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

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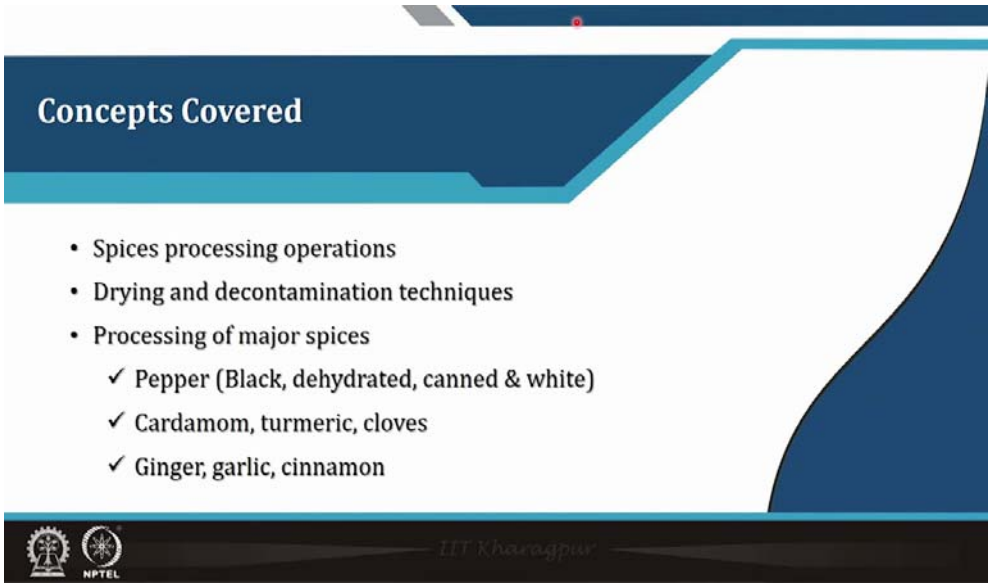
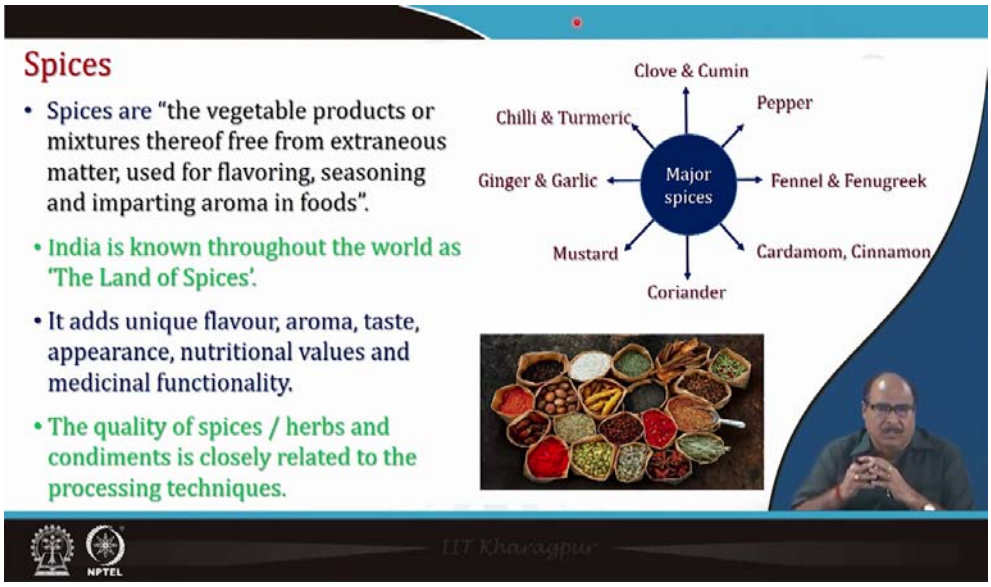
Lecture 41
Processing of Spices

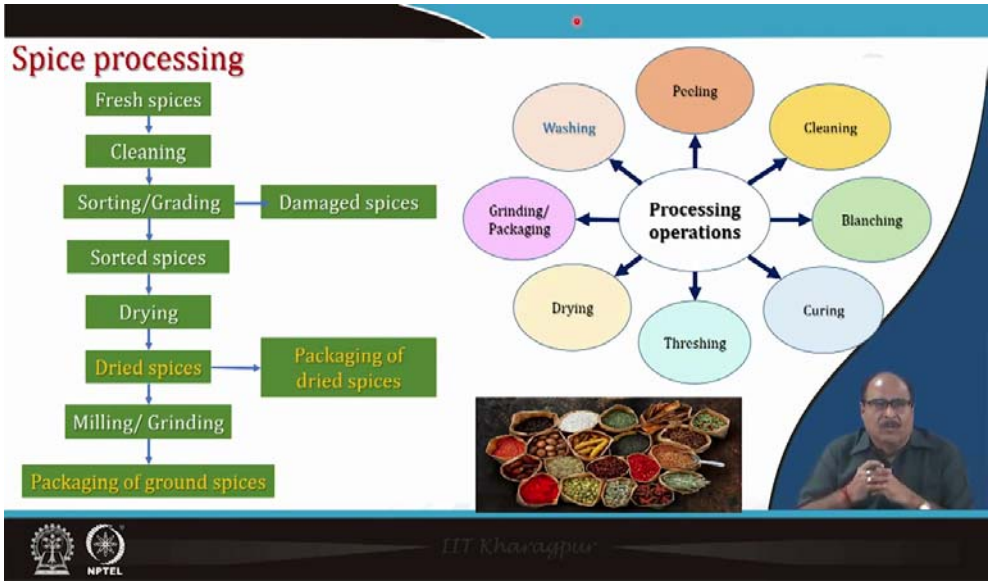


The concepts covered in this lecture are spices process operations, drying and decontamination techniques for spices and also the processing of major spices like pepper, cardamom, turmeric, cloves, ginger, garlic and cinnamon.



Spices

Spices are the vegetable products or mixtures which are free from extraneous matter and they are used for flavouring, seasoning and imparting aroma in foods. India is known as "The Land of Spices" throughout the world. It adds a unique flavour, aroma, taste, appearance, nutritional values and medicinal functionality to foods. However, the quality of the spices or herb and condiments is closely related to the processing techniques. The major spices of India are clove & cumin, pepper, fennel & fenugreek, cardamom, cinnamon, coriander, mustard, garlic, ginger, chilli, turmeric and so on.



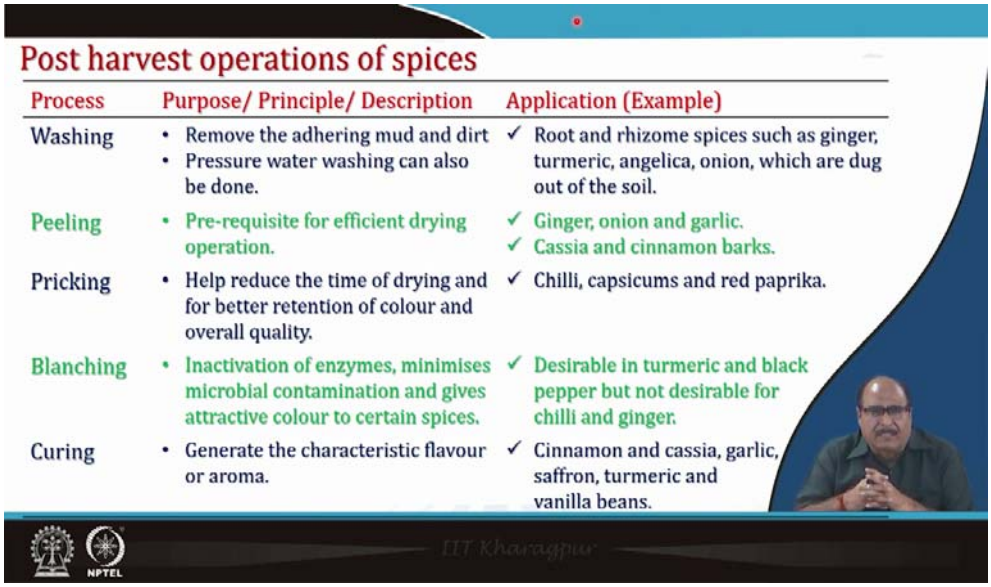
Spice processing

As far as the processing of spice is concerned after the commodity is harvested, it is subjected as usual in case of any horticultural and plantation crop, here spices are subjected to various treatments like washing, peeling, cleaning, then blanching, curing, threshing, drying, grinding and packaging, etc. depending upon the type of spice and its nature, its size where the curing and blanching these two operations are important; also the drying and grinding.

The dried spices can be packaged in the dried form and are available in the market as the packaged whole spices or alternatively, these dried spices they can also be pulverized or ground using appropriate technology for producing spice powders. All these spices or the spice powder, they can be subjected to various other treatments for extraction of essential oil, oleoresin, etc.

Post harvest operations of spices

For spices, the process, the purpose or principle or description of the process and application or example i.e. what are those major spices on which these operations becomes very important have been given in this table.



