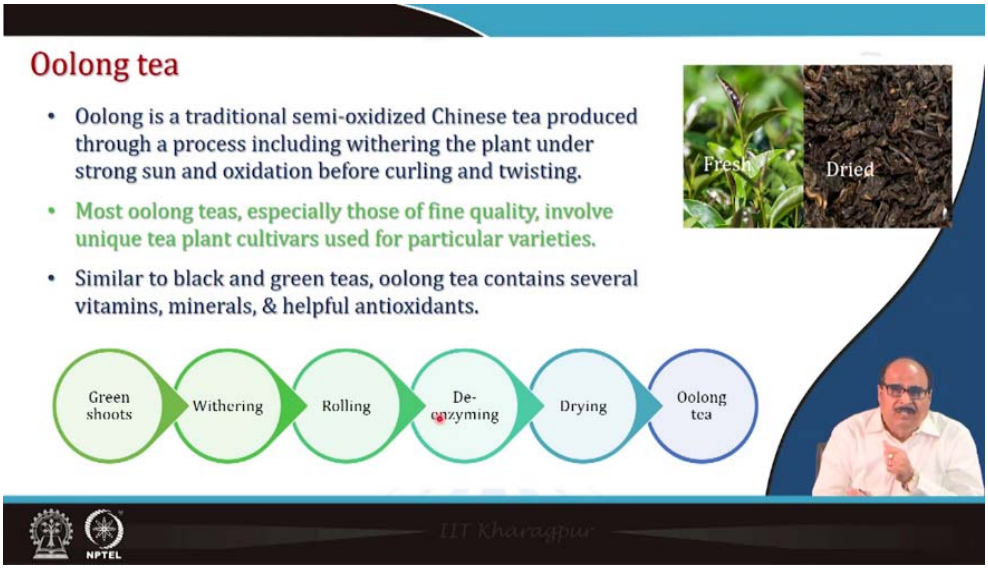
Black tea

Black tea is also called red tea in various Asian languages. It is a type of tree that is more oxidized than oolong, yellow, white and green teas. So, these tea shoots are taken, they are weathered and after weathering either by orthodox method or CTC method, they are prepared and then the cells are broken and finally, these cells are put for the fermentation and the fermented leaves are dried, and then subjected to a rotary sifter or breaker or stalk extractor and finally packaged. So, black tea is generally stronger in flavour than other teas and it is a good source of antioxidants.



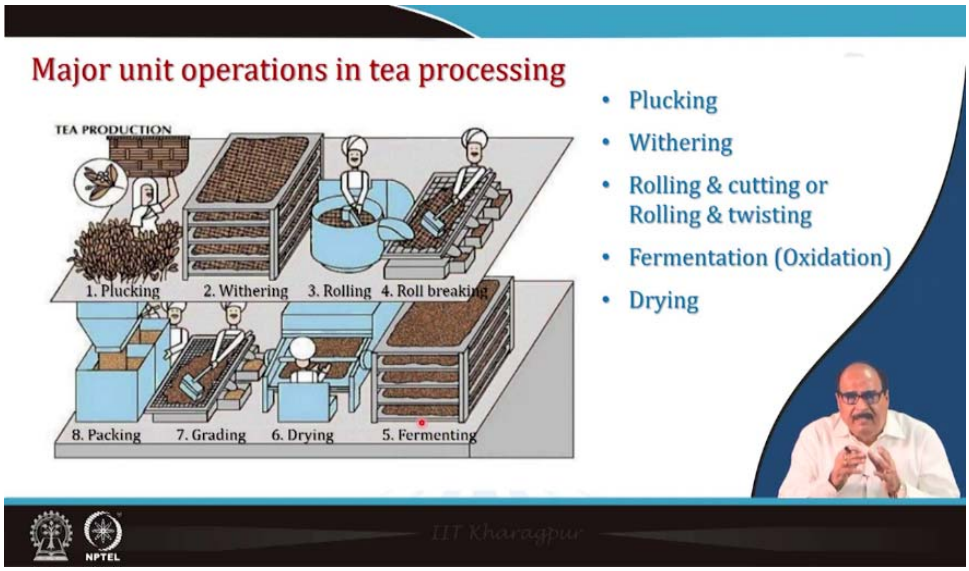
Orthodox tea

Black tea has two types depending upon the type of rolling used, the rolling method is either orthodox or CTC cut. It is prepared in either orthodox tea or CTC tea. In both teas, it is black tea, but the only difference is the method of rolling. In orthodox tea either hand rolling or such other rolling is used whereas in the case of CTC tea, the black tea leaves are passed through a series of cylindrical rollers with hundreds of sharp fresh teeth that crush, tear and curl the tea into a small pellet. So, the extent of the tissue damage is more. The CTC tea you get a large higher number of cups and also the brew has better colour, whereas orthodox tea is known for its better flavour.



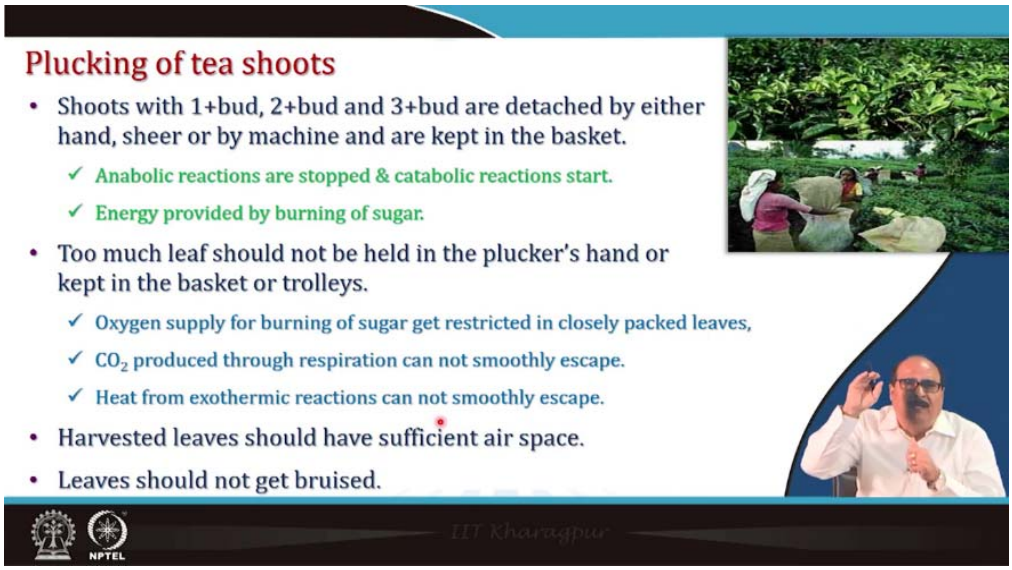
Oolong tea

Oolong tea, as I told you is in between black tea and green tea i.e. after the green tea shoot, they are withered, rolled, and then de-enzymed. There is a partial fermentation and after that, it is dried and you get the Oolong tea. So most oolong tea especially those of fine quality involve unique tea plant cultivars which are used for that particular variety.



Major unit operations in tea processing

Let us discuss the major unit operations in tea processing that include plucking, withering, rolling and cutting or rolling and twisting, fermentation, which is basically enzymatic oxidation, but in the tea industry, popularly it is known as fermentation, and then finally drying and packaging. These are the important unit operations. So, all the operations are very important as far as the quality of the final product is concerned.



