Food Oils and Fats: Chemistry and Technology
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Agricultural and Food Engineering Department
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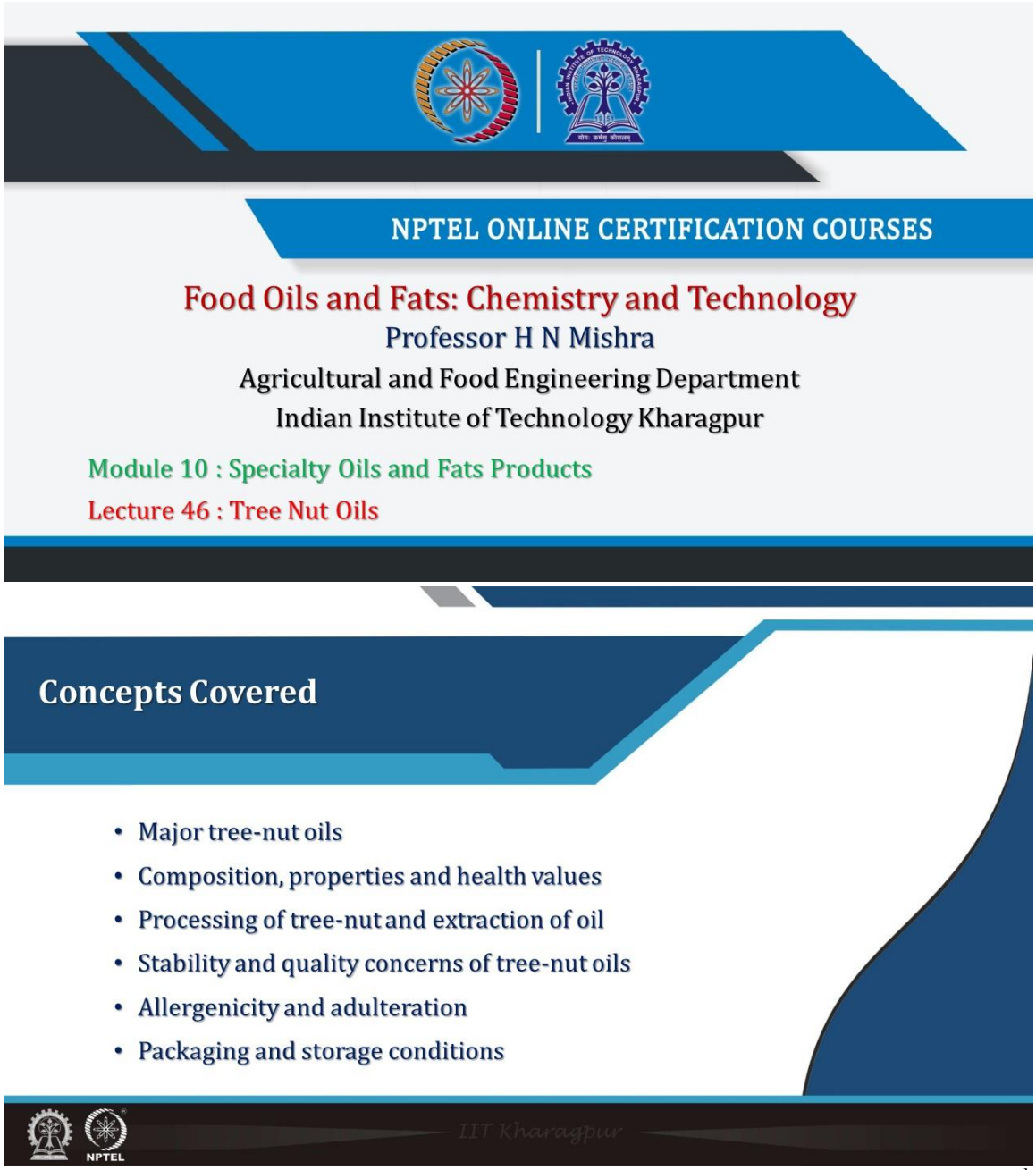
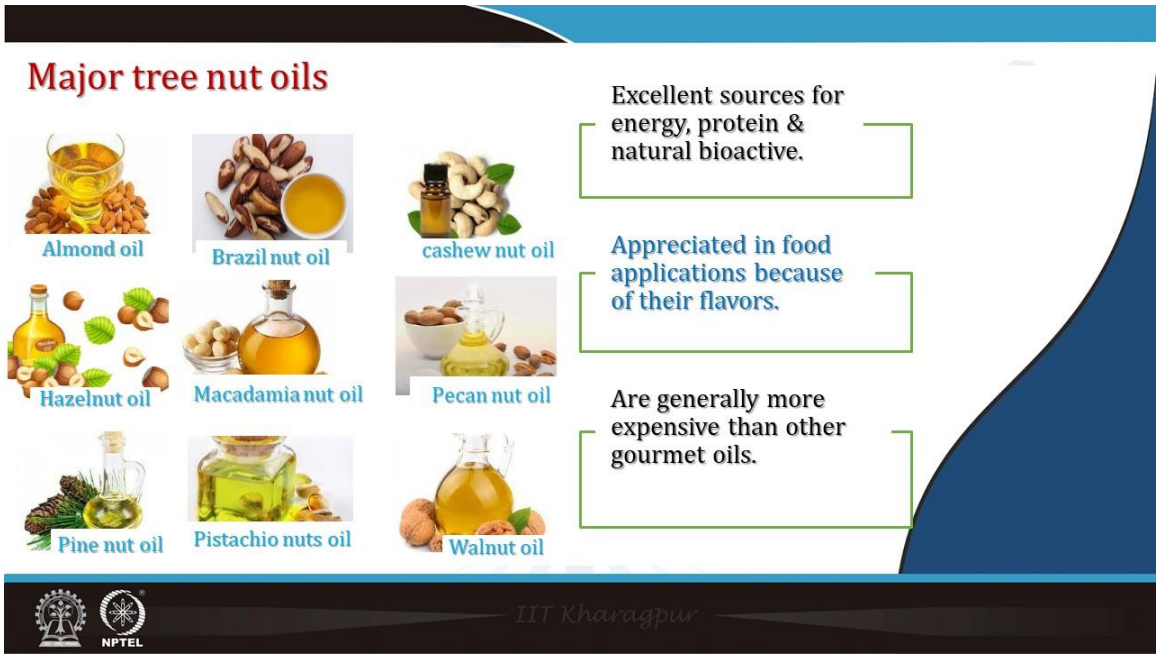
Module 10 : Specialty Oils and Fats Products
Lecture 46 : Tree Nut Oils