Washing: It is used to remove the adhering mud and dirt and normally either soaking water or pressure water washing etc. can be done. Different washing operations have already studied in the case of fruits and vegetables in earlier lecture. So same things can be applicable here also. For example, in the case of roots and rhizomes, the spices such as ginger, turmeric, angelica, onion which are dug out of the soil, this washing operation becomes very important. That is the washing as well as the decontamination.

Peeling: It is a prerequisite for efficient drying operations. Peeling operation is important for ginger, onion and garlic or cassia and cinnamon bark etc.

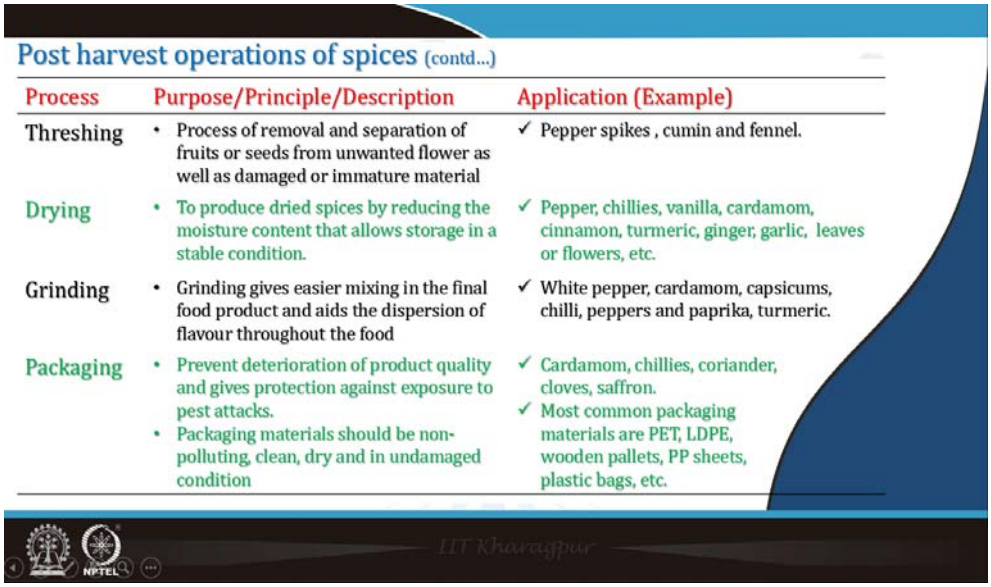
Pricking is done to reduce the time of drying and for better retention of colour and overall quality of the spice and this is important in the case of chilli, capsicum, red paprika, etc.

Blanching: It is used for the inactivation of enzymes. It minimizes microbial contamination and gives attractive colour to certain spices like turmeric, black pepper, but it is normally not done in the case of chili and ginger.

Curing is important for generating the characteristic flavour or aroma of the spices as it is very important for cinnamon, cassia, garlic, saffron, turmeric and vanilla beans.

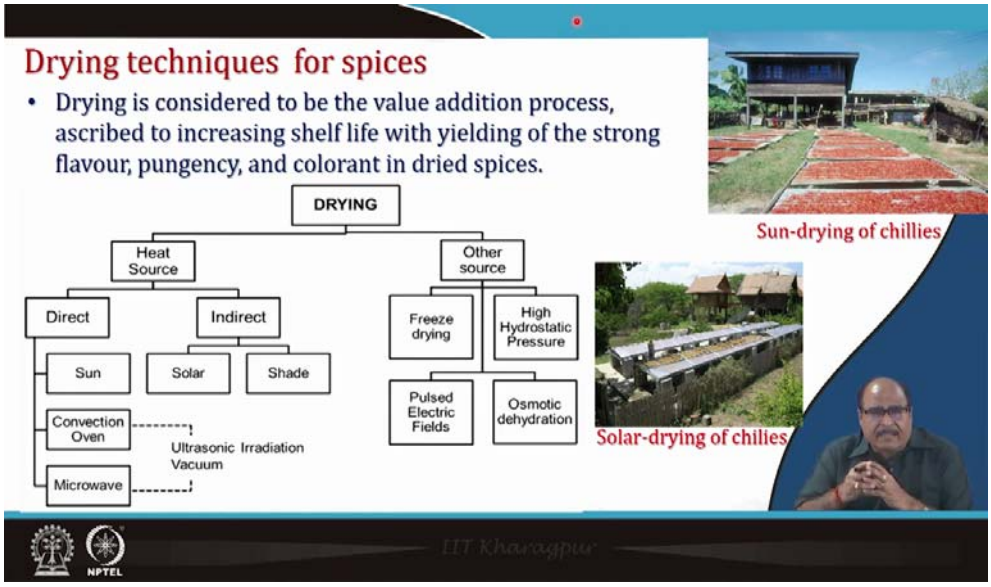
Threshing is the process of removal and separation of fruits or seeds from the unwanted flowers as well as damaged or immature material and this process becomes most importance in the spices like pepper spikes, cumin and fennel.

Drying is done obviously to reduce the moisture content and to make the spices shelf-stable by bringing down the moisture below the safe moisture content, to extend its shelf life. It is used in pepper, chillies, vanilla, cardamom, cinnamon, turmeric, ginger, garlic, leaves or flowers etc.



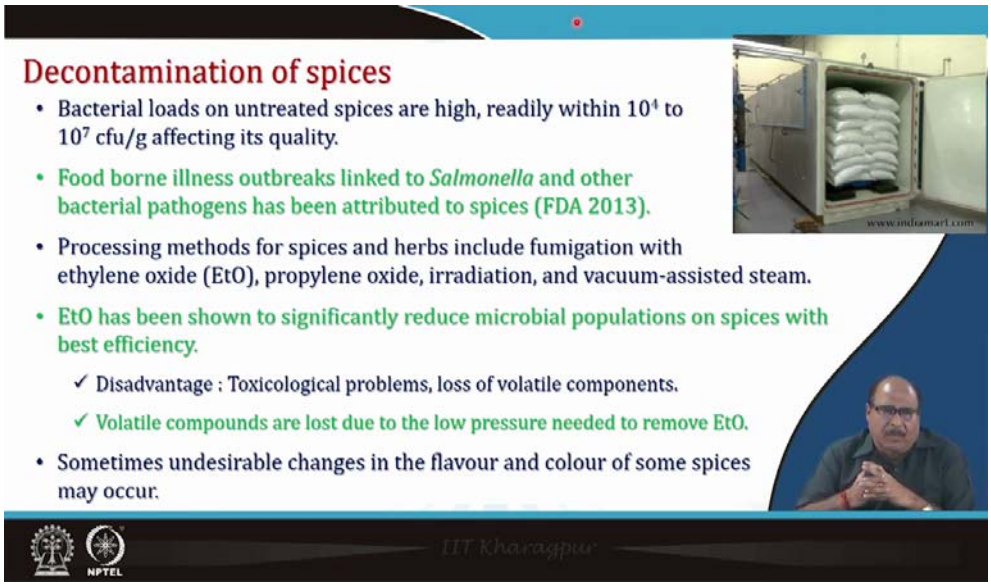
Grinding gives easier mixing in the final products like white pepper powder, cardamom powder, capsicum, chili, pepper, paprika, turmeric. All these spices, their dried form is ground into fine powder. So they are available in the market.

And then ultimately packaging. Packaging either in the form of whole spice or dried spices or in the form of powder or other materials is important. This is done to prevent deterioration of the product quality and it also gives protection against the exposure to pest attacks. Packaging materials should be non-polluting, clean, dry and in undamaged condition. Most common packaging materials are PET, LDPE, even wooden pallets, polypropylene sheets, plastic bags, etc. Cardamom, chilies, coriander, clove, saffron etc., almost all spices are packaged in this.



Drying techniques for spices

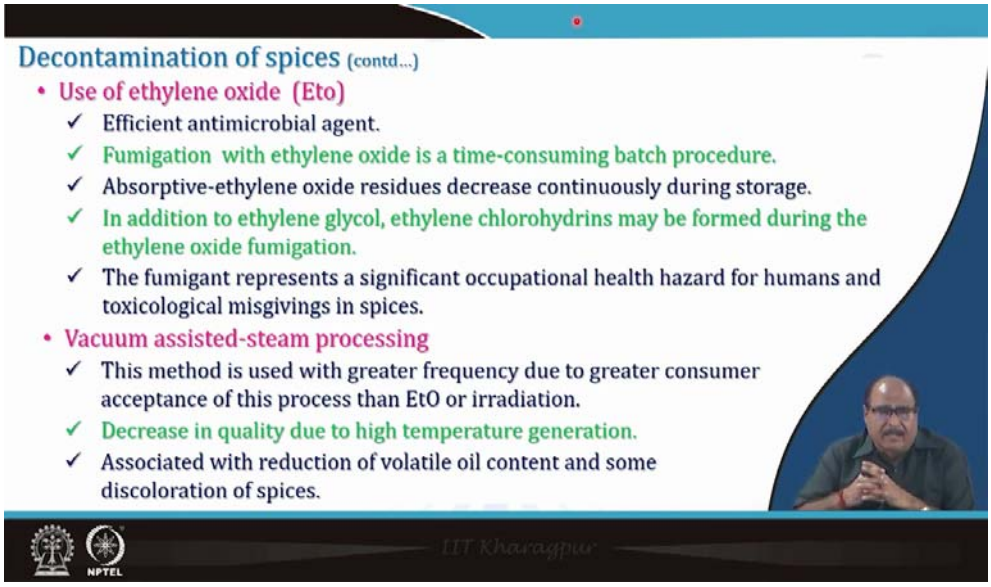
The drying techniques mostly used for spices are done traditionally. Drying is considered to be the value addition process, ascribed to increasing shelf life with yielding of the strong flavour, pungency, and colorant in dried spices. Spice drying is done by either solar drying or even now some progressive manufacturers they also use air drying, such as the convective air drying. But the direct drying i.e. sun drying or conventional drying even sometimes ultrasonic-assisted irradiation or vacuum drying in order to get the better quality of the product. Depending upon the specific spice, one has to control the process parameter in the case of air-drying or any other drying, the temperature is very important parameter because these spices mainly contains the essential or volatile oils, so high-temperature drying should be avoided.



