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

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

Lecture 34
RTE Fruit Products

The concepts covered in this lecture are ready-to-eat (RTE) fruit products, technology for the manufacture of common RTE fruit products such as fruit leather, raisins, and fruit chips.

RTE fruit products

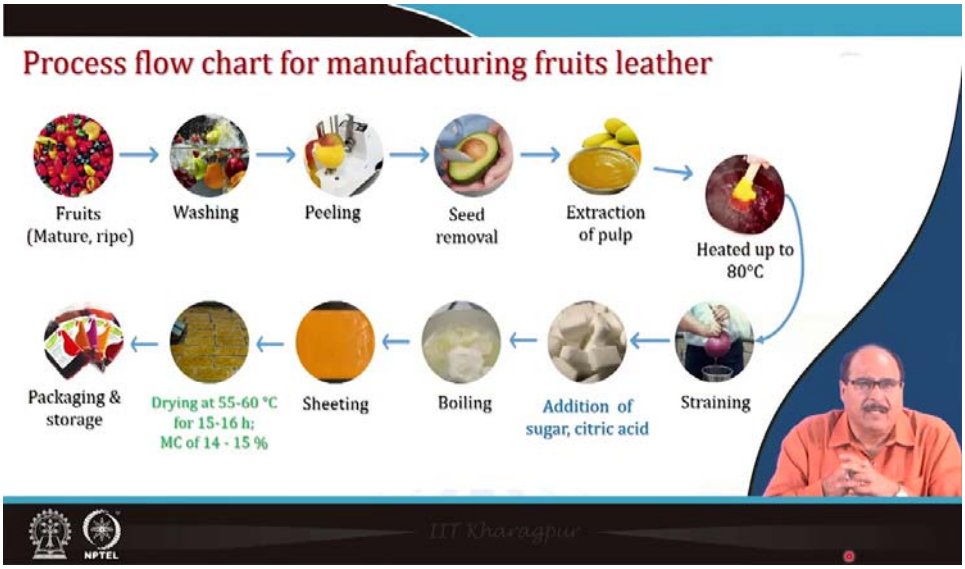
The ready to eat products refers to those products which are ready for direct consumption, without any preparation. A fast-paced herbal lifestyle, increasing dominance of nuclear family structure, raising disposable income, and convenience of use have made the RTE foods very popular, and particularly RTE fruit products because these fruits they are considered as a hub of health promoting components, micronutrients, macronutrients etc. So, the RTE fruit products are gaining more and more popularity among the consumers now.

The three common categories of RTE fruit products produced in the industries are leather, chips and dehydrated fruits like raisins, dates, mango leather, thick banana chips, pineapple chips and so on. All these products requires removal of moisture by one or other means by using a suitable drying technique. The heart of all this process is the drying and dehydration. In other words, the natural sugars present in the initial material are concentrated and gives the desired sensory and other characteristics, and also improves the shelf-life of the product.

Fruit leather

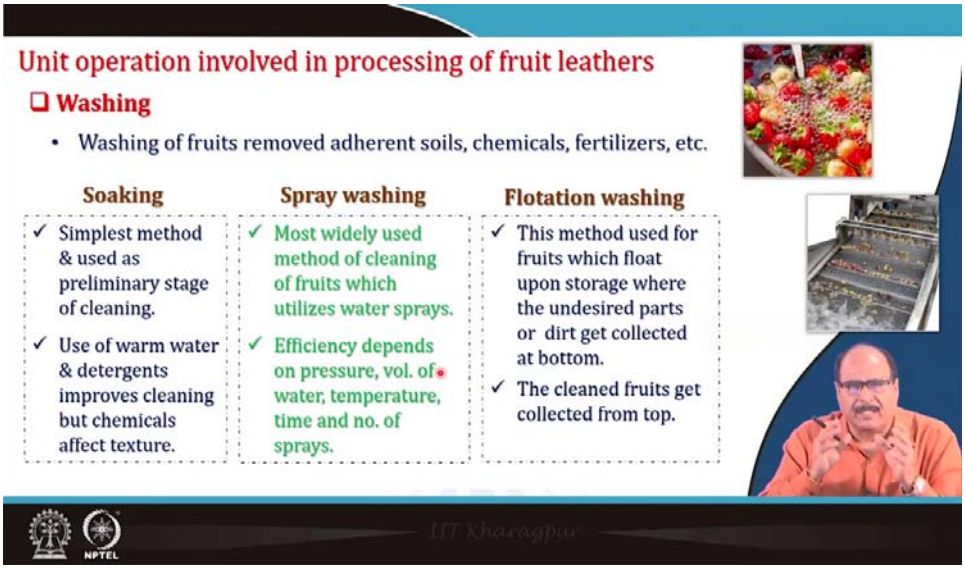
The fruit leathers are dried sheets of fruit pulp which have a soft, rubbery texture, and a sweet taste. These are chewy, flavorful, naturally low in fat, high in fiber and carbohydrates, and are also lightweight and can be easily stored and packed.

However, in their preparation, certain innovative/novel technologies are needed, because in drying of these fruits and vegetables for the preparation of leather, loss in color, bioactives, nutrients etc. is very high which makes the product not likeable by the consumers. The market available leathers are mostly made from apple, guava, jackfruit, kiwifruit, mango, pineapple, grape and pear. Any fleshy or pulpy fruit is suitable for making a leather. Mango leather is the most common and in villages it is easily available by ‘Aam papad’.



Process flowchart for manufacturing of fruit leathers

In the figure, the process flowchart for manufacturing fruit leather is shown. This process is applicable to all fruits. Only depending upon the type of fruit used, some treatments may differ. The first step is selecting ripe fruits. The obvious treatment of washing, peeling, then seed removal (in case of mango or similar fruits) where the seed kernels are removed. After that, the pulp is extracted and heated to around 75 to 80 °C for a few minutes. The heated pulp is strained to remove fibrous materials, then it is added with the citric acid and sugars. After that, it is boiled, then sheeted. It is spread in the form of a thin sheet in a container or in a tray, followed by drying at around 55 to 60 °C for about 15 to 16 hours. The final moisture content of these leathers may be 14 to 15 %. Finally, it is packaged and stored.



Unit operations involved in processing of fruit leathers

Washing

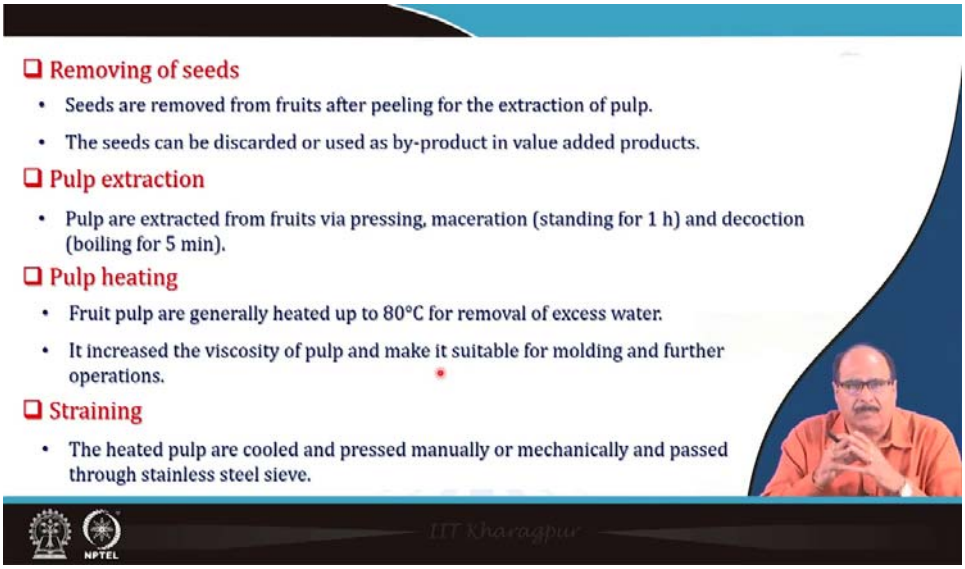
Washing is necessary as it remove soil, chemicals, fertilizers etc. There are various ways by which washing can be achieved such as soaking, spray washing, and flotation washing. During washing extra care is taken so that the skin should not get damaged. Otherwise, there may be leaching losses. Washing should be gentler in spray washing, and all undesirable materials should be clean, then removed.