Plucking of tea shoots

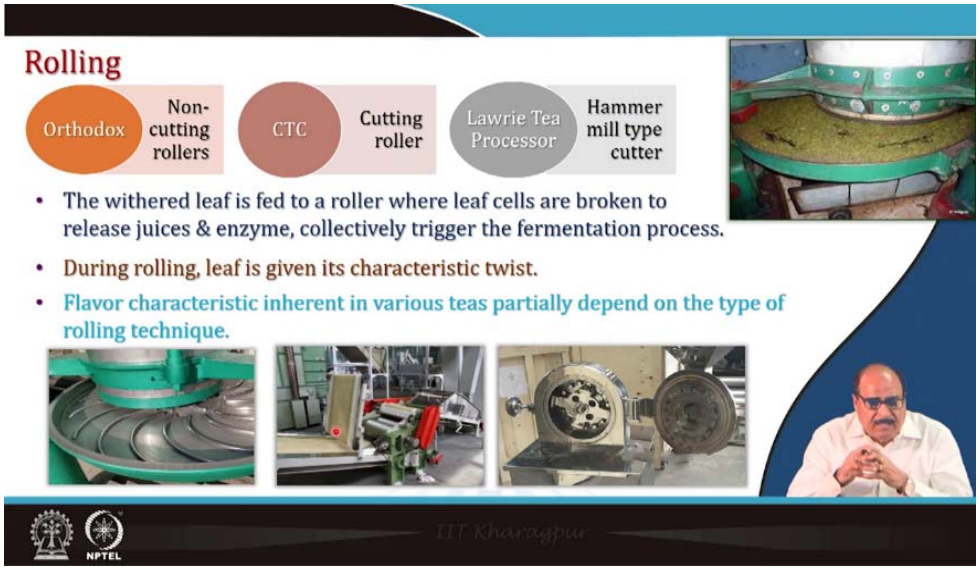
So, let's see the plucking of the tea shoots. As I told you, the shoots with one top bud and top leaf or bud plus top terminal two leaves or bud plus terminal three leaves are detached by either hand, shear or machine and they are kept in the basket. So, let me tell you here, if you go to a lower side, the number like, bud plus 4, bud plus 5 etc., the quantity of the tea will be more, but its quality will be less because in the top bud and terminal leaves, they have higher polyphenolic compounds and they have a better antioxidant and other capacities. So, once the tea leaves are detached from the plant, the anabolic reaction is stopped and catabolic reactions start and the energy for these catabolic reactions is provided by the burning of the sugar. So, care should be taken i.e. too much leave should not be held in the plucker's hand or it should not be kept in the basket or trolleys in too much-pressed form. Because oxygen supply for the burning of the sugar will get restricted in closely packaged leave, closely packed leaves, carbon dioxide produced through respiration will not be able to smoothly escape and heat from the exothermic reactions will not smoothly escape. Therefore, in order to maintain the leaves in their fresh form and suitable for the next operation, withering and rolling, etc., the harvested leaves should be loosely kept and there should be sufficient air space, and care should be taken that leaves should not get bruised otherwise there will be oozing of the water juice and water-soluble compounds also will lose out.

Withering of green tea leaves

The next operation is the withering of the green leaves. The withering is carried out by spreading tea leaves thinly on racks or selves and it is allowed till the water content in the leaf is lowered by approximately 40 percent. The next operation begins after a reduction in moisture by half. In this withering, the leaf becomes flaccid and assumes a velvety appearance. In the withering, sufficient air is applied and waited for a breakdown of large organic molecules into a simple structure.

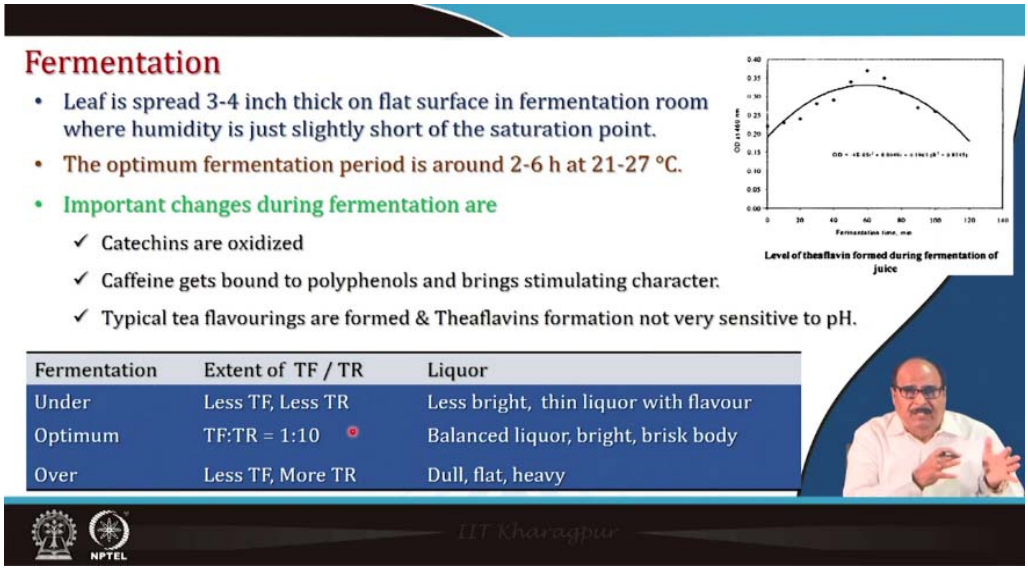
So, almost around 18 to 20 hours or overnight, withering is given and very important, the withering would be optimal. If there is an optimum withering, it will give a balance of theaflavin and thearubigins and the liquor produced from that will be bright and brisk and will have a good body. Overwithered leaves will have less theaflavin but more thearubigins, underwithered leaves will have more theaflavin, and less thearubigins and accordingly the liquor characteristics will also change.

Greenness reduces due to converting chlorophyll to pheophytins. The green colour of the leaf gets a little bit reduced during withering, about half of the moisture is removed from the leave and around overnight, about 18 to 20 hours are given for the conversion of some other product also.



Rolling

So, after withering, the next operation is rolling. As I told you it may be an orthodox roller using non-cutting rollers or CTC cutting rollers or Lawrie tea processor which is your hammer mill tight cutter. The withered leaf is here fed to the roller where the leaf cells are broken to release the juice as well as enzymes. Collectively, it triggers the fermentation process. It starts the fermentation process. The type of roller used, accordingly, the extent of the maceration, the extent of the breakage of the cells, the fermentation also will be there. During rolling, the leaf is given its characteristic twist and flavour characteristic inherent in various teas, particularly depend on the type of the rolling technique. As I told you that orthodox rollers give the best tea, they are best known for their flavouring characteristics worldwide.



Fermentation

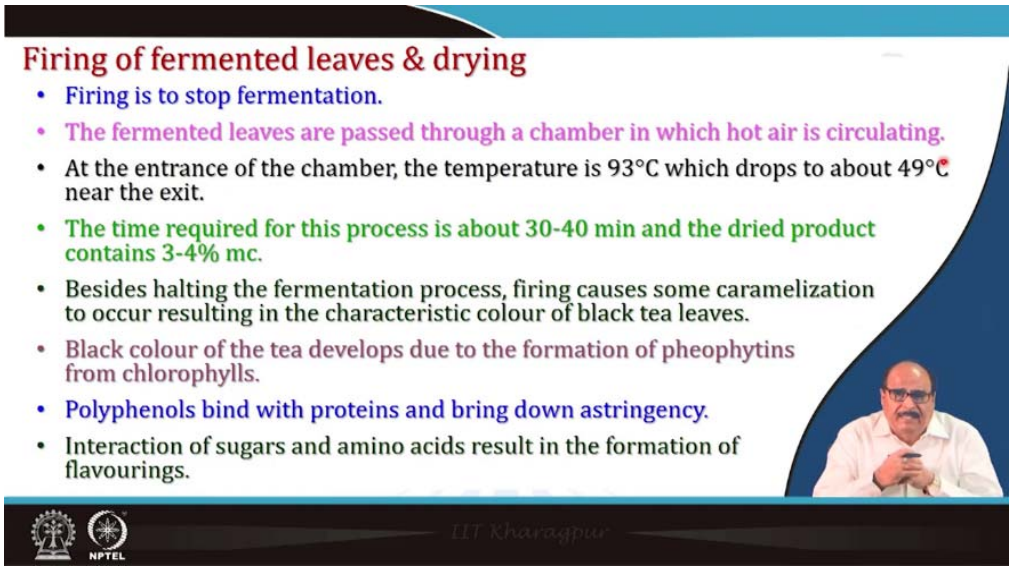
Fermentation means rolled leaves are given sufficient time for the action of the enzymes. The leaves are spread about 3 to 4 inches thick on a flat surface in the fermentation room, where humidity is just slightly short of the saturation point. The optimum fermentation period is around 2 to 6 hours at around 21 to 27 degrees Celsius temperature.