Decontamination of spices

Most of the spices are grown in close proximity to the soil. So, their bacterial load on untreated spices are generally high maybe to the tune of 10^4 to 10^7 cfu/g and also these spices, even dried spices are likely to be attacked by insects or pests. The foodborne illness outbreaks linked to *Salmonella* and other bacterial pathogens had been attributed to the spices as per FDA (2013). So it becomes very important that the spices are exposed to suitable treatment to decontaminate them.

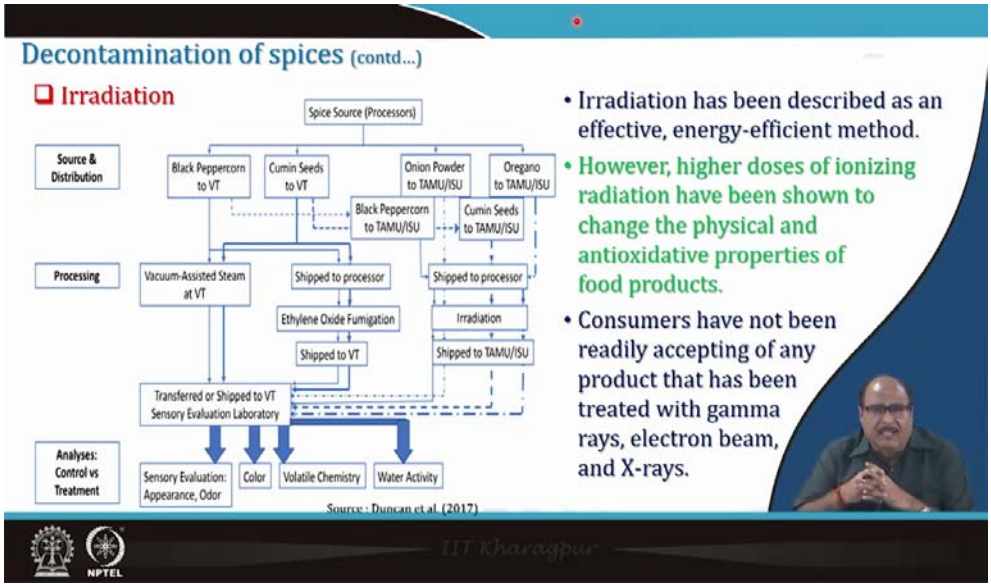
The commonly used decontamination includes fumigation with ethylene oxide (EtO), propylene oxide, irradiation, and vacuum-assisted steam etc. are used. Ethylene oxide has been known to significantly reduce microbial population and it is considered one of the best as per the efficiency of the processes concerned. However, there are certain technological or toxicological issues with ethylene oxide. There may be some loss of volatile components due to the low pressure needed to remove the EtO. Even, sometimes undesirable changes in the flavour and colour of some spices may also take place if the decontamination process is not properly conducted.



Use of ethylene oxide: it is an efficient antimicrobial agent, absorptive-ethylene oxide residues decreases continuously during storage. In addition to the ethylene glycol, ethylene chlorohydrins may be formed during the ethylene oxide fumigation and the fumigation represents a significant occupational health hazard for humans and toxicological misgivings in spices.

Vacuum-assisted stream processing is used with greater frequency due to greater consumer acceptance of this process than the ethylene oxide or irradiation. The decrease in quality due to high-temperature generation maybe there, it is also associated with the reduction of volatile oil content and some discoloration of spices may be there due to the effect of the high temperature.

Overall, this undesirable effect of high temperature need to be taken care of by having alternative methods of heating, advanced heating technologies, or alternative heat generation.



Irradiation

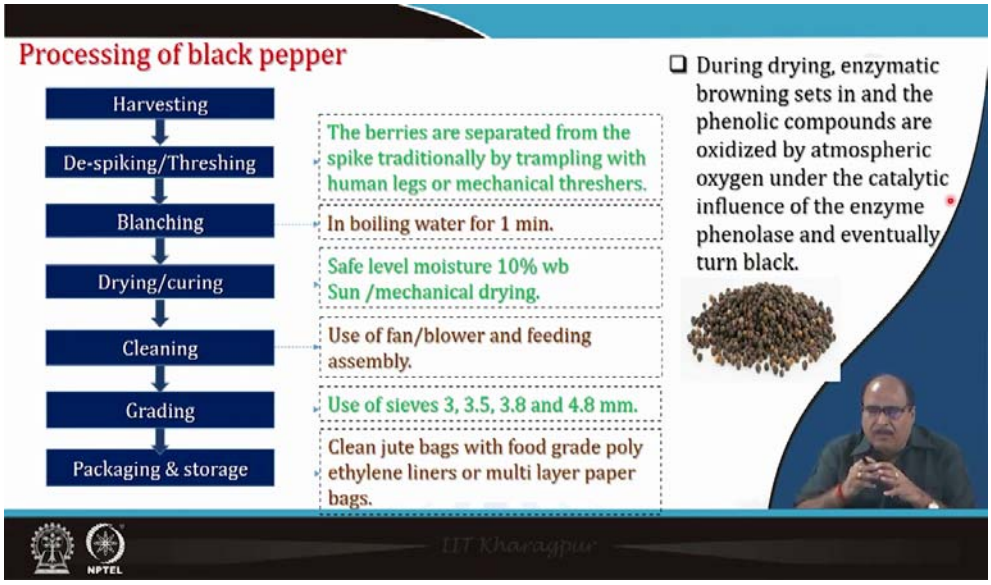
Irradiation technology is an old process and it is used for decontamination of spices. Even in India, there are a few radiation plants which are used for irradiating spices particularly to fumigate them or to avoid fumigation and control the insect, pests etc. The care has to be taken that the dose of ionizing radiation has to be properly selected which gives the beneficial effect, otherwise if they chooses higher dosage it may have some effect on the changes in the physical properties, even antioxidant potential of the spices, etc. may be adversely affected.

Pepper

Pepper i.e. *Piper nigrum*, known as the king of spices. It is a flowering vine and belongs to the family *Piperacea*e. Pepper is native to India and is cultivated in tropical regions. Pepper takes about 7 to 8 months after flowering to reach full maturity.

Optimum maturity at harvest for different pepper products is different and can be seen in the table.

Product	Stage maturity at harvest
✓ Canned pepper	✓ 4 - 5 months
✓ Dehydrated green pepper	✓ 10 -15 days before maturity
✓ Black pepper	✓ Fully mature and 1 - 2 berries start turning from yellow to red in each spike
✓ White pepper	✓ Fully ripe
✓ Pepper powder	✓ Fully mature with maximum starch
✓ Oleoresin and essential oil	✓ 15 - 20 days before maturity