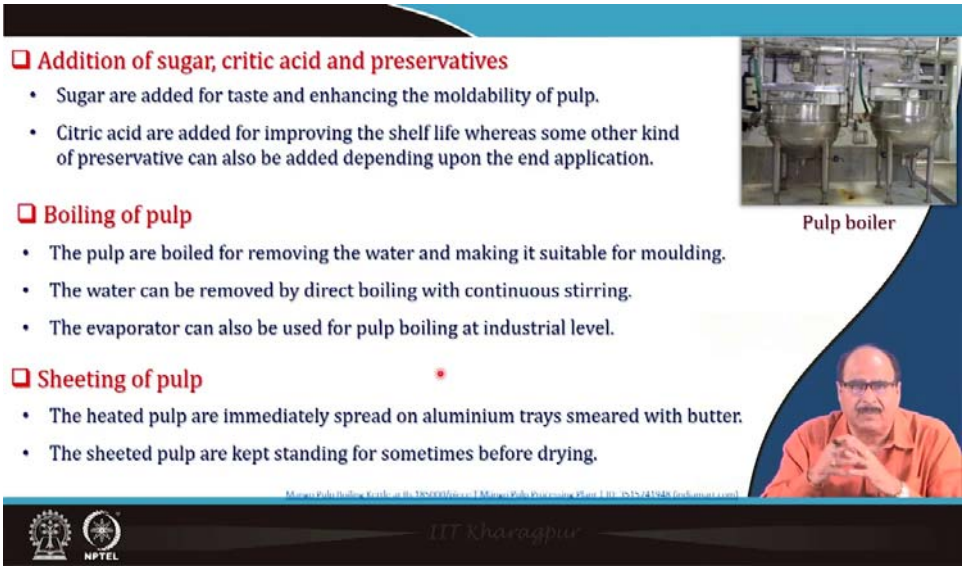
Peeling

After washing, next step is peeling. Peeling removes the inedible portion (peel, seeds, and stalks etc.). Peeling is categorized into five types depending upon the type of fruits used and its structures viz. manual peeling, chemical peeling, enzymatic peeling, mechanical peeling, and thermal peeling.

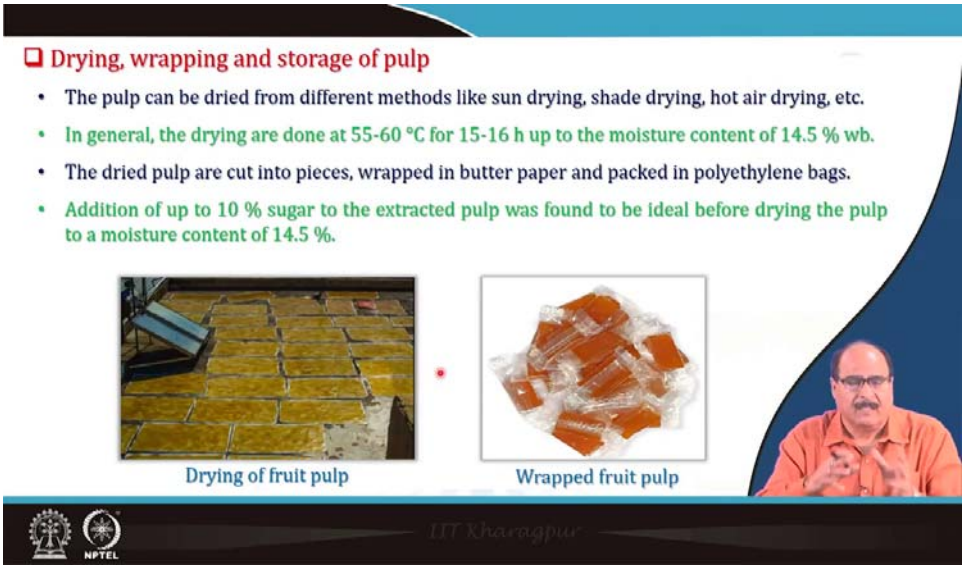
The seeds are removed from the fruits after peeling for the extraction of pulp. The seeds can be discarded or can be used as by-product in value added products.

The pulps are extracted from the fruits by either pressing or by maceration extending for 1 hour, or by decoction i.e. boiling for 5 minutes. For example, in case of mango, the mango kernel powder is prepared which are very good source of valuable fat i.e. kernel oil. After that, the pulp is heated up to 80 °C for the removal of excess moisture and it increases the viscosity of the pulp and makes it suitable for molding and further operations. The heated pulps are cooled and pressed manually or mechanically and passed through stainless sieve to remove the fibrous materials or some fine seeds etc. in the case of guava or other such products.

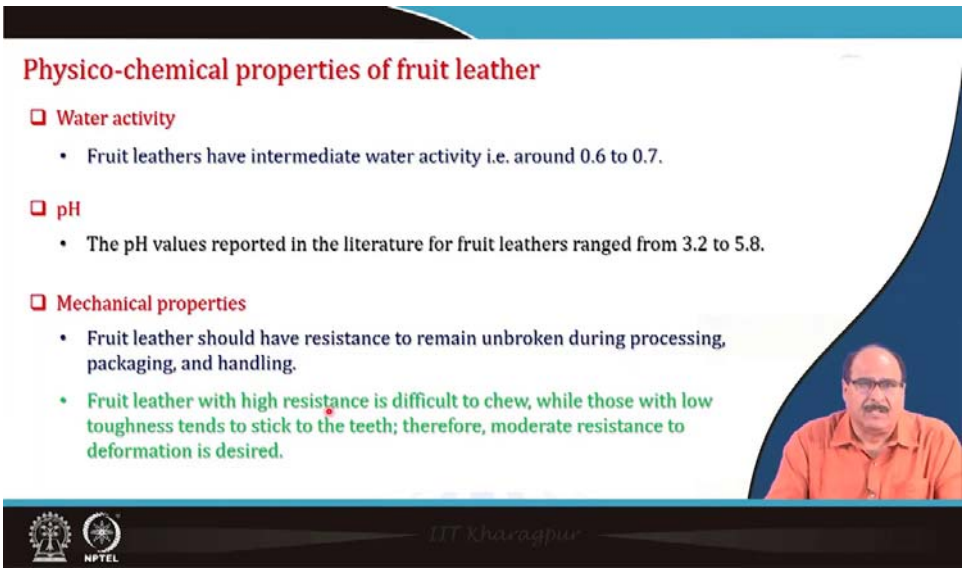




After straining the pulp, sugar, citric acid and other preservatives are added. Sugars also improves the taste and enhances the moldability of pulp. Citric acid is added for improving the shelf life whereas some other kind of preservatives can also be added depending upon the end application. The pulp is boiled and the purpose of boiling is the removal of water and making it a suitable for molding. Basically, it is the concentration. The water can be removed by direct boiling with continuous stirring or the evaporator can also be used for pulp boiling at industrial level. During boiling, appropriate novel methods should be used to reduce the nutrient losses. After boiling, the next step is the sheeting of the pulp. The heated pulps are immediately spread on aluminum trays smeared with butter, and this sheeted pulp are then kept standing for sometime before they are put for proper setting. And once it is set, then it is put into the drying chamber.