The important changes during the fermentation are that the catechins get oxidized, caffeine gets bound to polyphenols and brings stimulating character to the drink and typical tea flavourings are formed. Theaflavins and thearubigins are formed.

Here you can see that it is the fermentation time and OD, around an hour or so, that the optimum fermentation reaches and when the optimum fermentation comes in the tea brew, the leaf will be coppery brew in colour. If the fermentation is more, the colour will change.

In fact, the theaflavins and thearubigins, because the catechins get oxidized and theaflavins are formed and polymerized. If there is excessive fermentation, more and more theaflavins will be polymerized into thearubigins. So, you will have more thearubigins and less theaflavins. So, the brew prepared from such will be dull, flat and heavy. The optimum theaflavins to thearubigins ratio in properly fermented leaves is reported to be 1:10.

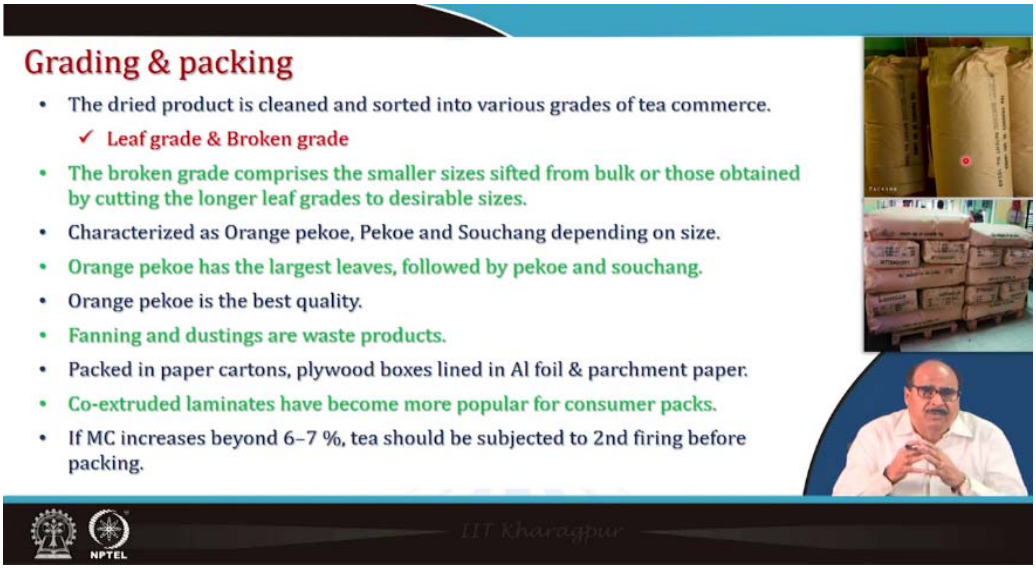
So, it will give a balanced liquor which is bright and has a brisk body. Under fermented leaves will have less theaflavins as well as less thearubigins. That is very important for the quality of the brew when it is properly fermented when it has a copper brew colour. So, it should be immediately, fermentation should be immediately stopped.



Firing of fermented leaves and drying

The next process is firing, process or firing or drying. So, the firing is to stop the fermentation. So, fermented leaves are passed through a chamber in which hot air is circulating and at the entrance of the chamber, the temperature is around 90 degrees plus maybe 93 degrees or 95 degrees which dropped to around 49 degrees Celsius near the exit. The time required for this process is about 30 to 40 minutes and the dried product contains 3 to 4 percent moisture content.

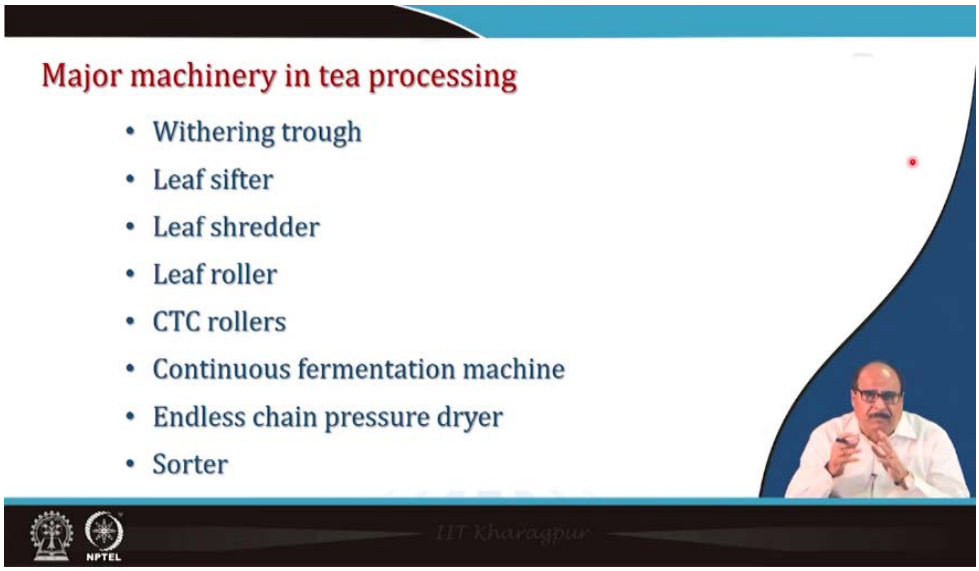
So, besides halting the fermentation process firing also causes some caramelization to occur resulting in the characteristic colour of the black tea leaves. The black colour of tea developed due to the formation of pheophytins from chlorophylls, also polyphenols bind with the proteins and bring down astringency. Interaction of sugar and amino acid results in the formation of flavouring compounds, etc.



Grading and packing

Then, next comes the grading and packaging. So, the dried product is cleaned and sorted into various grades of tea of commerce. There is a leaf grade or broken grade. The Broken grade comprises smaller sizes sifted from the bulk or those obtained by cutting the longer leaf grades to a desirable size. Both the leaf grade and broken grade are further characterized as orange, pekoe, pekoe and souchang depending upon the size. Orange pekoe has the largest leaves followed by pekoe and souchang. orange pekoe is perhaps the best quality. Fanning and dusting are the waste products also which are there.

These are all packed in paper, cartoons, plywood boxes lined with aluminium foil and parchment paper. That is very important, that the packaging material, will be fully water vapour impermeable. Coextruded laminates have become more popular for consumer packs nowadays. It is as per the regulation in India as well, because if the moisture content goes beyond 6 to 7 percent, the tea should be subjected to second firing or second drying before packaging.



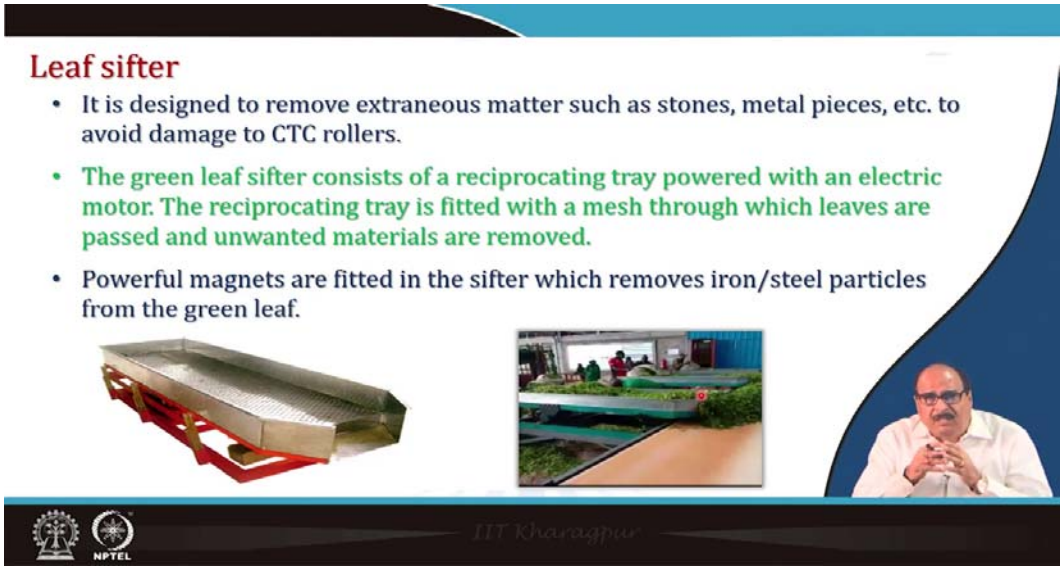
Major machinery in tea processing

Now, let us see briefly the major machinery used in tea processing like a withering trough, leaf sifter, leaf shredder, leaf roller, CTC roller, continuous fermentation machine, endless chain pressure dryer and sorter.