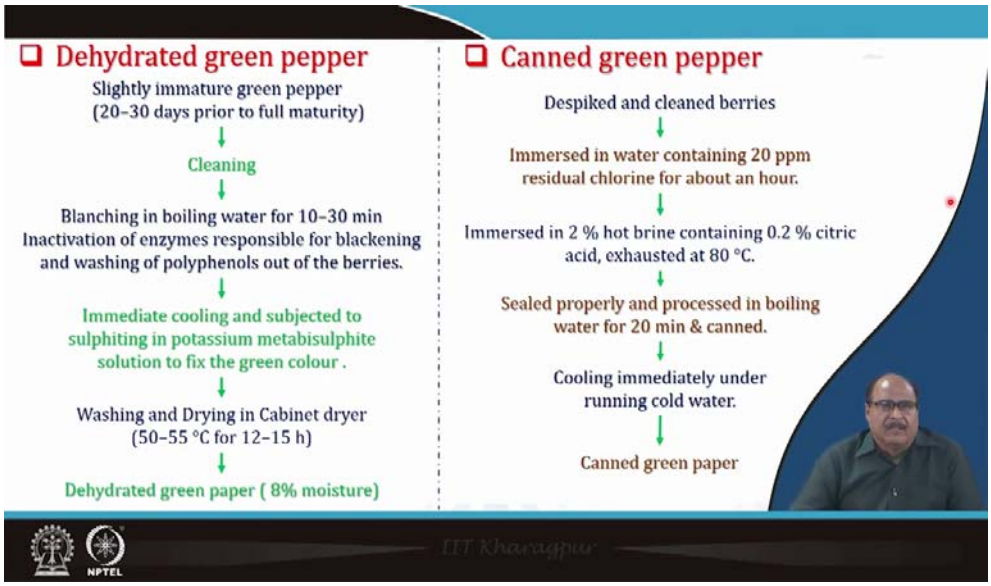
Processing of black pepper

As far as the processing a pepper is concerned after harvesting, they are subjected to de-spiking or threshing where the berries are separated from the spike traditionally by trampling with the human legs or mechanical threshers and then they are blanched in boiling water for about 1 minute followed by suitable drying using appropriate method either sun drying or mechanical drying and the moisture content is brought to safe level i.e. 10 % wet basis. Drying is followed by cleaning and then grading. Even for the grading, sieves of 3, 3.5 3.8 and 4.8 mm are used and finally, the clean jute bags with food grade polyethylene liners or multi-layer paper bags are used for packaging. So, particularly during the drying operation, the enzymatic browning sets in and the phenolic compounds are oxidized by atmospheric oxygen under the catalytic influence of the enzyme phenolase and eventually the pepper turns black. So, by the enzymatic oxidation the black colour of the pepper develops particularly during the drying operation.

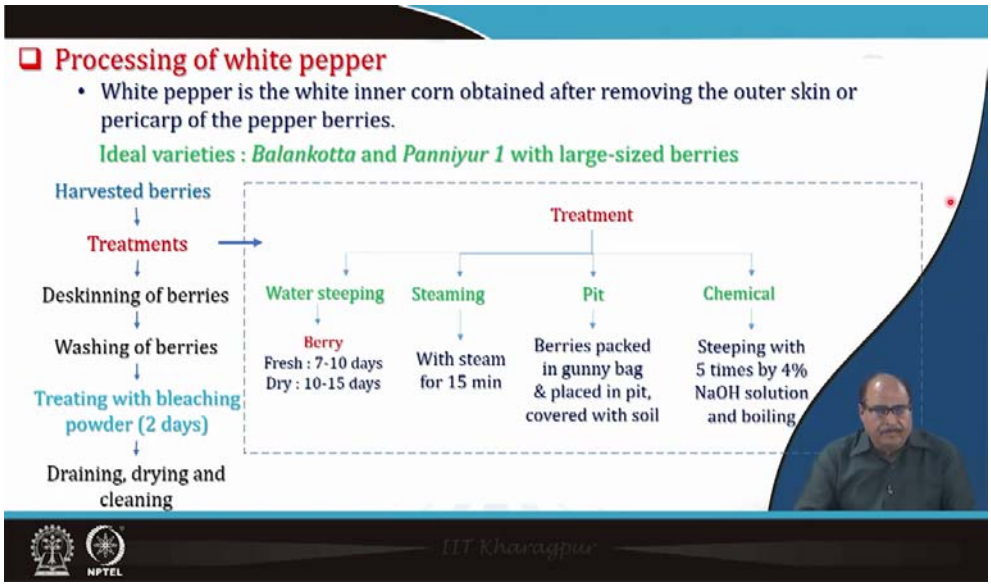
Dehydrated green pepper

The process for making dehydrated green pepper or canned green pepper is shown. In the dehydrated green pepper, slightly immature green pepper maybe 20 to 30 days prior to full maturity is harvested, cleaned and then blanched in boiling water for about 10 to 30 min which tends to inactivate the enzyme that is responsible for blackening and washing of polyphenols out of the berries. After blanching, the berries are immediately cooled and subjected to sulphiting in potassium metabisulfite solution to fix the green colour and this is followed by washing and drying in cabinet dryer at around 50 to 55 °C temperature for 10 to

15 h. Here the KMS solution dripping, it fixes the green colour and you get the dehydrated green pepper. Its final moisture content maybe around 8 % or so.



In the canned green pepper, a despiked and cleaned berries from the earlier process are used, they are immersed in water containing 20 ppm residual chlorine for about an hour and then it is followed by immersion in 2 % hot brine solution containing maybe 0.2 % citric acid and then it is exhausted at 80 °C. They are sealed properly and processed in boiling water for about 20 min and then finally it is canned and cooled immediately under running cold water to get the end-product like canned green pepper.



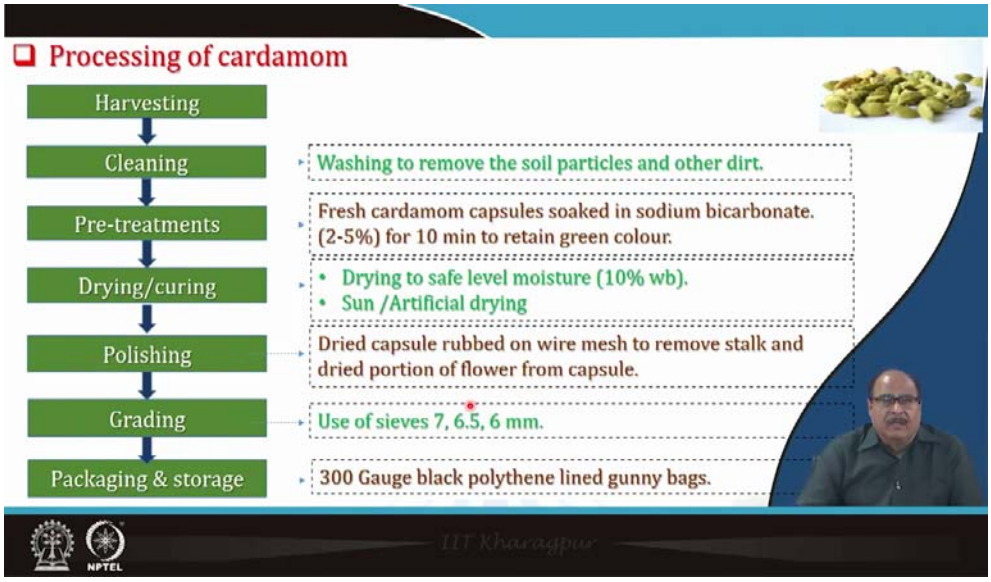
Processing of white pepper

White pepper is the white inner corn obtained after removing the outer skin or pericarp of the pepper berries and ideal varieties for making white pepper include *Balankotta* and *Panniyur 1* with large-sized berries. For making white pepper, the harvested berries are subjected to various treatments like water steeping where the fresh berries for 7 to 8 days and dry berries for 10 to 15 days are carried out. Then it may be subjected to steaming for about 15 min. Even sometimes berries are packed in gunny bag and they are placed in pit which is covered with soil or even chemical treatment can be given where steeping with 5 times by 4 % sodium hydroxide solution and boiling. So either of these treatments is done. The treated berries are deskinned, subjected to the deskinning process followed by washing and then finally they are further treated with bleaching powder for 2 days followed by draining, drying and cleaning to get the white pepper.

Cardamom

Cardamom plants start bearing 2 or 3 years after planting suckers or seedlings, respectively. The capsules ripen within a period of 120 to135 days after its formation. The two main types of cardamom are true or green cardamom or when bleached they also become white cardamom. This comes from the species *Elettaria cardamomum* and is distributed from India to Malaysia. The black cardamom also known as brown, greater, large, longer, or Nepal cardamom, it comes from a species *Amomum subulatum* and is native to the eastern Himalayas and it is mostly cultivated in Eastern Nepal, Sikkim and parts of Darjeeling districts in West Bengal of India and also in southern Bhutan.

Both forms of cardamom are used as flavourings and cooking spices in both food and drink and also as a medicine. *E. cardamom* i.e. green cardamom is used as a spice, a masticatory and in medicine. It is also smoked.