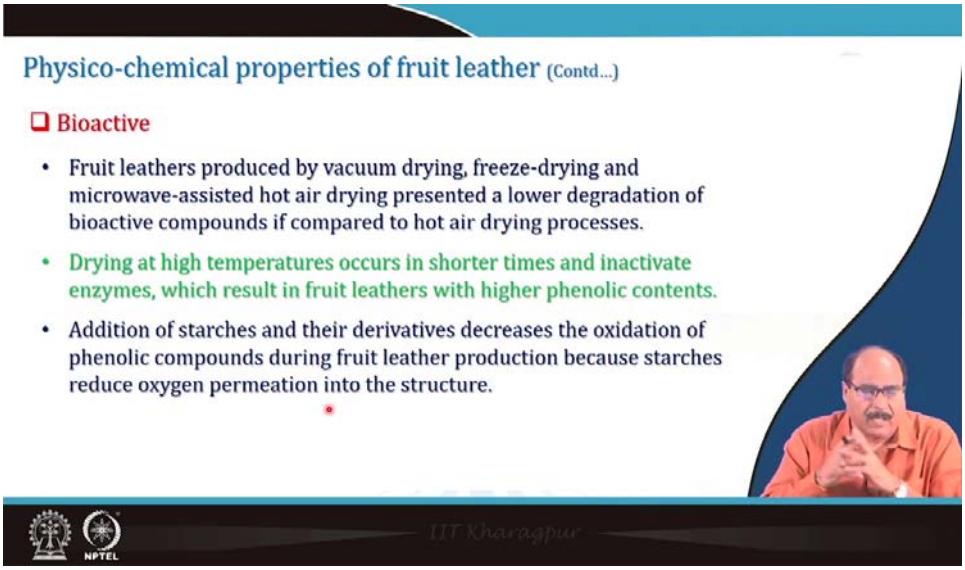
The pulp can be dried from different methods like sun drying, shade drying, hot air drying, etc. In fact, sun drying is the most commonly used method in the villages for making mango leather. In general, one layer is dried, and after that another layer of the pulp is put and then it is dried, then third layer, fourth layer. Layer after layer is added. The drying is done at 55-60 °C for 15-16 h up to the moisture content of 14.5 % wb. The dried pulp are cut into pieces, wrapped in butter paper and packed in polyethylene bags. The addition of up to 10 % sugar to the extracted pulp was found to be ideal before drying the pulp to a moisture content 14.5 %.



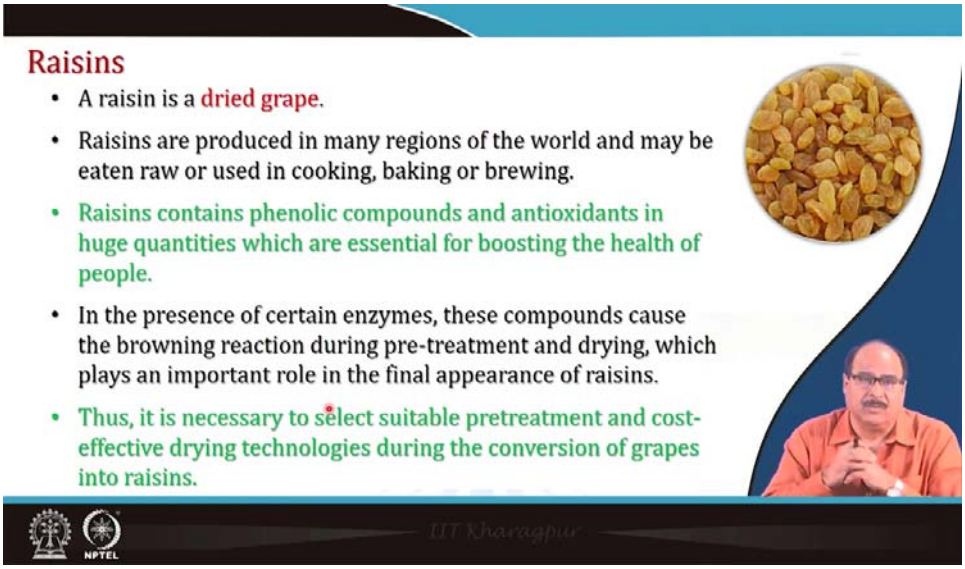
Physico-chemical properties of fruit leathers

Water activity is very important, because in fruit leather as the concentration and addition of sugar takes place which binds the water. The fruit leathers have intermediate water activity range

of around 0. 6 to 0.7. The pH values reported in the literature for fruit leathers ranged from 3.2 to 5.8 depending upon the fruit used. The fruit leather should have resistance to remain unbroken during processing, packaging and handling. These leathers with high resistance is difficult to chew, while those with low toughness tends to stick to the teeth; therefore, moderate resistance to the deformation is desired.

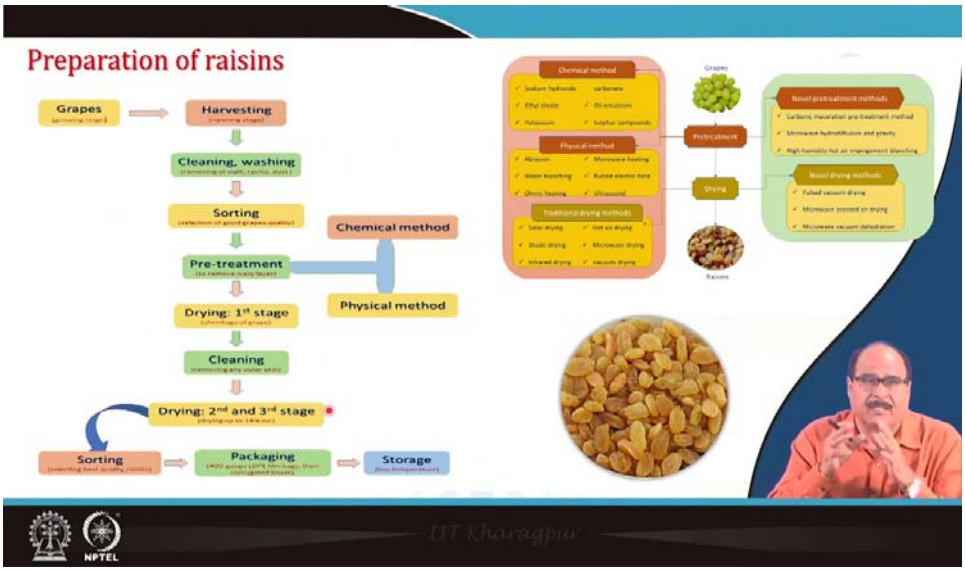


In order to retain the bioactives, vacuum drying, freeze-drying, and microwave-assisted hot-air drying are used. Drying at high temperature occurs in shorter times and inactivates enzymes which results in fruit leathers with high phenolic contents. Sometimes, starches and their derivatives are added to decrease the oxidation of phenolic compounds during fruit leather production. The starches reduce oxygen permeation into the structure.



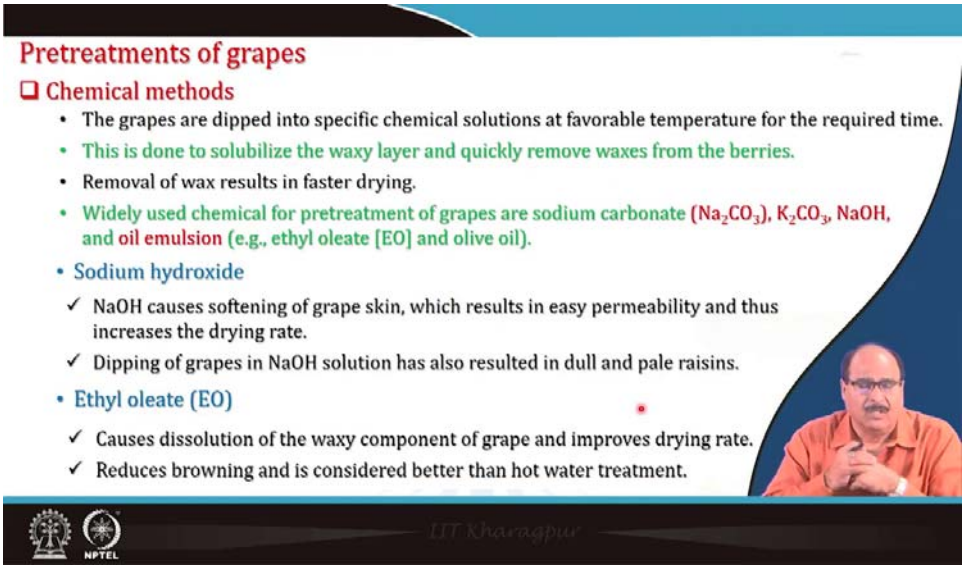
Raisins

Raisins are basically the dried grapes. These are produced in many regions of the world and may be eaten raw or are used in cooking, baking and many other purposes. India also produces a significant amount of good quality raisins. Raisins contains phenolic compounds and antioxidants in huge quantities which are essential for boosting the health of the people. In the presence of certain enzymes, these compounds cause the browning reactions during pretreatment and drying, which plays an important role in the appearance of the raisins. In fact, the outward color development and glassy nature, just the other raisins are different, there is appearance and glassy natures are available. It is done by properly controlling the pretreatment and the drying process parameter. Thus, it is necessary to select suitable pretreatment and cost-effective drying technique to convert grapes into raisins.