Withering trough

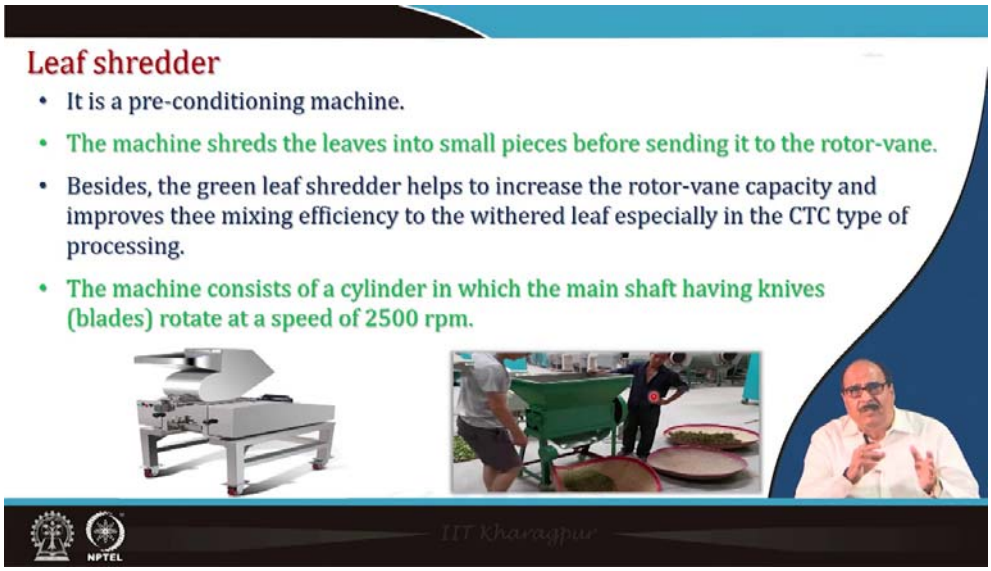
Withering trough, you can see here. Withering trough are used for preconditioning the green leaves. Green leaves from the garden first come to leave the withering house and then spread on

a number of tea withering troughs for several hours, these are wire mesh trays and these tea withering troughs are fitted with the axial flow fan to blow air to the leaves, sometimes vertically, sometimes from the bottom to leave or over the leaves at room temperature so that it facilitates the removal of the moisture.



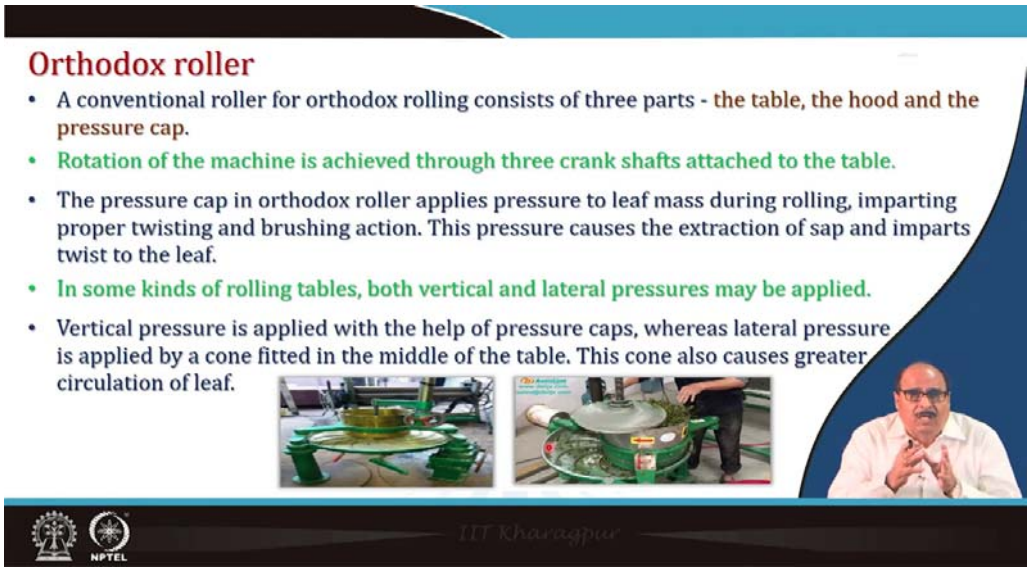
Leaf sifter

Leaf sifter you can see in the figure. It is designed to remove extraneous matters such as stones, metal pieces, etc., to avoid damage to the CTC roller. The Greenleaf sifter consists of a reciprocating tray powered with an electric motor, the reciprocating tray is fitted with a mesh through which leaves are past and unwanted materials are removed. Powerful magnets are also fitted in the sifter which removes some iron or steel parts, etc. if there are any.



Leaf shredder

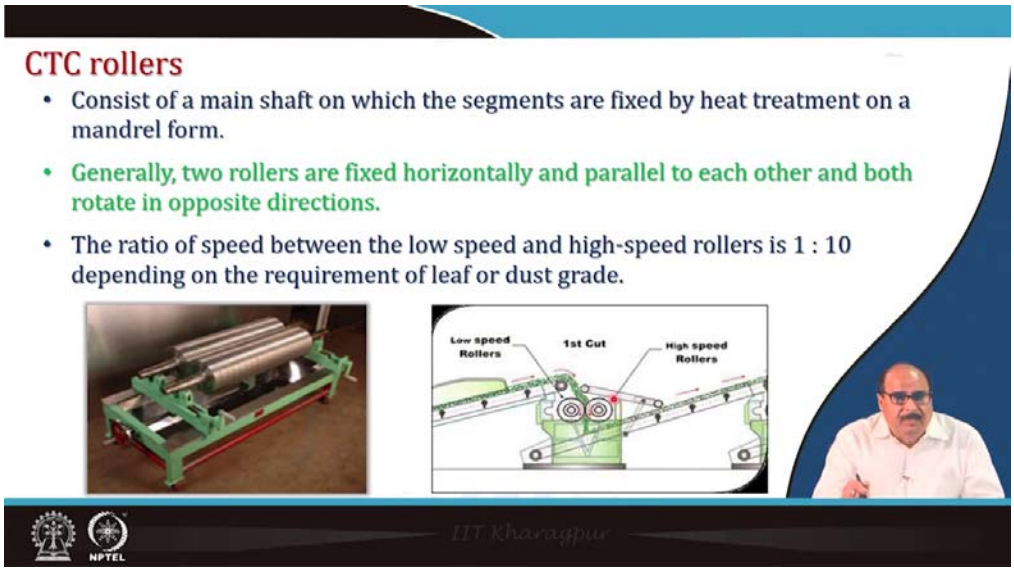
A leaf shredder is a preconditioning machine. This machine shreds the leave into a smaller piece before sending it to the rotor vane. Besides the green leaf, the shredder helps to increase the rotor vane capacity and improves the mixing efficiency of the withered leaf, especially in the CTC type of processing. The machine consists of a cylinder, as you can see here in the figure, in which the main shaft having knives or blades rotating at a speed of around 25,000 rpm.