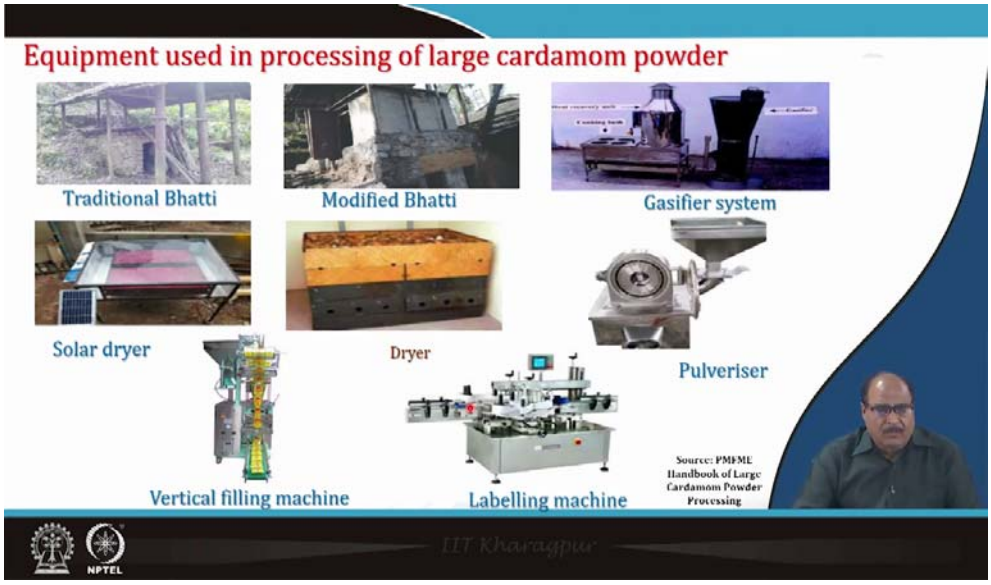


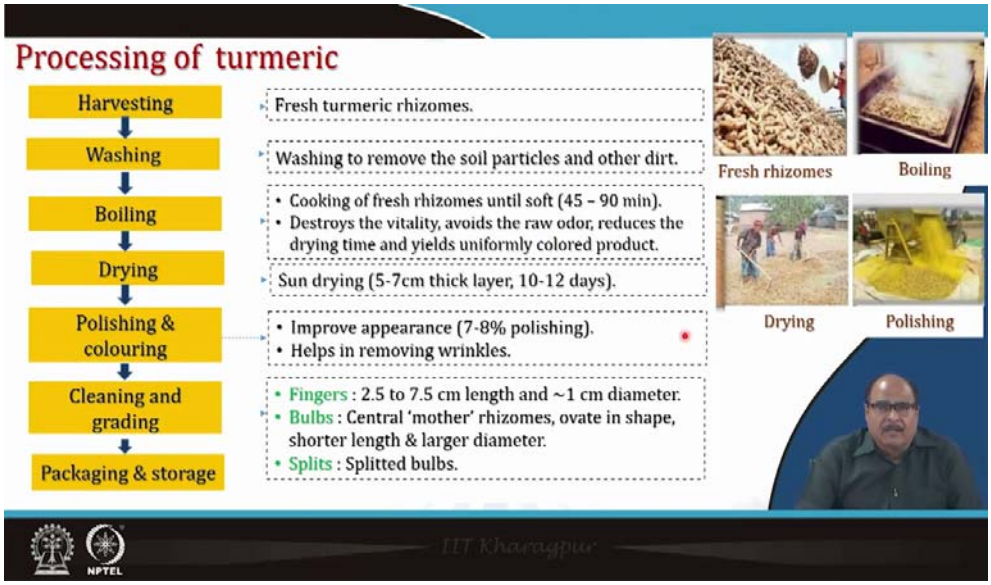
Processing of the cardamom

After harvesting, cleaning i.e. washing is done to remove the soil particles and other dirt, etc. Then it is given pre-treatments like it is soaked in sodium bicarbonate 2 to 5 % solution for 10 min to retain the green colour followed by drying or curing to safe moisture level up to 10 % either by sun drying or by artificial drying. Then, this dried cardamom is subjected to polishing treatment where the dried capsules are rubbed on wire mesh to remove the stalk and the dried portion of flower from the capsule. Grading is done using sieves of 7, 6.5, or 6 mm dimensions but that is precise sieve size and then it is packaged in 300 Gauge black polythene lined gunny bags and stored.

Equipment used in processing of large cardamom powder

Traditional Bhatti for curing and drying. Modified Bhatti i.e. there are some big bricks and cement which are used in these Bhattis, Also, the gasifier system can be used for drying. Pulveriser which is used for grinding the dried cardamom. Dryers either solar dryer or mechanical radar and vertical filling machine and labelling etc. These are some of the equipment which can be used for processing as well as making powder of the cardamom.

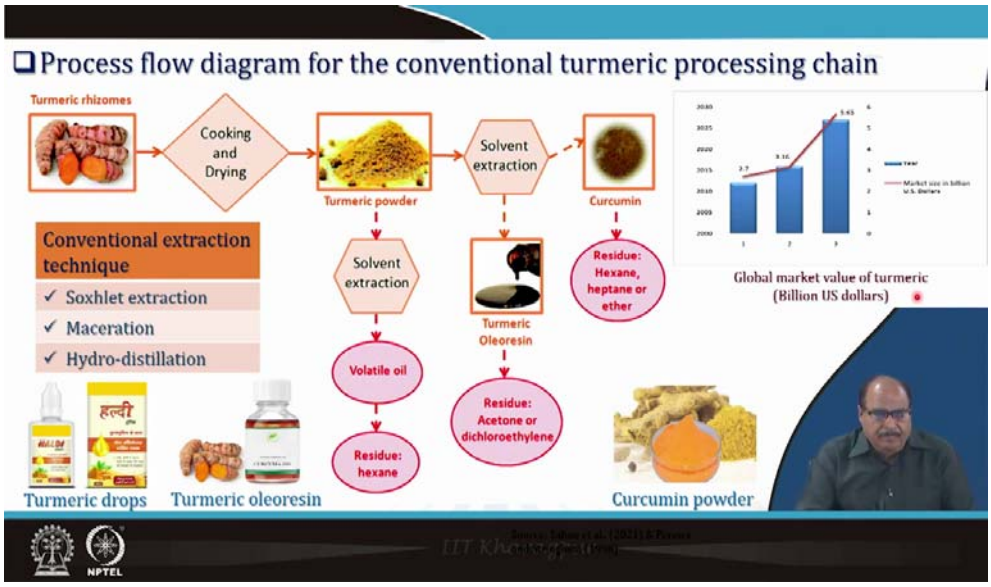




Processing of turmeric

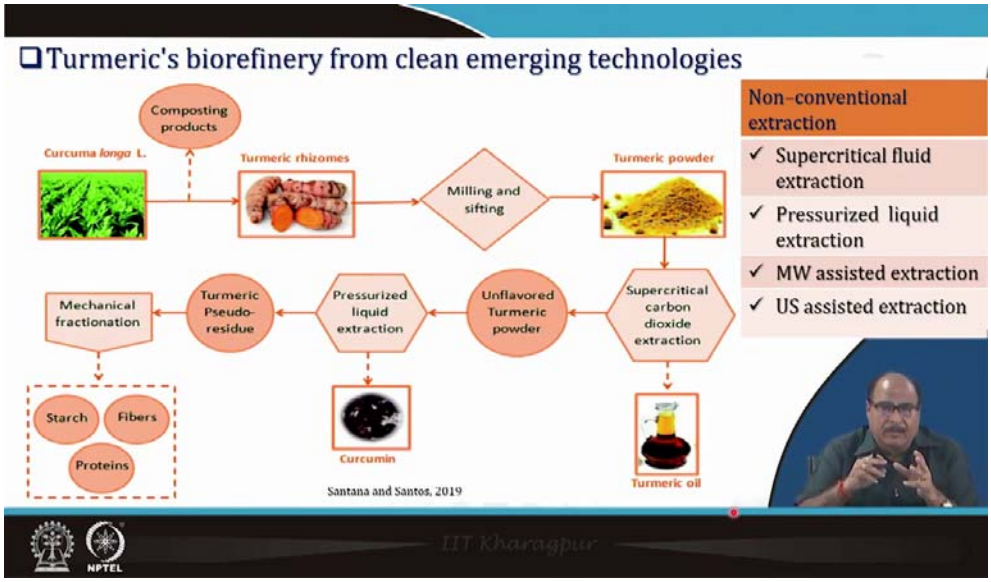
Turmeric i.e. the fresh turmeric rhizome is harvested and then it is subjected to washing treatment to remove soil particles and other dirt followed by boiling where cooking of the fresh rhizome is done until it becomes soft maybe boiled for about 45 to 90 min. This process destroys the vitality, avoids raw odour, reduces the drying time and also yields uniformly coloured products. Drying is done traditionally i.e. sun drying is used where rhizomes are spread in a thick layer of 5 to 7 cm for 10 to 12 days. However, the artificial drying can also be used. After drying, the polishing or colouring is an important operation which improves the appearance by polishing 7 to 8 %. This polishing also helps in removing the wrinkles from the dried material. Then cleaning and grading is done where fingers of 2.5 to 7.5 cm length and about 1 cm diameter; bulbs that the central mother rhizomes, oval in shape, shorter

in length and larger diameter or splits that the splitted bulbs. So they are graded in this either fingers or bulbs or splits and finally they are packed.