Preparation of raisins

The main steps for the preparation of raisins are discussed. The grapes are taken at proper maturity, the viticulture is very important now in India, then it is given to certain pretreatment, and then finally, drying. The other obvious operations like washing, cleaning, sorting etc. must be carried out initially. The pretreatment may be either chemical pretreatment or physical pretreatment, and next comes the drying. The drying method, the conventional trying method or the novel drying methods can be used. In order to get the better quality, novel technologies for pretreatment as well as drying of grapes are of utmost importance. Drying may be carried out in to two or three stages, to get the end product of proper characteristics which are packed and stored.



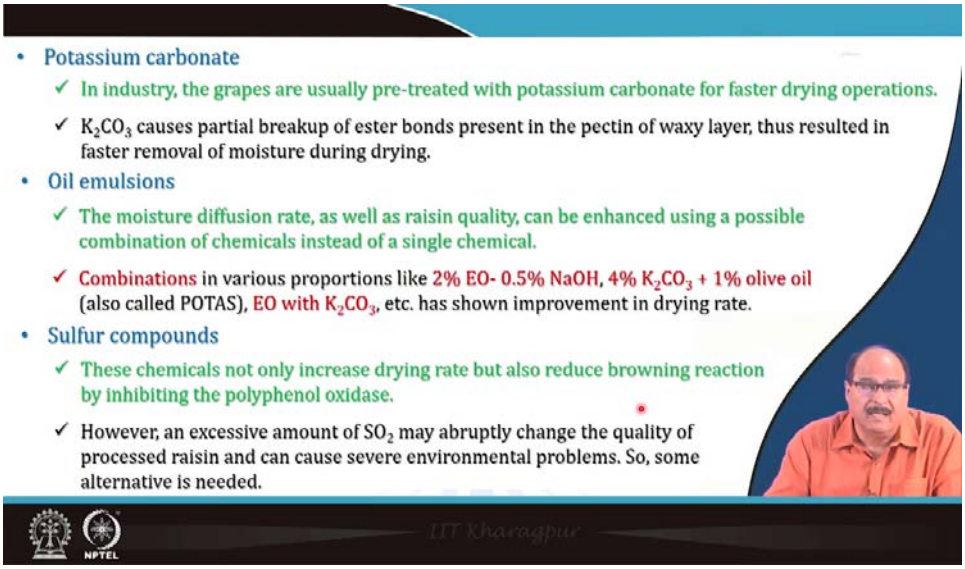
Pretreatments of grapes

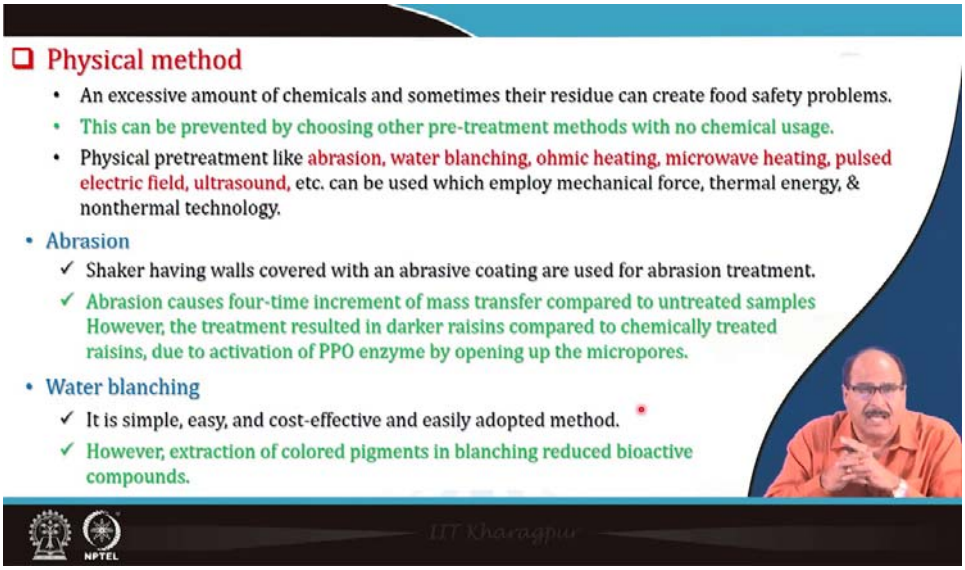
There are there types of pretreatment available for grapes, some are explained below. The chemical methods for pretreatment. In the chemical pretreatment, the grapes are dipped into specific chemical solutions at favorable temperature for the required time, and this is basically done to solubilize the waxy layer and quickly remove waxes from the grapes. This removal of wax results in a faster drying rate. The widely used chemicals for pretreatment of grapes include sodium carbonate, potassium carbonate, sodium hydroxide or even sometimes an oil emulsion like ethyl oleate or olive oils etc. Sodium hydroxide causes softening of grape skin, which results in easy permeability, and thus increases the drying rate. Dipping of grapes in sodium hydroxide solution has also resulted in dull and pale raisins. Ethyl oleate causes dissolution of the waxy component of grapes and improves the drying rate. It reduces browning and is considered better than the hot water treatment.

When the grapes are pretreated with potassium carbonate, the drying process is improved. Potassium carbonate causes partial breakup of ester bonds present in the pectin of waxy layer, thus resulted in faster removal of moisture during drying, and the drying operation is fast.

The moisture diffusion rate as well as the raisin quality can be enhanced using a possible combination of chemicals instead of a single chemical. The combination of various proportions of the chemicals, like 2 % ethyl oleate, and 0.5 % sodium hydroxide, 4 % potassium carbonate, and 1 % olive oil, also called POTAS, EO with K_2CO_3 has shown improvement in drying rate.

These sulfur like KMS, not only increases the drying rate but also reduces the browning reactions by inhibiting the polyphenol oxidase enzyme. However, an excessive amount of sulfur dioxide may abruptly change the quality of the processed raisins and can cause severe environmental problems.



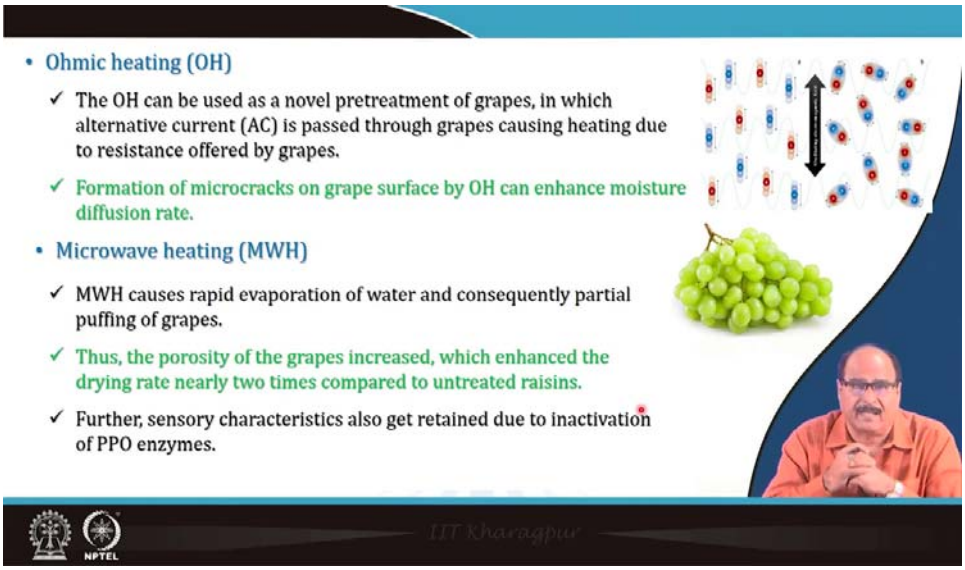


Physical method

An excessive amount of chemicals and sometime their residues can create the food safety problems. So, the physical treatment like abrasion, water blanching, ohmic heating, microwave heating, pulse electric field, ultrasound etc. can be used which employ mechanical force, thermal energy and even non-thermal technology to improve the drying rate as well as appearance and other characteristics of the product.