Orthodox roller

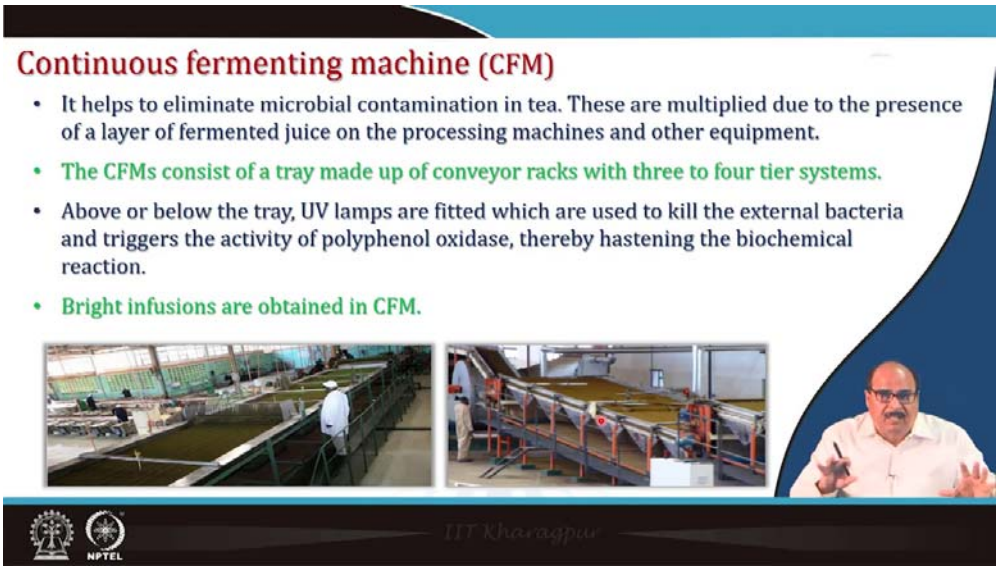
Orthodox roller sees here, in the figure, it is shown. It is a conventional roller for orthodox rolling. It consists of three-part, the table, hood and pressure cap. Rotation of the machine is achieved through three crankshafts attached to the table. The pressure cap in the orthodox roller applies pressure to leaf mass during rolling, imparting proper twisting and brushing action. This pressure causes the extraction of sap and twist to the leaf.

In some kind of rolling tables. both vertical and lateral pressure may be applied. Vertical pressure is applied with the help of the pressure caps whereas lateral pressure is applied by a cone fitted in the middle of the table. This cone also causes greater circulation of the leaf. Sometimes tea of a certain grade where they are made by normal hand rolling.



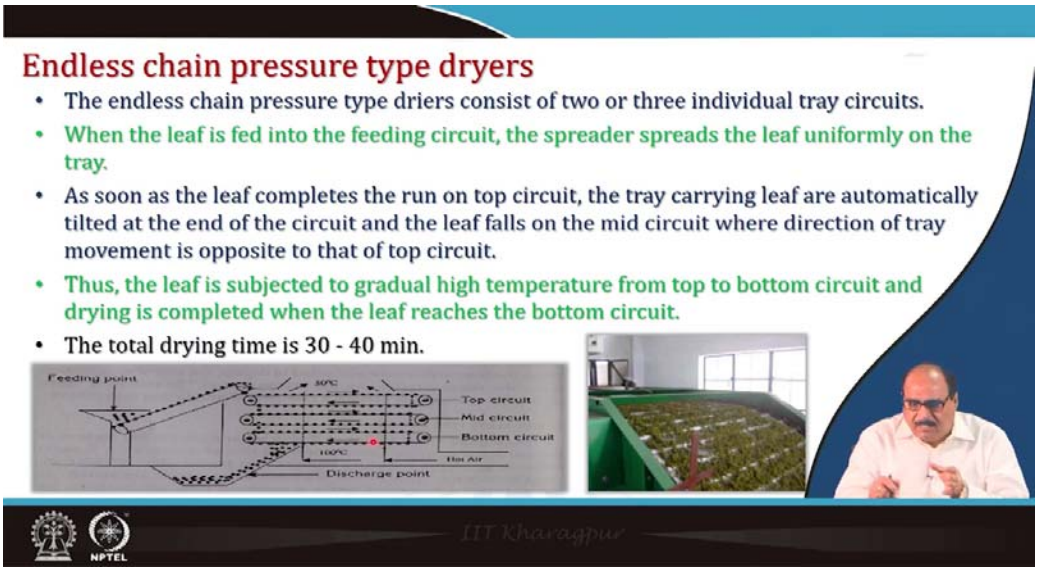
CTC rollers

It consists of the main shaft, which you can see here, the main shaft on which the segments are fixed by heat treatment and a mandrel form. Generally, two rollers are fixed horizontally and parallel to each other and both rotate in opposite directions. The ratio of speed between the low-speed and high-speed rollers may be around 1 to 10 depending upon the requirement of the leaf or dust grade.



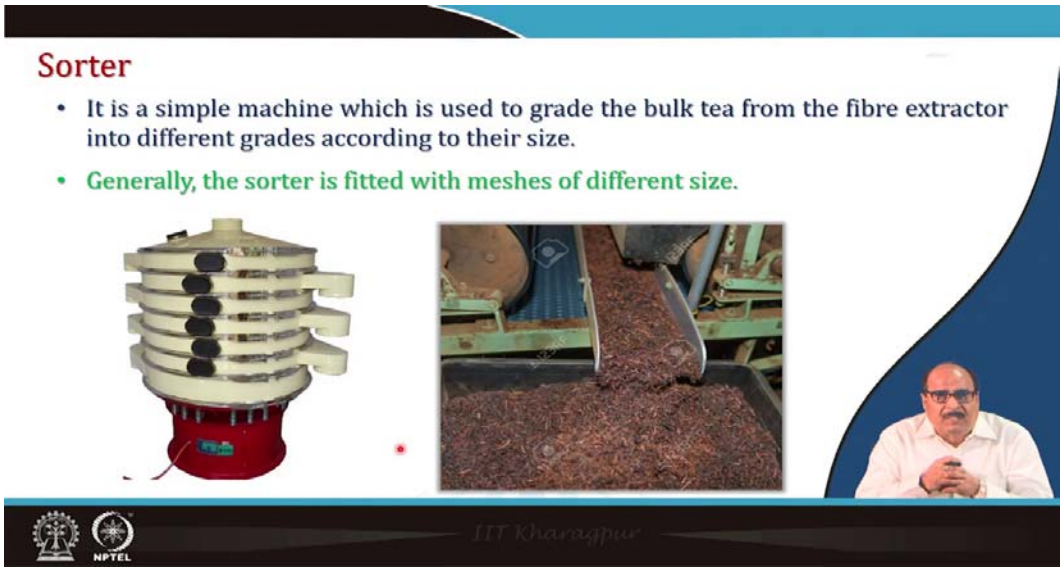
Continuous fermenting machines (CFM)

It is, sometimes basically, a room which is controlled temperature and humidity. It helps eliminate microbial contamination. The continuous fermenting machine consists of a tray, as I told you, made of conveyor racks with 3 to 4 tier systems. Above or below the tray, ultraviolet lamps are fitted which are used to kill the external bacteria and trigger the activity of polyphenol oxidase thereby hastening the biochemical reaction. So, bright infusions are obtained in CFM fermented teas.



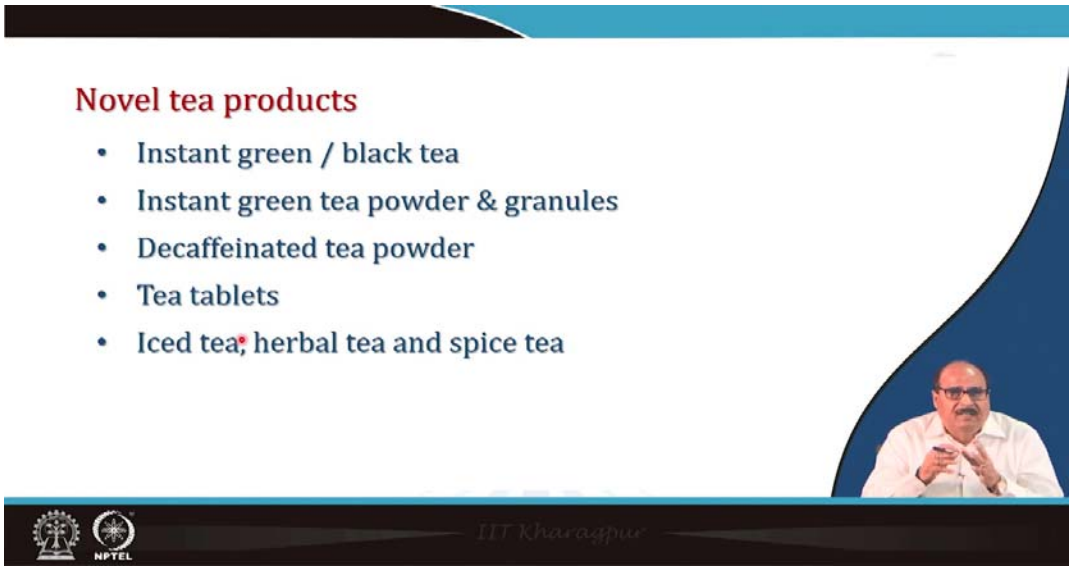
Endless chain pressure type dryers

You can see here, the feeding point and then it is a moving tray. Top circuit, mid circuit, bottom circuits etc., you can see here in this figure. So, the endless chain pressure type dryers consist of two or three individual tray circuits. When the leaf is fed into the feeding circuit, the spreader spreads the leaf uniformly on the tray. As soon as the leaf completes the run on the top circuit, the tray carrying the leaf is automatically tilted at the end of the circuit and the leaf falls on the mid circuit where the direction of the tray, movement is opposite to that of the top circuit. You can see, it here in the mid circuit. Thus, the leaf is subjected to a gradual high temperature from top to bottom circuit and then drying is completed when the leaf reaches the bottom circuit. So, the total drying time in this process may be around between half an hour or 30 to 40 minutes.