Process flow diagram for the conventional turmeric processing chain

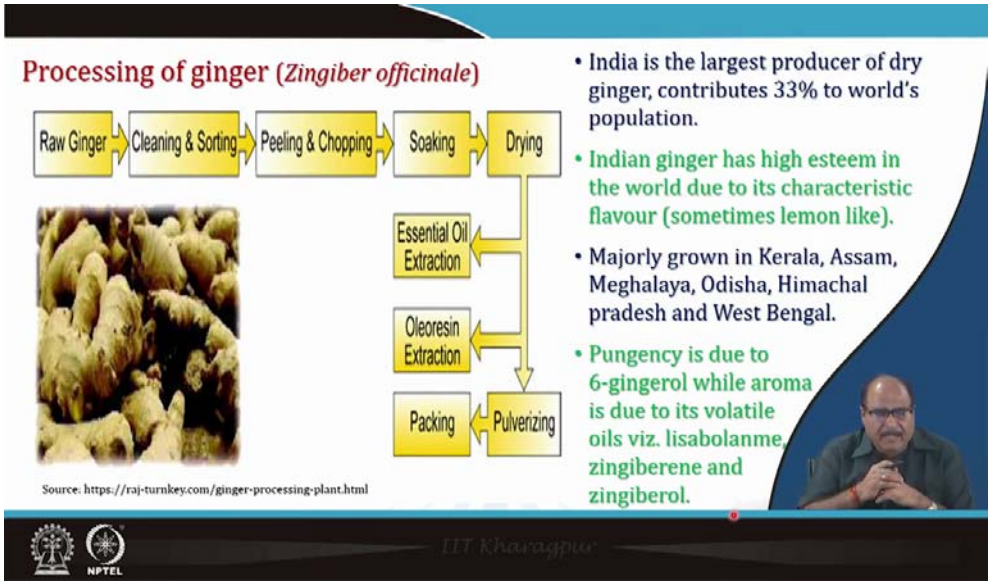
By this process the rhizome, i.e. dried rhizomes they are pulverized using appropriate grinding machines into powder and this powder will be treated with the extraction techniques like solvent extraction, maceration, or hydro-distillation and then this product like turmeric drops, turmeric oleoresins or even curcumin powder by extraction is obtained.



Turmeric's biorefinery from clean emerging technologies

These conventional extraction techniques nowadays is being replaced with the other advanced technique, particularly to get maximum antioxidant potential and other bioactive

properties, functional properties and these processes like supercritical fluid extraction or pressurized liquid extraction, microwave-assisted extraction or ultrasound-assisted extraction are used and the products like turmeric oil, curcumin, or various fractions of the rhizome like starch, fibres, protein for application in other food products etc. as flavour enhancers or for other purposes are produced and available in the market.



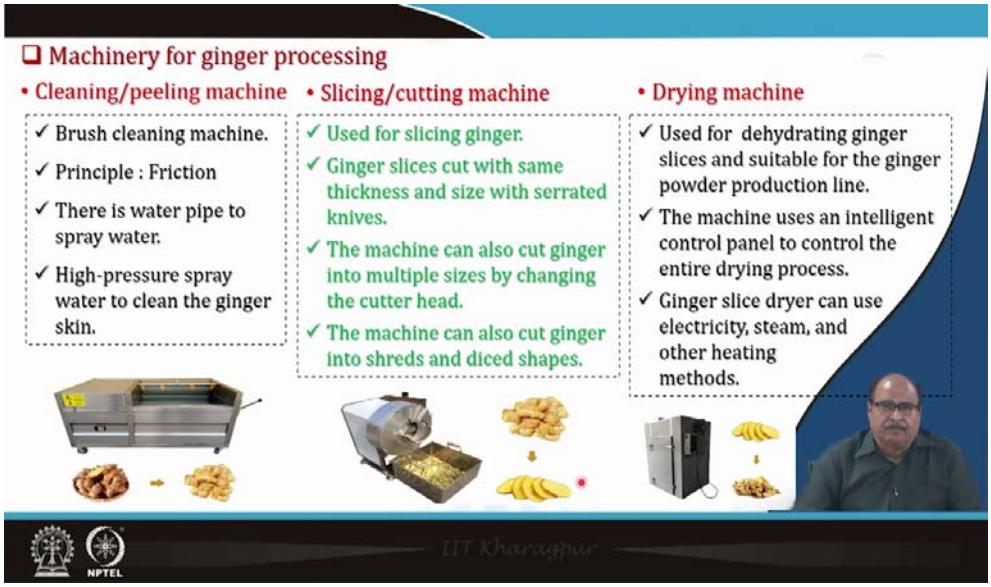
Processing of ginger

India is the largest producer of dry ginger. It contributes about 33 % to the world's population. Indian ginger has high esteem in the world due to its characteristic flavour even sometimes that it gives a lemon-like taste. It is majorly grown in southern states like Kerala, and also in the northern part in Assam, Meghalaya, Orissa, and Himachal Pradesh as well as in West Bengal. Pungency of ginger is mainly due to the presence of 6-gingerol while the aroma is due to its volatile oil like lisabolanme, zingiberene, and zingiberol.

As far as the processing of the ginger is concerned, there are steps after it is obtained from the field then it is subjected to various treatments like sorting, washing, peeling, drying, polishing, cleaning, grading and then finally storage.

Sorting involves the separation of good rhizomes from the shrivelled ones and extraneous matter is removed. Then in the washing, harvested rhizomes are either soaking in the water overnight or even by spraying the water the outer skin is scraped off with a bamboo splinter. Peeling is done to remove scaly epidermis and to facilitate drying. Peeled rhizomes are washed before drying. The moisture content almost 80 % during harvesting is brought down

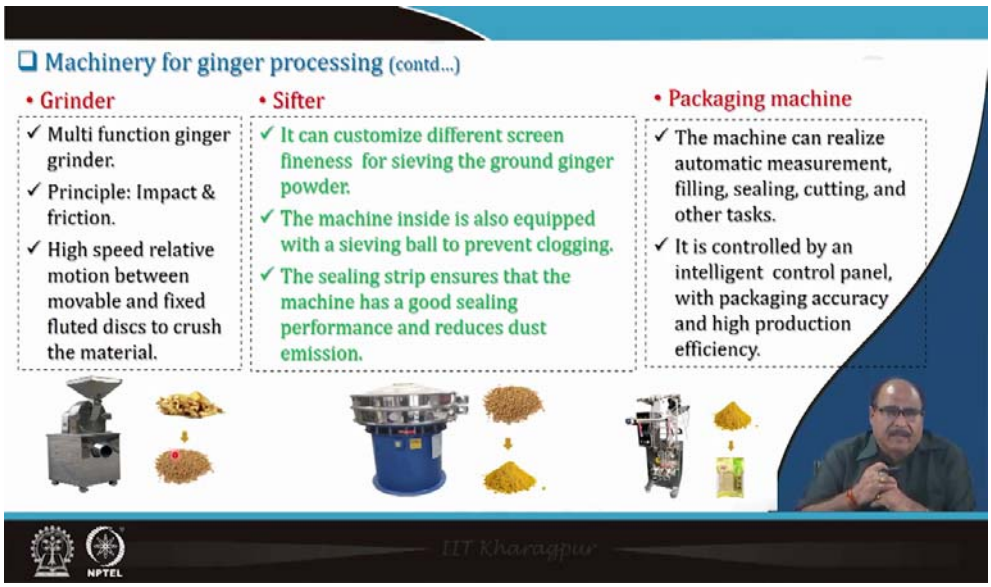
to 10 % after the drying. Polishing is done to remove the dry skin and wrinkles which are developed on the surface during drying process. It is done by abrasive tools. Cleaning is done to remove the undesirable matter and the dried peels attached to the rhizome surface. Grading is done for obtaining rhizomes with good quality and commercial value and fully dried rhizomes are stored in airtight containers, HDPE, etc. or they are sent for the various process operation- preparation of powder, extraction of essential oils, oleoresins and so on.



Machinery for ginger processing

Normally, brush cleaning machine is used for cleaning and the principle of its operation is friction and there is water pipe to spray the water and high-pressure spray water to clean the ginger skin. Slicing and cutting machines are used to cut the ginger into multiple sizes by

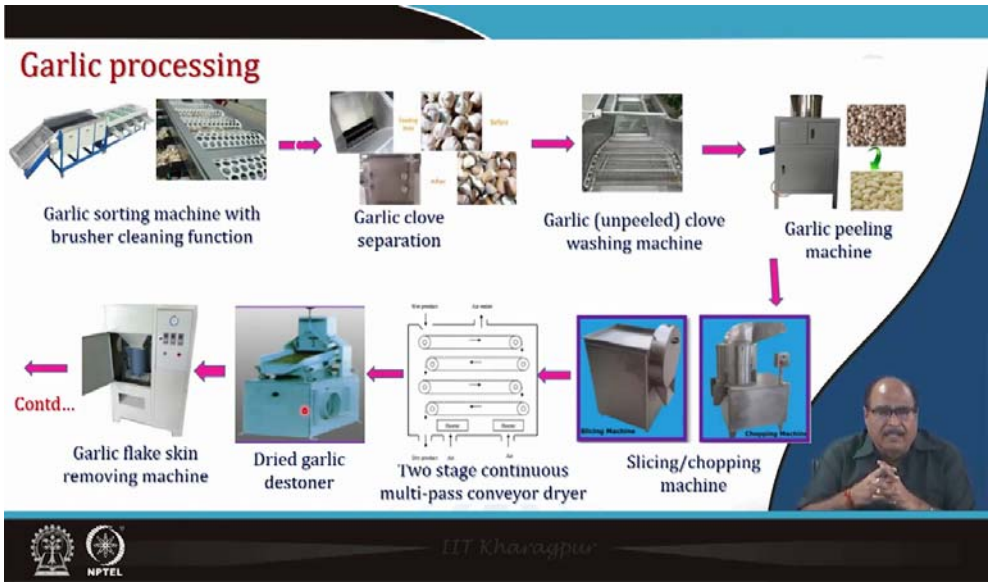
changing the cutter head. The machine can cut the ginger into shreds and diced shapes. Drying machine is used for dehydration of the ginger. Machine uses an intelligent control panel to control the entire drying process. Air stream should be controlled to get the dried product with maximum retention of the volatiles and other bioactives.