In abrasion, a shaker having walls covered with an abrasive coating are used for abrasion treatment. Abrasion causes four-time increment of mass transfer compared to untreated samples. However, the treatment also resulted in darker raisins compared to the chemically treated, due to the activation of polyphenol oxidase enzyme by opening up the micropores.

Water blanching is simple, easy, cost-effective and easily adopted method. However, during the extraction in water blanching, there are high chances of extraction of colored pigments in the blanching water which reduced the bioactive components.

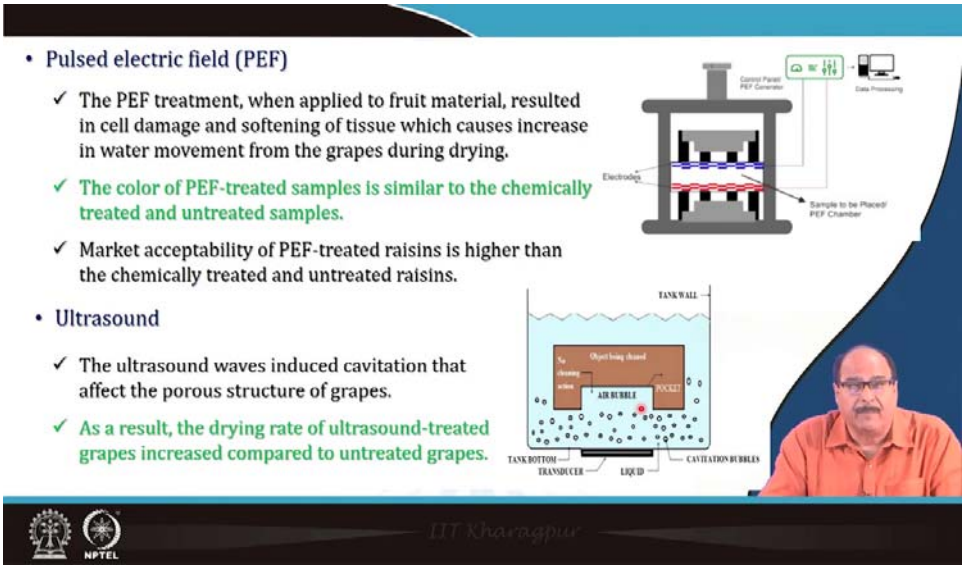


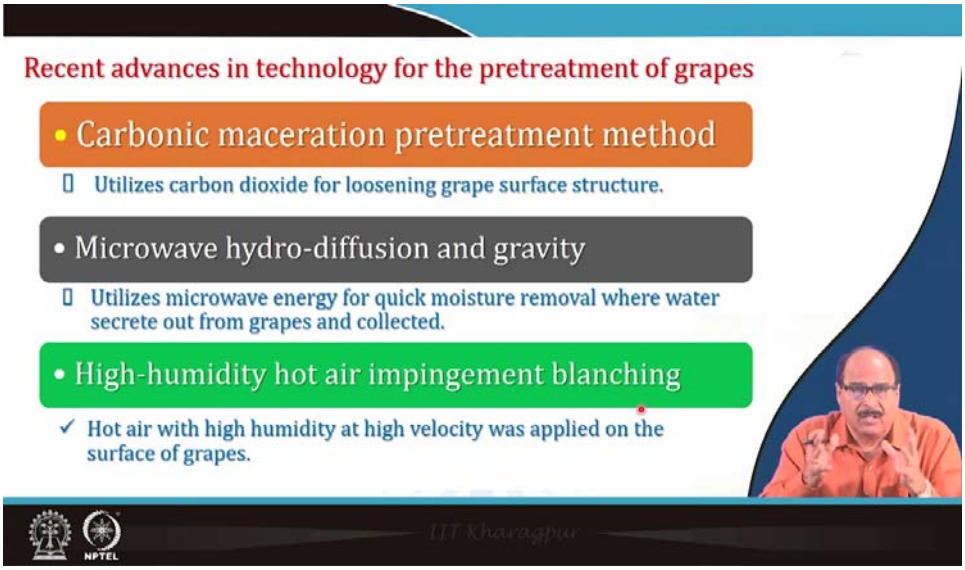
Ohmic heating can be used as a novel pretreatment of grapes in which an alternating current (AC) is passed through the grapes causing heating due to the resistance offered by grapes. The formation of microcracks on the grape surface by ohmic heating can enhance moisture diffusion rate.

Microwave heating causes rapid evaporation of water and consequently partial puffing of the grapes. Thus, porosity of the grape is increased which enhances the rate of drying by nearly two times compared to untreated raisins. Further, sensory characteristics also get retained due to inactivation of enzymes.

Pulse electric field treatment, when applied to fruit material, resulted in cell damage and softening of tissues which causes increase in water movement from the grapes during drying. The color of PEF treated samples is similar to that of the chemically treated samples or even untreated samples. The market acceptability of PEF treated raisins is reported to be higher than that of chemically treated or untreated raisins.

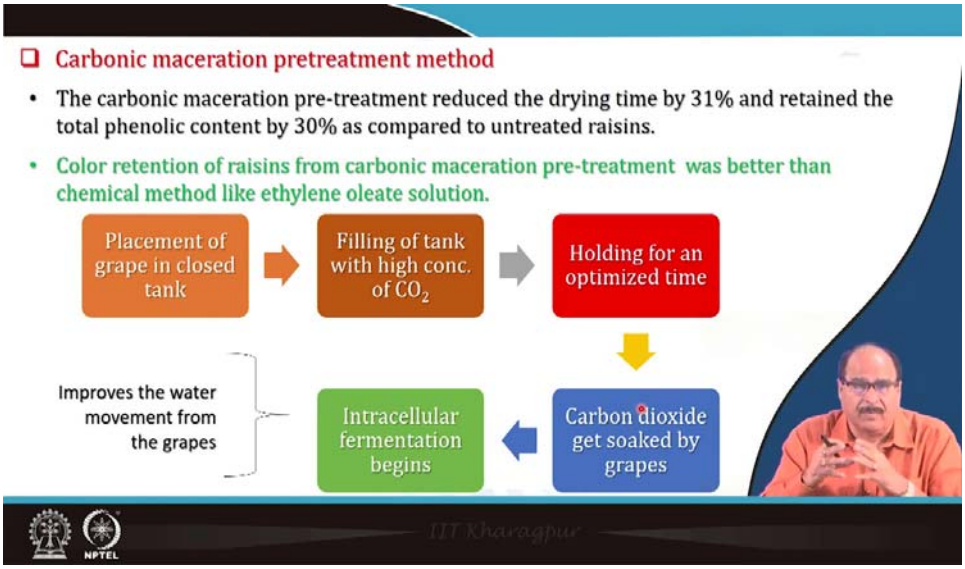
Ultrasound treatment also can be induced. It induces cavitation that affects the porous structure of the grapes. As a result, the drying rate of ultrasound treated grapes increased compared to untreated grapes, and also, the dried raisins, it has a good textural characteristics.