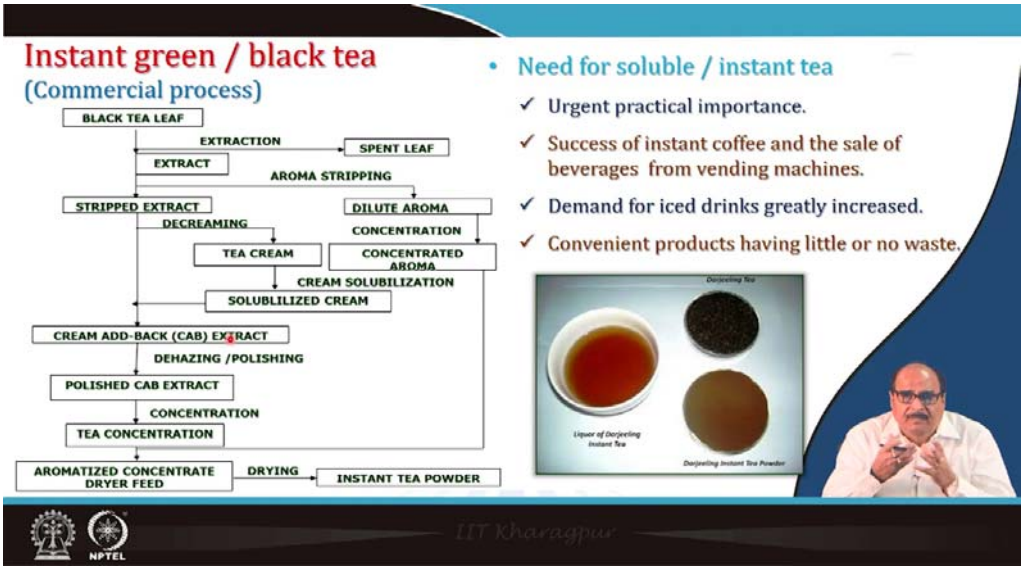
Sorter

It is a simple machine which is used to grade the bulk tea from the fibre extractor into different grades according to the size. Generally, the sorter is fitted with a mesh of different sizes i.e. wire meshes, and accordingly, it is sorted into different sizes, and then finally it is packaged. That, we have already discussed in the packaging type.



Novel tea products

Now, let us discuss some of the novel tea products like instant green tea or instant black tea, instant green tea powder and granules, decaffeinated tea powder, tea tablets, iced tea, herbal tea, and spice tea. India makes all types of these teas and they are exported and sold in the market worldwide.



Instant green/black tea

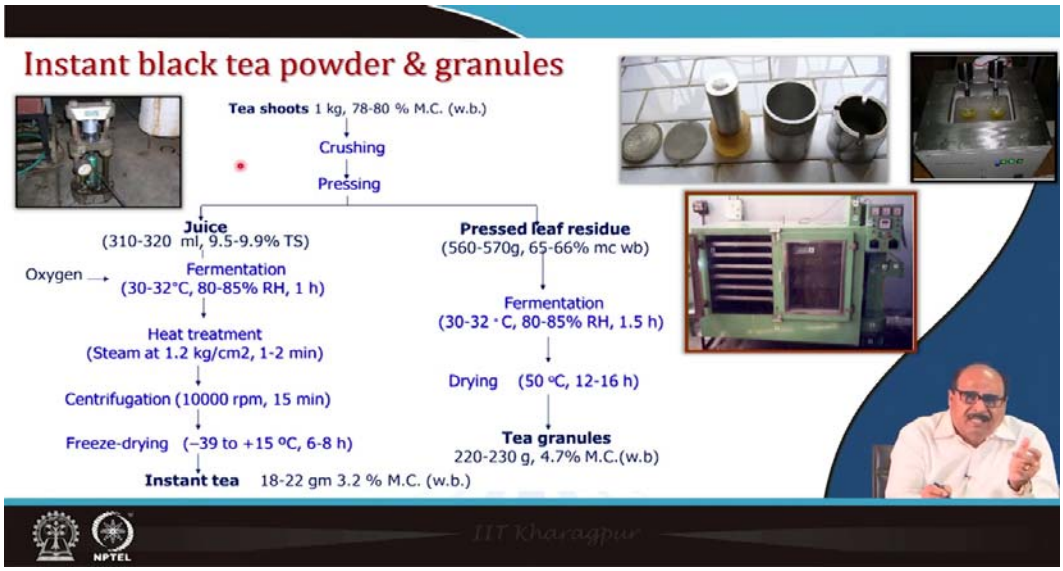
So, in this process flowchart, I have shown you the commercial process for making instant green tea or instant black tea. What is the need of making soluble tea or instant tea? Because it is of urgent practical importance. The success of instant coffee is that you get the coffee from the coffee vending machines and this has necessitated the need of making similarly soluble tea so that the same vending machine can be used for its making.

Demand for ice drinks greatly increased and convenient products have little or no waste. The commercial process for making instant green tea or black tea, so far whatever process we have discussed. Either black tea or green tea prepared is taken and it is subjected to extraction, that is the tea brew just like we make the tea in our home. Similarly, at the industrial level, there are six or seven columns of hot water which recirculates with the tea leaves in opposite direction, it may be around 170 or 180 degrees Celsius, water at high temperature. So, from the tea leaves, the water-soluble flavouring and colouring compounds get extracted. So, that is basically the extraction. This extract is taken and the spent leaf is used as manure or for other purposes. These

extract leaves are then subjected to aroma stripping, by an appropriate method, the aromatic compounds are stripped, and collected from this extract and the dilute aroma is concentrated by freeze or vacuum drying. So, the concentrated aroma is kept separately. The de-aromatised extract is put next to the decreaming treatment. Decreaming means, during the fermentation process, the tea cream is formed like polyphenol and caffeine, they form a polyphenolic caffeine complex and this is soluble in hot and in cold, it becomes insoluble. After the tea brew is made, the tea cream is responsible for the haziness and cloudiness of the brew. So, it is subjected, in this step, to avoid haziness and cloudiness. It is subjected to the cream solubilisation treatment, which means the caffeine polyphenol complex is broken, then by using appropriate methods, so soluble cream is taken and it is added back into the extract. So, the cream is added back to the CAB extract, and it is passed to the dehazing and polishing filters to have complete thorough mixing.

So, you get a polished cream added back extract. And then in polish cream added back extract, it is concentrated, so one gets tea concentrate, and then this earlier this aromatized concentrated aroma or flavour, now it is added back. So, aromatized concentrate is used, that it is used as a dryer feed, so either in the spray drying or in that freeze drying, it put and you get instant soluble powder.

So, that is the commercial process. But you see, this is a highly energy-intensive operation, there are certain problems with the flavour because the flavouring compounds are extracted and then it is given cream solubilisation treatment, etc. So, these teas are always, they have some issues with the that is either highly energy intensive or also the flavours, etc.