Hello everyone, namaskar. Now, we are entering module 10 of this course and the 46th lectures of this module will be devoted to specialty oils and Fat Products. In this lecture, we will in the next half an hour we will talk about tree-nut oils. So, we will cover what are the major tree-nut oils, what is the composition properties, and health value of tree-

nut oils, the processing, and extraction of oils from tree-nut, stability and quality concerns, allergenicity, allergens found in tree-nut oils, and packaging and storage conditions.



So, you see the major tree-nut oils include Almond oil, Brazil nut oil, Cashew nut oil, Hazelnut, Macadamia, Pecan, Pine nut, Pistachio nuts, and Walnut oils. So, these are the major tree nuts and they contain good quality oils. They are excellent sources of energy protein and natural bio-octaves, they are appreciated in food applications because of their flavors and they are generally more expensive than other gourmet oils. So, these are the major sources, they are used for making specialty oils, high-quality oils, which have various applications in food, pharma, and others because of their composition.

Oil content of major nuts

Nut	Kernel oil (%)
Almonds	41 – 60
Brazil nuts	61 – 69
Cashew nuts	40 – 49
Hazelnuts	49 – 67
Macadamia nuts	59 – 78
Pecan nuts	58 – 74
Pine nuts	59 – 71
Pistachio nuts	45 – 59
Walnuts	51 – 65

Sources: USDA (2001); Maguire et al. (2004); Ryan et al. (2006); Kornsteiner et al. (2006).