Recent advances in technology for the pretreatment of grapes

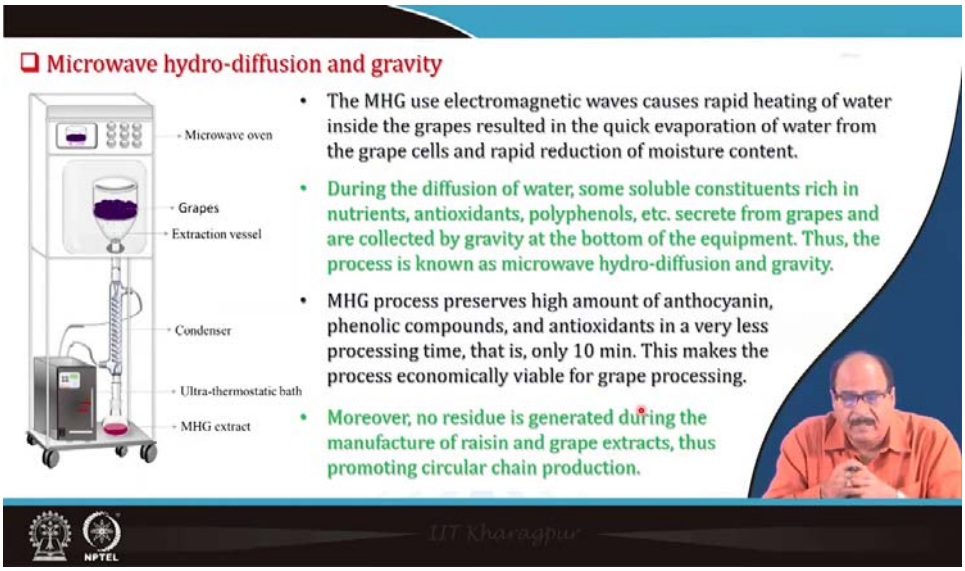
The quality of the final raisin, to a great extent, depends upon the pretreatment of the grape and then finally, of course, the drying technology. Some recent technological advances are discussed such as carbonic maceration pretreatment method which utilizes carbon dioxide for loosening grape surface structure; microwave hydro-diffusion and gravity method which utilizes microwave energy for quick moisture removal, where water secrete out of the grape and is collected; and the third method is high-humidity hot-air impediment blanching, where hot air with the high humidity at high velocity is applied on the surface of the grapes.



Carbonic maceration pretreatment method

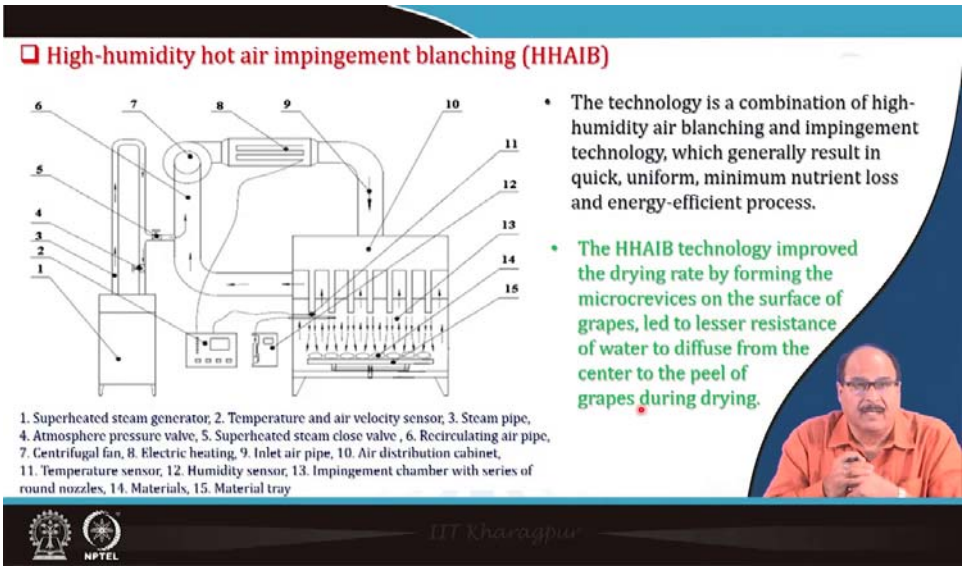
It reduced the drying time by 31 % and retained the total phenolic content by 30 % as compared to the untreated raisins. The color retention of raisins from the carbonic maceration treatment was also reported to be better than the chemical methods like ethylene oleate solutions.

The process of carbonic maceration is as follows. The grapes are placed in a closed tank and the tank was filled with high concentration CO_2. Then, holding for an optimized time in that tank was done, CO_2 gets soaked by the grapes, and then intracellular fermentation begins which improves the water movement from the grapes.



Microwave hydro-diffusion and gravity method

It is commonly known as MHG. It uses electromagnetic waves which causes rapid heating of water inside the grapes resulted in quick evaporation of water from the grape cells and rapid retention of the moisture content. During the diffusion of water, some soluble constituents which are rich in nutrients like antioxidant, polyphenols etc. secrete from grapes and are collected by gravity at the bottom of the equipment. Thus, the process is known as microwave hydro-diffusion and gravity. MHG process preserves high amount of anthocyanins, phenolic compounds, and antioxidants in a very less processing time of 10 min. This makes the process economically viable for grape processing. Moreover, no residue is generated during the manufacture of raisins and grape extracts. Thus, it promotes a circular chain production, and it gives a very good quality raisin.



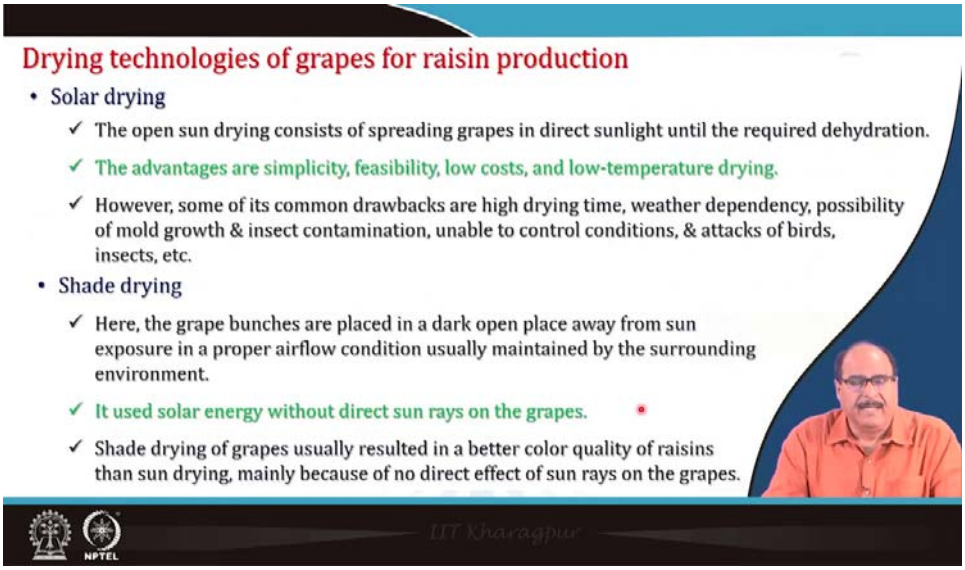
High humidity hot air impingement blanching (HHAIB)