Grinder- a multifunctional ginger grinder is used where high speed relative motion between the movable and fixed fluted discs to crush the material and it works on the principle of impact and friction. The sifter customizes different screen fineness for sieving the ground ginger powder. The sealing strip ensures that the machine has a good sealing performance and reduces the dust emission from the system. And then finally the packaging machine. The filling, sealing packaging machine is used for both powder as well as the ground material or even other products can be used.

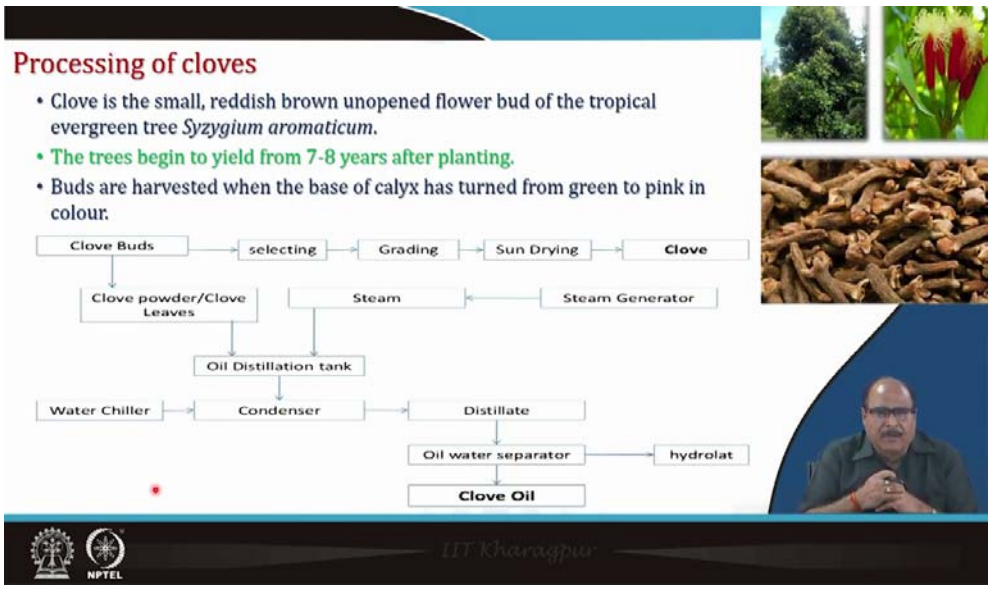
Value-added products made from ginger

Ginger splits, bleached ginger, dry ginger, ginger powder, ginger preserve, ginger pickle, candies made of ginger, ginger oleoresin and ginger essential oils. These are all available in the market. So ginger is one spice which is used for various value-added product making.



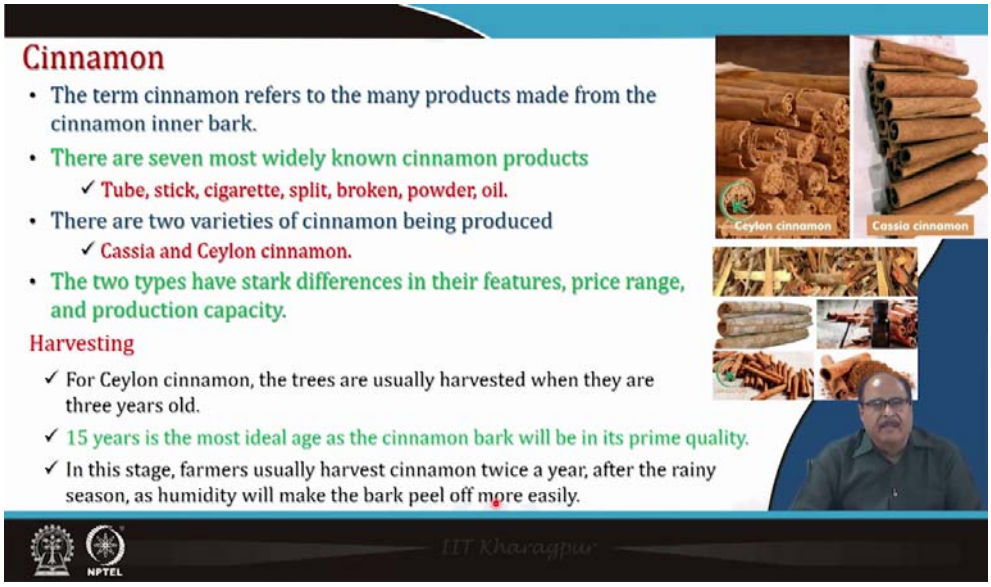
Garlic processing

Garlic is another important commodity. It is first harvested from the field then subjected to sorting into sorting machine with the brusher cleaning function. After sorting, the cloves are separated and these cloves i.e. garlic cloves unpeeled, they are sent to the washing machine, properly washed and followed by peeling where the cloves are peeled. Then, it is subjected to slicing or chopping machines where they are cut into smaller slices or may be converted into paste since garlic paste is available in the market. Slices or even paste, they can be sent to the appropriate drying method either slices to a two-stage continuous multi-pass conveyor dryer or this paste can be sent to the spreader, freeze dried, for making powder. The slices can be passed to the destoner, garlic flake skin removal machine from the dried if there is any. Then it is subjected to the dried garlic vibrator classifier, magnetic separator, colour sorters, metal detector, particularly for the dried garlic chips. The paste, accordingly the paste or powder also are suitably packaged and then kept.



Processing of cloves

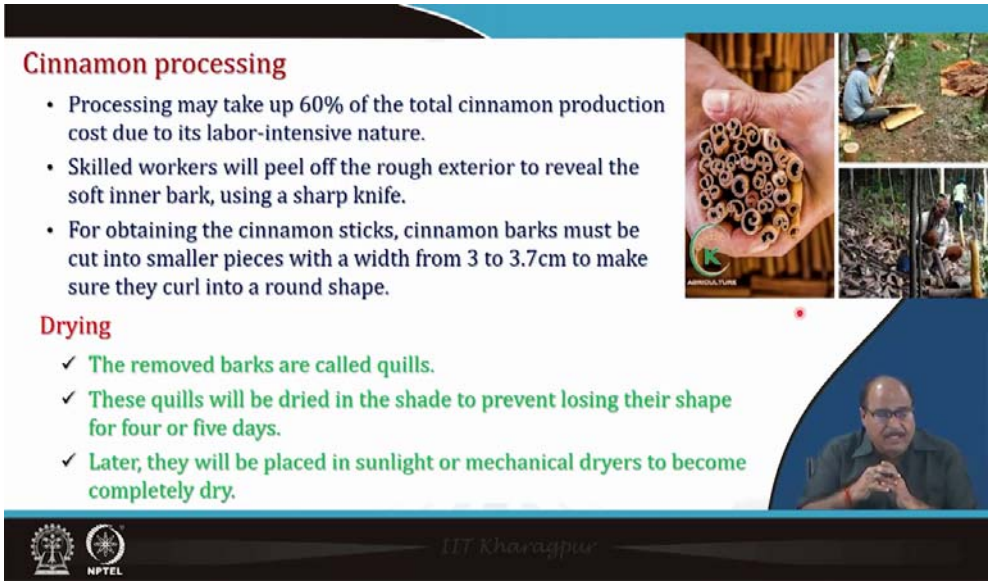
It is a small, reddish brown unopened flower bud of the tropical evergreen tree *Syzygium aromaticum*. The trees begin to yield from 7 to 8 years after planting and the buds are harvested when the base of calyx has turned from green to pink in colour. India produces a significant amount of the cloves and these cloves are known for their essential oil, eugenol content. Eugenol is a very good raw material for pharmaceutical companies for the medicine for teeth, etc. Clove is extracted either using appropriate supercritical fluid extraction technology, eugenol is extracted from it or alternatively even sometimes that is the oil distillation tank, a solvent distillation can also be used to take out the clove oil and remaining the solvent extracted as supercritical extracted clove is sent to the market for the use as spices.



Cinnamon

The term cinnamon refers to many products made from the cinnamon inner bark. There are 7 most widely known cinnamon products like tube, stick, cigarette, split, broken, powder, oil, etc. There are two varieties of cinnamon being procured like Cassia and Ceylon cinnamon. The two types have stark differences in their features, price range and production capacity.