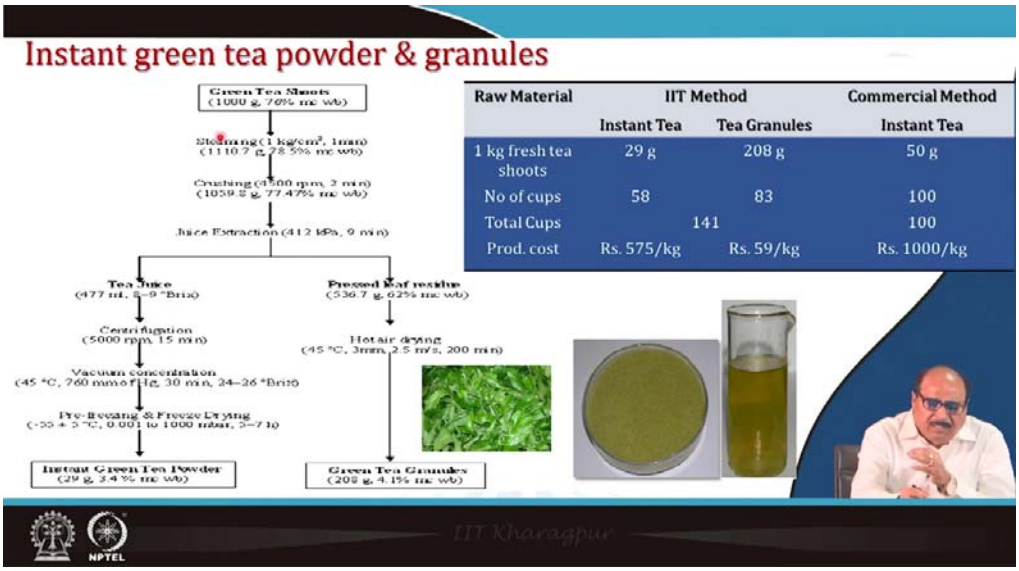


Instant black tea powder and granules

So, to avoid that, at our institute, we have developed and patented a process technology for making both instant green tea powder as well as granules as well as instant black tea powders and granules. For the black tea process, what we took, we took green shoots after it is plucked from the field, then it is crushed and pressed, and this pressing process we optimized. So, we get to the juice.

Approximately, half of the juice and along with the juice water-soluble components, we are pressing, and the remaining half we are leaving in the fresh leaf, and then it is subjected to, this liquid is put to the fermentation where oxygen supply is given. After that, it is given some sort of heat treatment to stop the fermentation process. After the fermentation is complete, centrifuge and freeze-dried, and we get instant tea.

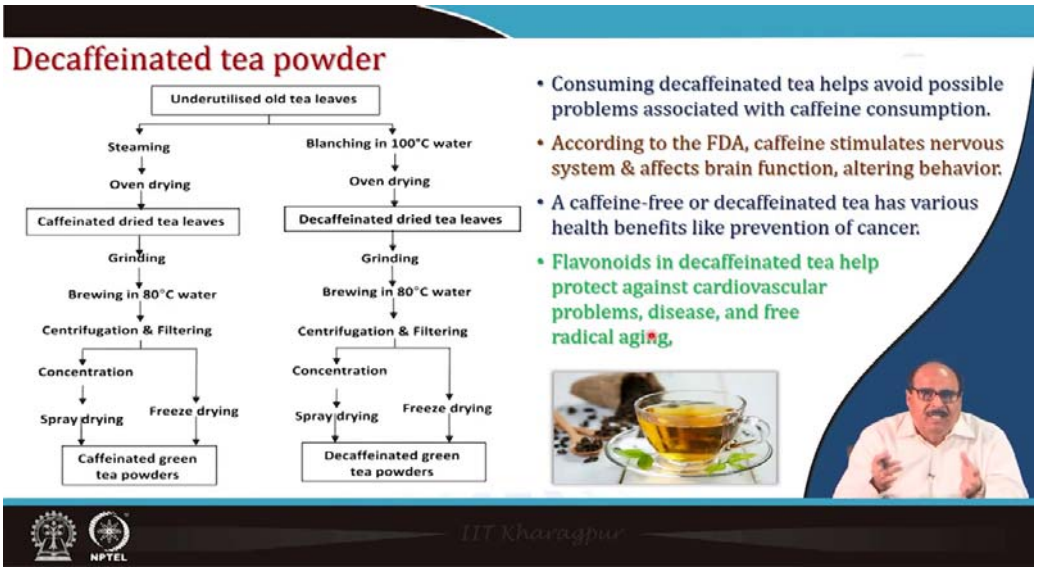
So, from about that, we get around 18 to 20 grams or 1 kg of the leaf, which has a 3.2 percent moisture content wet basis and the pressed leaf residue, we put to the same process that is fermentation and tea granules. We getting a tea granule which is equivalent to the CTC tea. So, from the same leaf, we are getting, and also, we have avoided the withering process and we are getting instant tea as well as tea granules. This is a patented process and both the teas, have good liquoring capacity.



Instant tea powder and granules

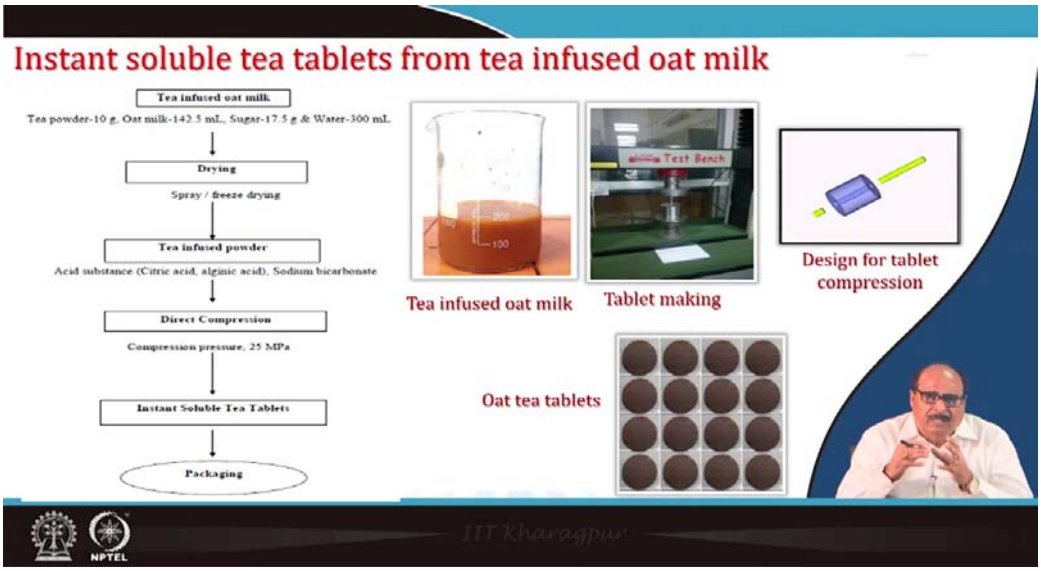
Here, there is, after tea shoots are taken, they are immediately given some steam treatment before crushing so that this steam treatment inactivates the enzymes and then the rest process is almost the same. Of course, the process parameter, a little bit varies.

So, we are getting here that is around 29 to 30 grams of green tea powder from 1 kg leaf and around 208 to 210 grams of green tea granules. Both are these, you see green tea granules, powders, and granules and this is the tea prepared from this. You see that instant tea, we get from 1 kg fresh tea about 29 grams and 208-gram granules. In the commercial method from 1 kg tea, you will get 50 grams. The number of cups of instant tea 9 grams, you get 58 cups and here tea granules, are 83 cups. The total, we get 141 cups, whereas from the commercial method of instant tea production from 1 kg tea, finally, one gets 100 cups. So there is the excess, advantage of this, that is from the same product, we are getting both the instant tea as well as granules, CTC, comparable weightage.



Decaffeinated tea powder

As I told you the caffeine, so the consuming caffeine may, excessive consumption of caffeine may cause, in the long run, some extreme caffeinism like sleep disturbance and such other problems, etc. According to the FDA, caffeine stimulates the nervous system and affects brain function-altering behaviours. Such persons who are sensitive to caffeinism or caffeine, want to avoid caffeine consumption, for them, decaffeinated tea is also available in the market. The process here is, these green tea leaves, they are using either the supercritical fluid extraction method or such other methods that caffeine is extracted from the leaf and then, it is a decaffeinated leaf is passed, put to the next process in the usual form. You get that decaffeinated green tea powders or decaffeinated black tea powders as the case may be.