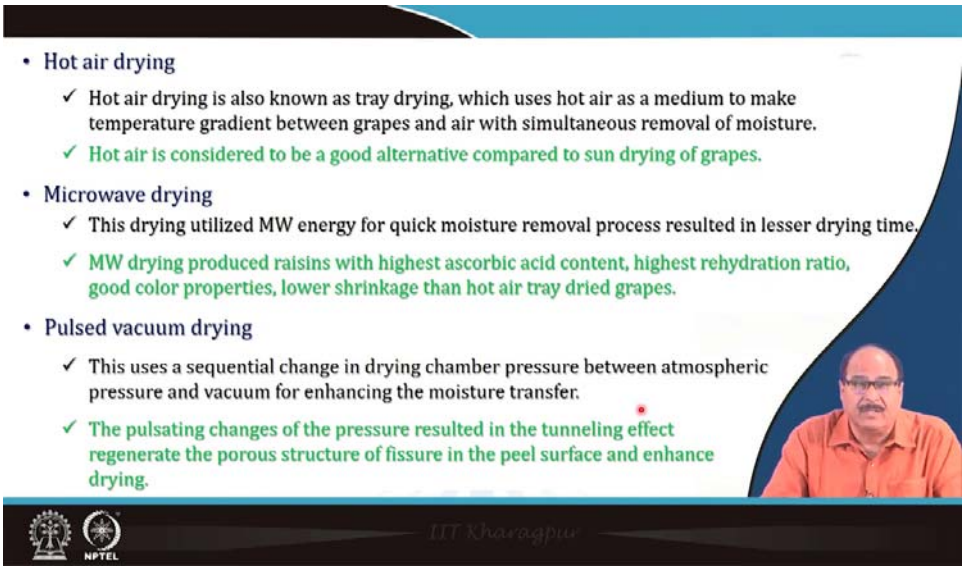
The schematic representation is shown here. This technology is a combination of high humidity air blanching and impingement technology, which generally result in quick, uniform, minimum nutrient loss and energy efficient process. The HHAIB technology improved the drying rate by forming the microcrevices on the surface of the grapes that led to lesser resistance of water to diffuse from the center to the peel of grapes during drying.

Drying technologies of grapes for raisin production

A variety of drying technologies can be used for the production of raisins from grapes. However, novel thermal or non-thermal drying techniques are the necessity to retain the product characteristics with least nutrient loss. The open sun drying consists of spreading grapes in direct sunlight until the required dehydration. The advantages are simplicity, feasibility, low-cost, and low-temperature of drying. However, some of its common drawbacks are high drying time, weather dependency, possibility of mold growth and insect contamination, unable to control the conditions, attacks of birds bodies etc.

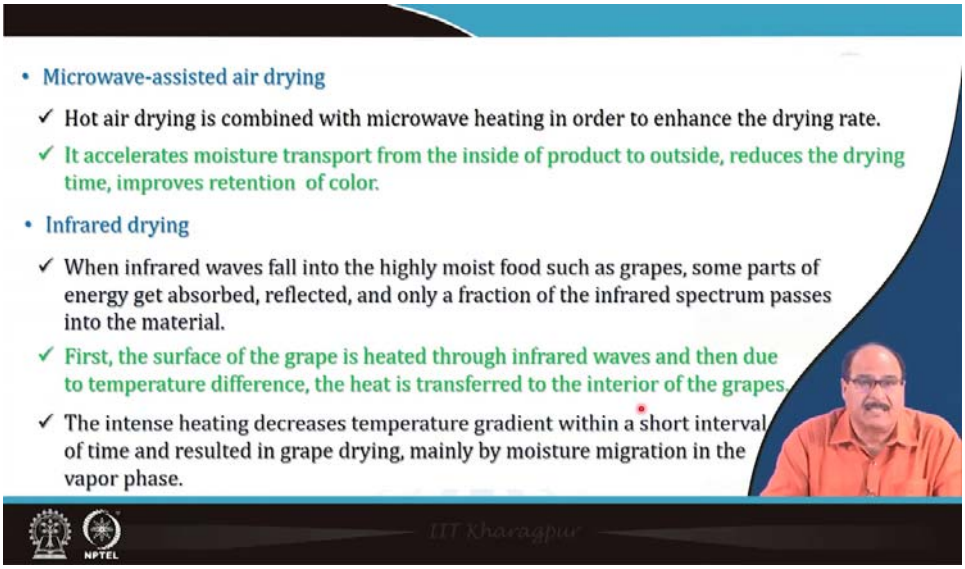
In the shade drying, the grape bunches are placed in a dark open place away from sun exposure in a proper airflow condition, and usually they are maintained by the surrounding environment. It uses the solar energy without direct sun rays on the grapes. Shade drying of grapes usually resulted in a better color quality of raisins than the sun drying mainly because of the no direct effect on the sun rays on the grapes.



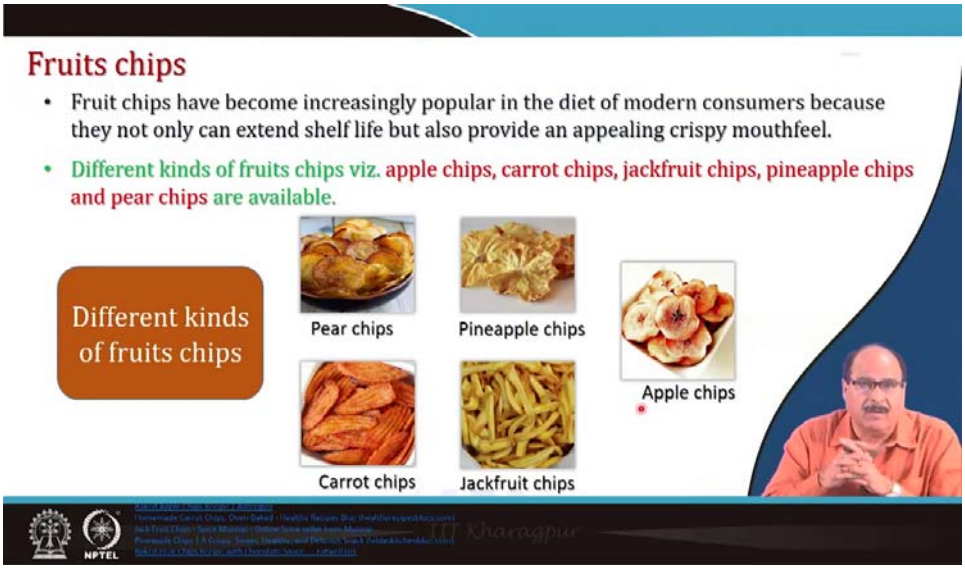


Hot air drying is also known as tray drying, uses hot air as a medium to make temperature gradient between grapes and air with simultaneous removal of moisture. It is considered to be a good alternative compared to the sun drying of grapes. But the novel methods of drying like microwave drying produces raisins with highest ascorbic acid content, highest rehydration ratio, good color properties lower shrinkage than the hot air drying. This uses a sequential change in drying chamber pressure between atmospheric pressure and vacuum for enhancing the moisture

transfer. The pulsating changes of the pressure resulted in the tunneling effect regenerate the porous structure of fissure in the peel surface and enhance drying.

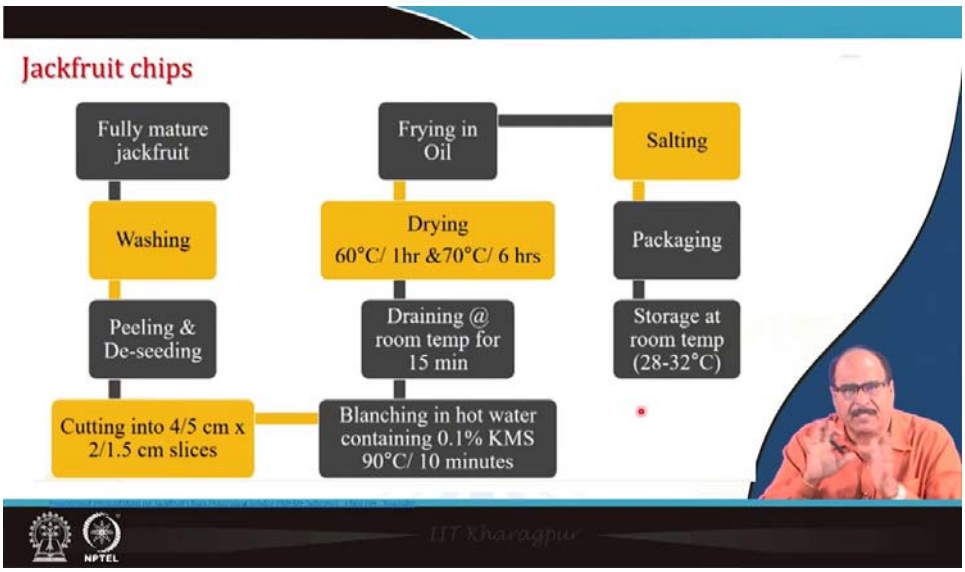


In microwave-assisted air drying, hot air is combined with microwave heating to enhance the drying rate. It accelerates the moisture transport from the inside of the particle to outside, reduces the drying time, and improves retention of color. When infrared waves fall into the highly moist food such as grapes, some parts of energy get absorbed, reflected, and only a fraction of the infrared spectrum passes into the material. First, the surface of the grape is heated through the infrared waves, and then due to temperature difference, the heat is transferred to the interior of the grapes. The intense heating decreases temperature gradient within a short interval of time and it results in grape drying, mainly by moisture migration in the vapor phase.