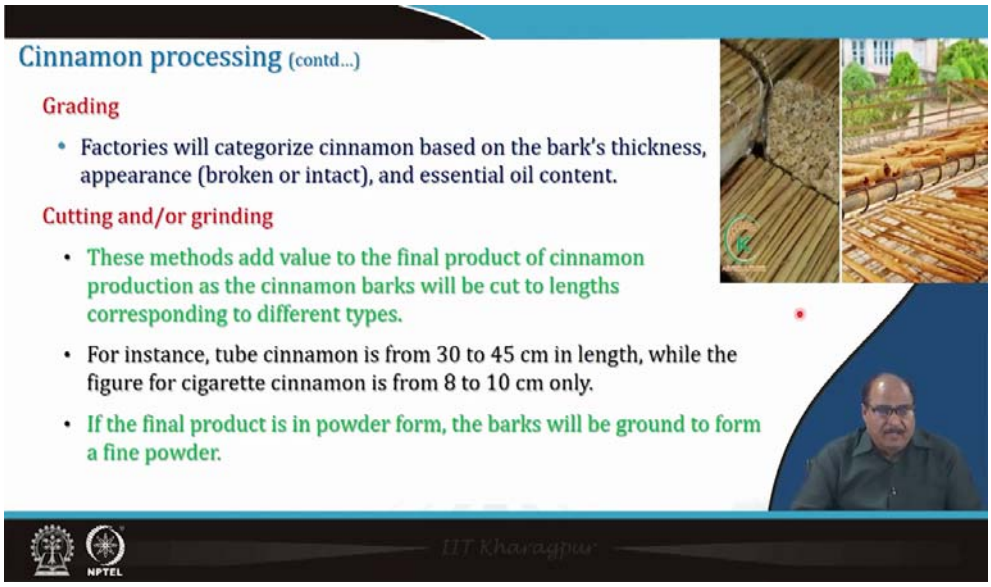
As far as the harvesting is concerned, for Ceylon cinnamon, the trees are usually harvested when they are 3 years old. However, 15 years is the most ideal stage as the cinnamon bark will be in its prime quality. In this stage, farmers usually harvest cinnamon twice a year after the rainy season, as humidity will make the bark peel off more easily.



Cinnamon processing

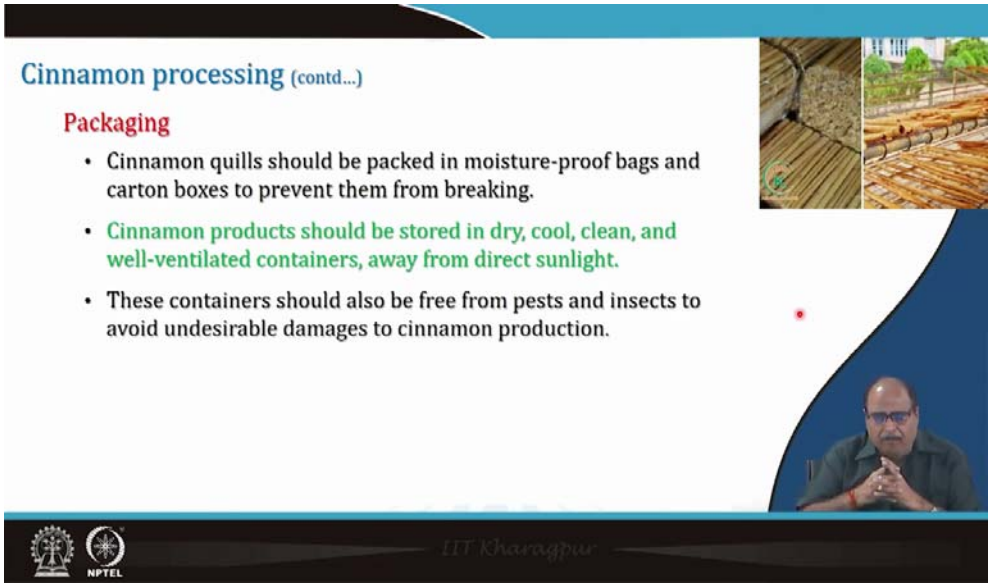
It is a purely labour-intensive operation and about 60 % of the cost of the cinnamon is its processing cost. For obtaining cinnamon sticks, cinnamon bark must be cut into smaller pieces with a width up around 3 to 3.7 cm to make sure they curl into a round shape.

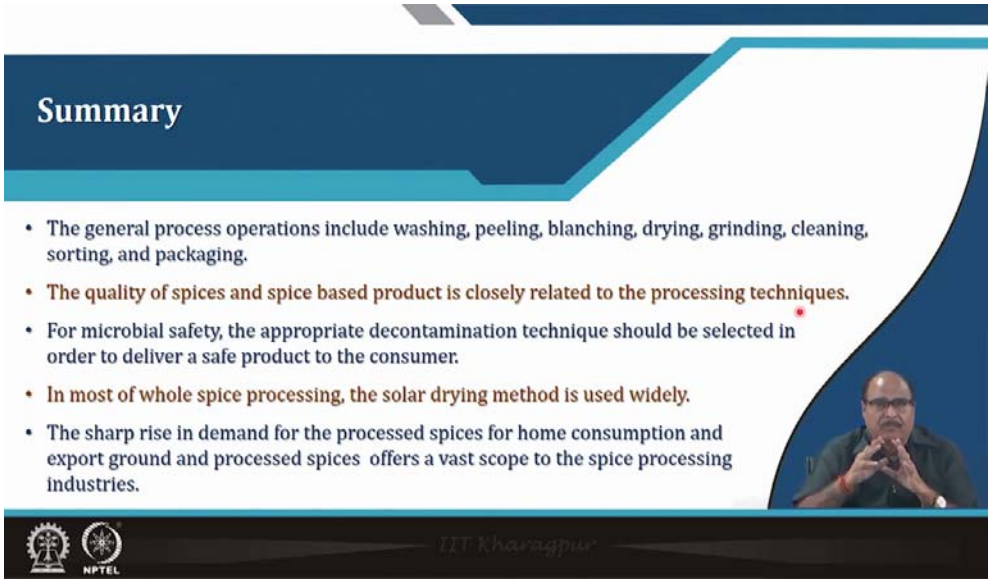
Then they are dried. The removed barks are called quills and these quills are dried in shade to prevent losing their shape for about 4 to 5 days. Later, they will be placed in sunlight or in a mechanical dryer to become completely dry.



Factories categorize cinnamon based on the bark's thickness, appearance, and its essential oil content. After grading, cutting or grinding is carried out depending on the final product size. For instance, tube cinnamon is from 30 to 45 cm in length, while the figure for cigarette cinnamon is from 8 to 10 cm only. The final product maybe in the powder form, the bark will be ground to form a fine powder.

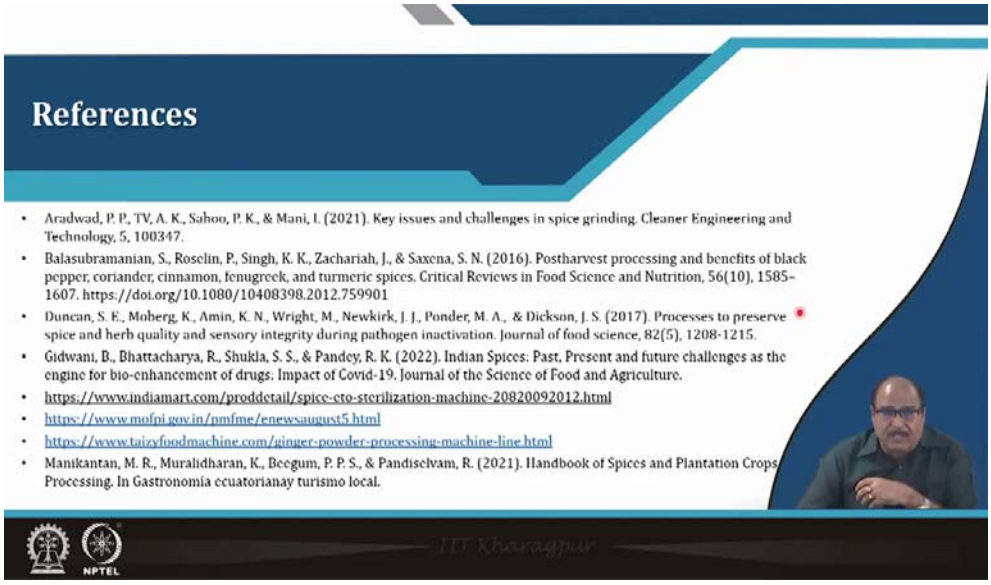
Cinnamon products are packed in moisture proof bags or polythene plastic, PPE or PET materials and this would be stored in dry, cool, clean and well-ventilated containers which are away from directly sunlight otherwise light may oxidise its flavouring components. These containers should also be free from pests and insects to avoid undesirable damage to the cinnamon product.





Summary

Spices are very important commodity particularly in the Indian cuisine but after their harvesting, they should go to various processes and all the processes should be conducted properly so that the value of the spices particularly essential oil, antioxidant potential, other bioactive functional, their medicinal value is retained. These spices are made available in the market for use in various products for direct use in the cooking operation. These spices contain various anti-microbials, antioxidants, and oleoresins, essential oils that are extracted using appropriate extraction technologies. So they are very valuable. They add to the food taste, flavour and many other functional characteristics, etc. In fact, there are many spices which are reported in Ayurvedas, these spices have the good healing properties, antibacterial activity.



These are the references used. Thank You.