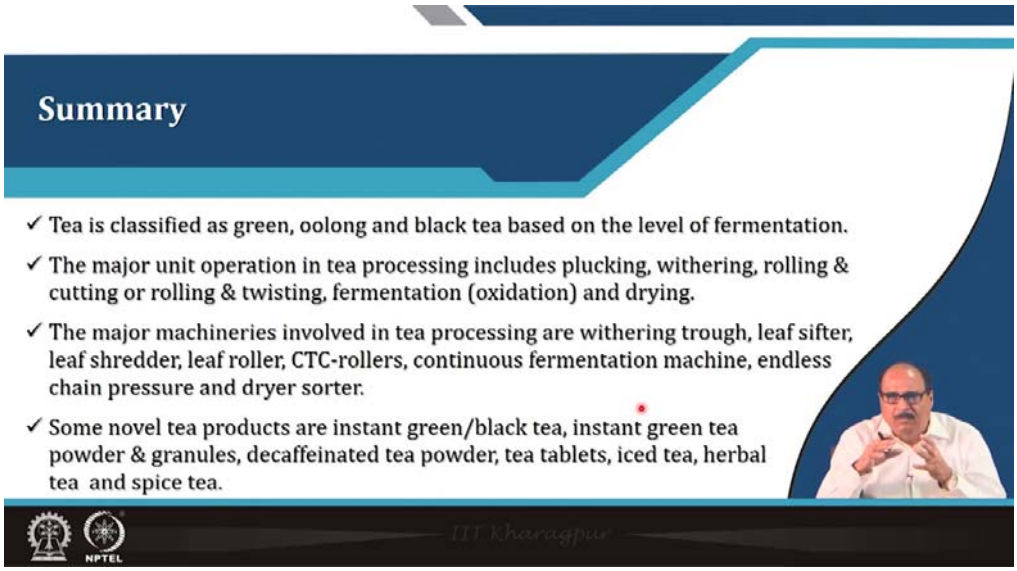


Instant soluble tea tablets from tea-infused oat milk

Finally, that is, we have, instant tea. This instant tea, soluble tea tablet also we have designed, and it is patented. We have applied for the patent, and it is an awarded method. The award has been received for this process, we have, tablet making machine. This tablet-making machine although we are using for the making of the milk powder tablet, at the same time, for green tea tablets, we have standardized them here. In the green tea tablets experiment, we used oatmeal, so, for lactose intolerant people, normal milk also can be preferred. So, either the milk can be added with the milk powder and this instant tea powder giving some binding agents, and this is, by the tablet pressing machine, these tablets are made, or even the instant tea, green tea, black tea which is a very good source of antioxidant. So, the, such can be put, pressed into the machine and you can get only green tea tablet or pure black tea tablet and that, this tablet size, etc. we have developed the frame and maybe one tablet or two tablets can be put in 200 ml or 50 ml water and one can get the desired brew. So, that is the instant soluble tea tablet that facilitates, becomes very convenient for use.

Different kinds of instant tea products of India

These are the different kinds of instant tea products available in India like herbal tea, immunity boosting, spiced tea or frozen tea concentrates, iced tea, made tea, ready tea and so far, various combinations and permutations are made. A lot of variety of products are available.

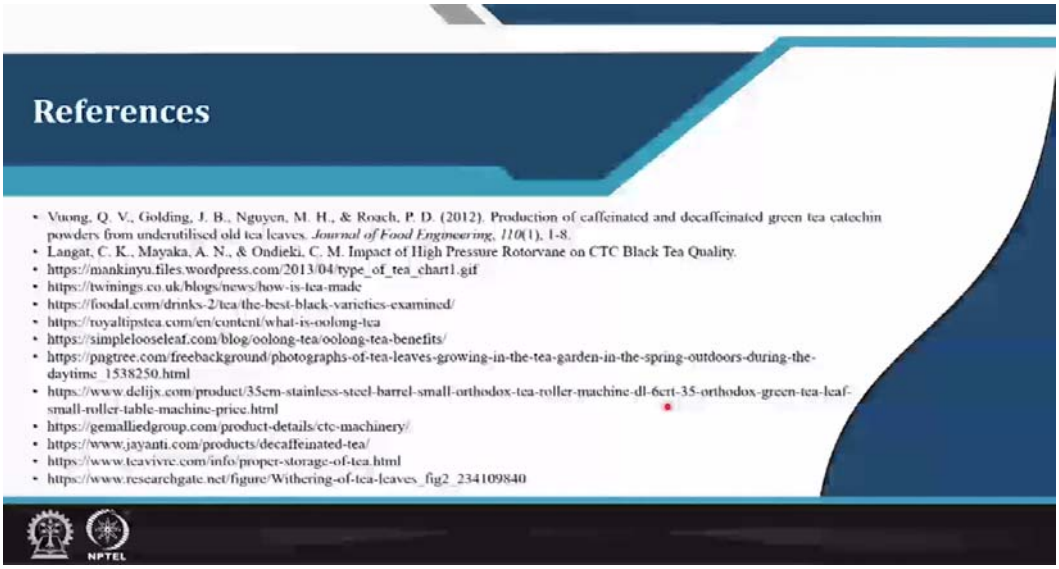


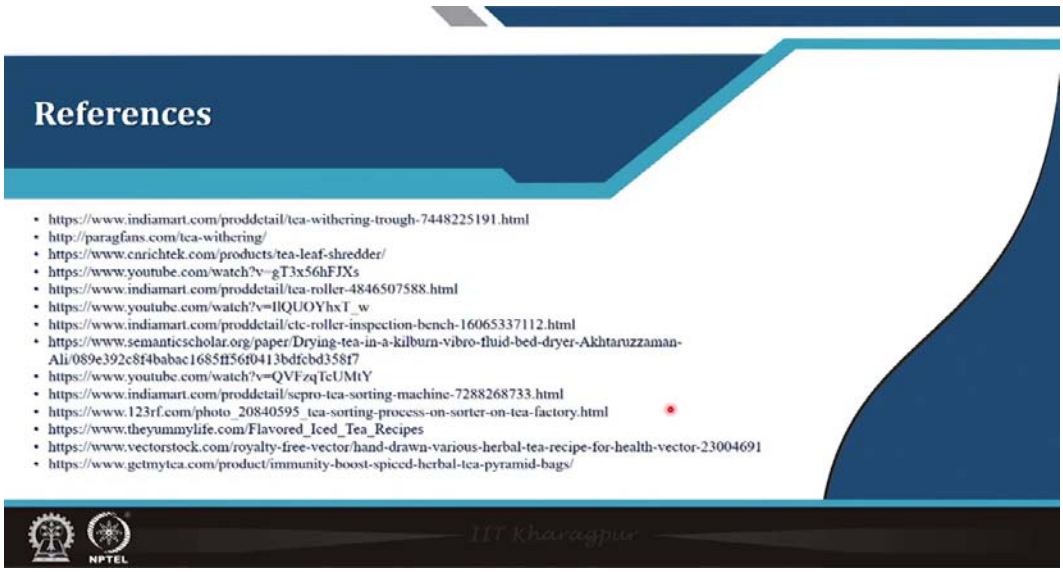
Summary

But the preparation method is almost in all the products are basically, that is tea in the tea leaves, these compounds, there is a water-soluble compound, water-insoluble compounds, they are

manipulated in such a way that they are converted into a good flavouring and colouring compounds. These flavouring and colouring compounds are both water-soluble compounds, which are further extracted using, in the hot water, and we give that tea brew.

So, this hot water brew, which is obtained, these brews can be further concentrated, and dehydrated in the form of, spray drying or freeze drying. It may be freeze-dried powder, spread-dried powder or even frozen concentrate, or iced concentrate in different parts. These tea powders can be mixed with the appropriate amount of sugar and milk. It can be made into readymade tea or other tea products, etc.





So, these are the references used in this lecture. With this, thank you very much for your patience here. Thank you.