Fruit chips

The third category of the popular important dried RTE product is the fruit chips. They have become increasingly popular in the diet of the modern consumers because not only they can extend shelf life but also provide a purely crispy mouthfeel, and they provide good nutrition. Different kinds of fruit chips available in the market are apple chips, carrot chips, jackfruit chips, pineapple chips, pear chips or even the potato chips are very common products.



Jackfruit chips

The methodology for all these chips preparation is almost same. Depending upon the type of fruit or vegetables, some minor adjustment in the processing conditions are made or sometimes one or two unit operations are changed. For jackfruit chips preparation, mature jackfruits are taken, then basic unit operations such as washing, sorting, peeling, deseeding, etc. are done. After that, peeled jackfruit was cut into 4/5 cm × 2/1.5 cm slices. These slices are blanched in a brine solution in case of apple or potato chips as enzymatic darkening is very common there.

In case of jackfruit, the jackfruit is dipped into 0.1 % KMS is used at 90 °C for 10 min. In the potato chips, it is generally boiled for 2 to 4 min so that gelatinization of the starch also takes place, and it is important to slice, the thin slices are fully cooked. So, then after that the draining of the water, i.e. the surface water is removed by keeping it in for 10-15 min, and then finally it is put into the dryer. So, appropriate drying, there is normally tray drying, 60 °C for 1 h or 70 °C for 6 h. In drying, for initial first hour, crust formation is taken on the surface and then temperature is raised to 70 °C, and it continues around 6 hours, 7 hours or so. So, this again, drying condition here is depending upon the fruits or even novel methods of drying like microwave drying, vacuum drying etc. will give better quality products.

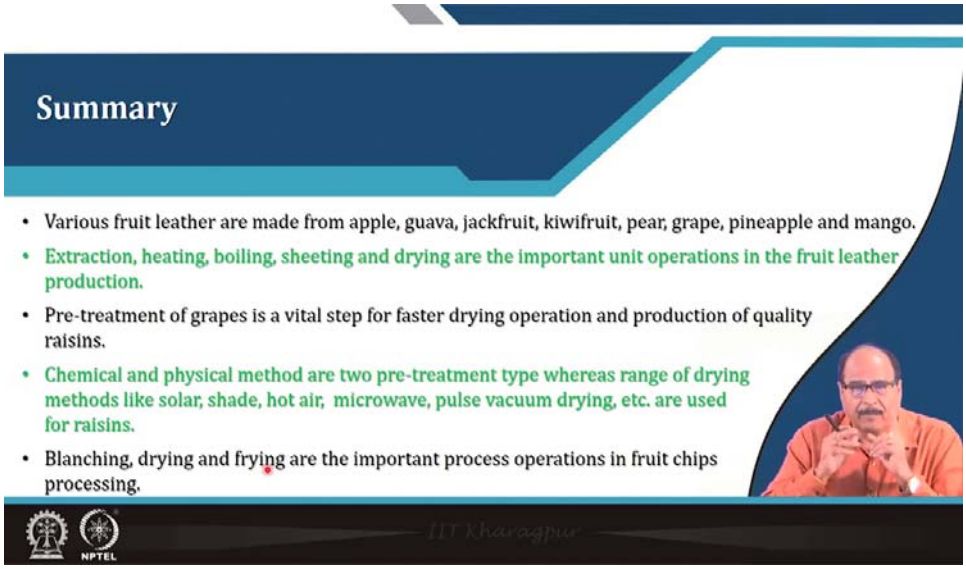
So, after drying, these materials are packaged and sent to the markets and at the time of consumption, they are fried in the oil, salted and used. They are also made available in the form of ready to eat or like there is after drying, they are fried in oil, salted, spiced and smeared with seasonings in the industry only. Finally, they are transported and stored at ambient condition after packaging.

But packaging is important aspect because these are normally the chips, they contain comparatively lower moisture content, maybe 3 to 4 percent moisture content. They are highly hygroscopic. So, during, if the packaging is not good, so they may have charged moisture and their crispiness for which these chips etc. are known, may get adversely affected.

Banana chips

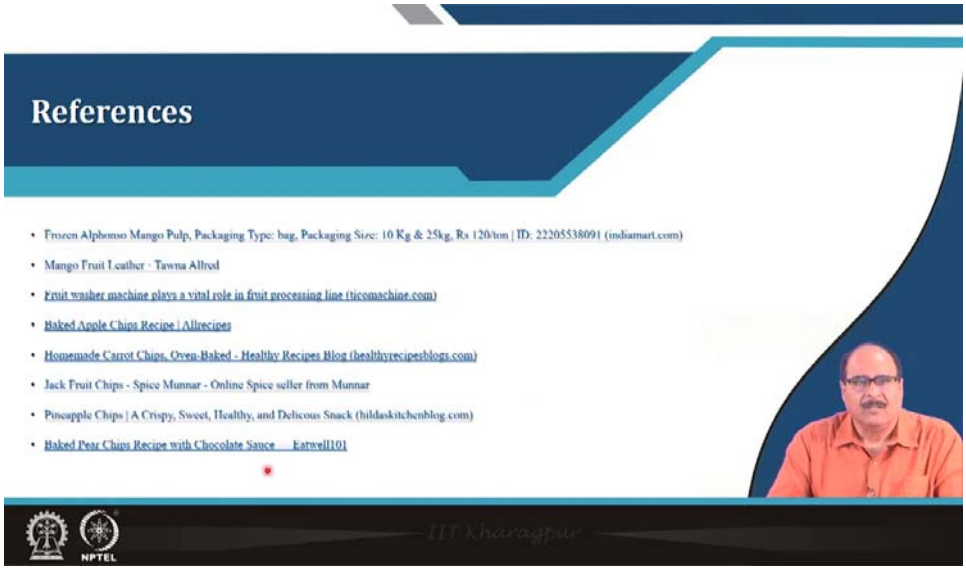
Green bananas are taken, washed, peeled, and sliced into thin slices. These slices are blanched into the hot water blanching, dried, fried, salted and seasonings etc. are added, and then they are packaged.

And these banana chips, they are deep fried snacks that are very popular now in many countries. Even India produce a significant of banana chips, and it is exported even, to many other countries. It contain good amount of magnesium, Vitamin A, iron, phosphorus, potassium in small quantities.



Summary

The important thing in order to make RTE products is pretreatment as depending upon the type of the fruit pretreatment will change. In the form of pulp, these pulps are dried and so that its shelf life is improved, or the materials are dried and converted in the form of raisins or dried chips et cetera. But in all the case, that is to make them stable by using one or the other methods, the moisture is removed. The pretreatments like blanching, drying, all those things, as far as possible, improved method should be used so that the product quality can be retained for which these fruits and vegetables are known. The packaging material characteristics becomes important. Otherwise, these products are known for their crispy texture and good sensory characteristics. If they are not properly packaged, then they may absorb moisture and their whole purpose may get defeated. Their shelf-life and eating quality and sensory characteristics may be adversely affected.



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