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So, the oil content of the major tree nuts is shown in the table. Major nuts here you see almonds which contain around 41 to 60 percent oil, brazil nut contains 61 to 69 percent, cashew nut contains around 40 to 49 percent oil, hazel nut 49 to 67 percent, macadamia nut contains around 59 to as high as 78 percent oil. Similarly, pecan nut contains 58 to 74 percent, Pine nut around 60 to 70 percent, Pistachio nuts about 45 to 60 percent and Walnut contains 60 to 65 percent of oil. So, you can see all these nuts contain considerably good amounts, even more than 50 percent. Half of their contents are good quality oils.

Lipid-class distribution (relative %) of selected nuts

Compound	Almond	Brazil nut	Hazelnut	Pecan	Pine nut	Pistachio	Walnut
Triacylglycerols	98.2	96.7	98.0	96.4	97.6	96.2	97.2
Sterols (free)	0.22	0.18	0.21	0.26	0.13	0.19	0.26
Sterol esters	0.05	0.05	0.04	0.07	0.06	0.03	0.09
Phosphatidylserine	0.21	0.26	0.27	0.39	0.23	0.47	0.37
Phosphatidylinositol	0.11	0.09	0.06	0.15	0.14	0.21	0.25
Phosphatidylcholine	0.21	0.34	0.24	0.21	0.19	0.52	0.34
Phosphatidic acid	—	—	0.02	—	—	—	—
Sphingolipids	0.53	0.83	0.26	0.48	0.45	0.73	0.54

Source: Miraliakbari & Shahidi (2008)

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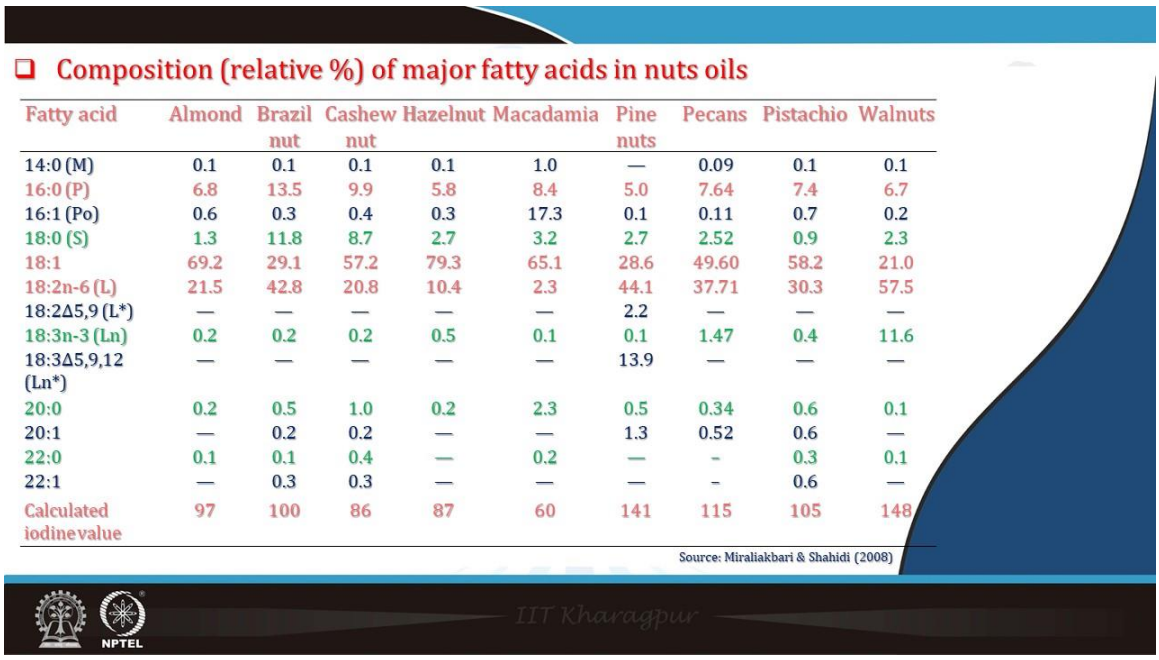
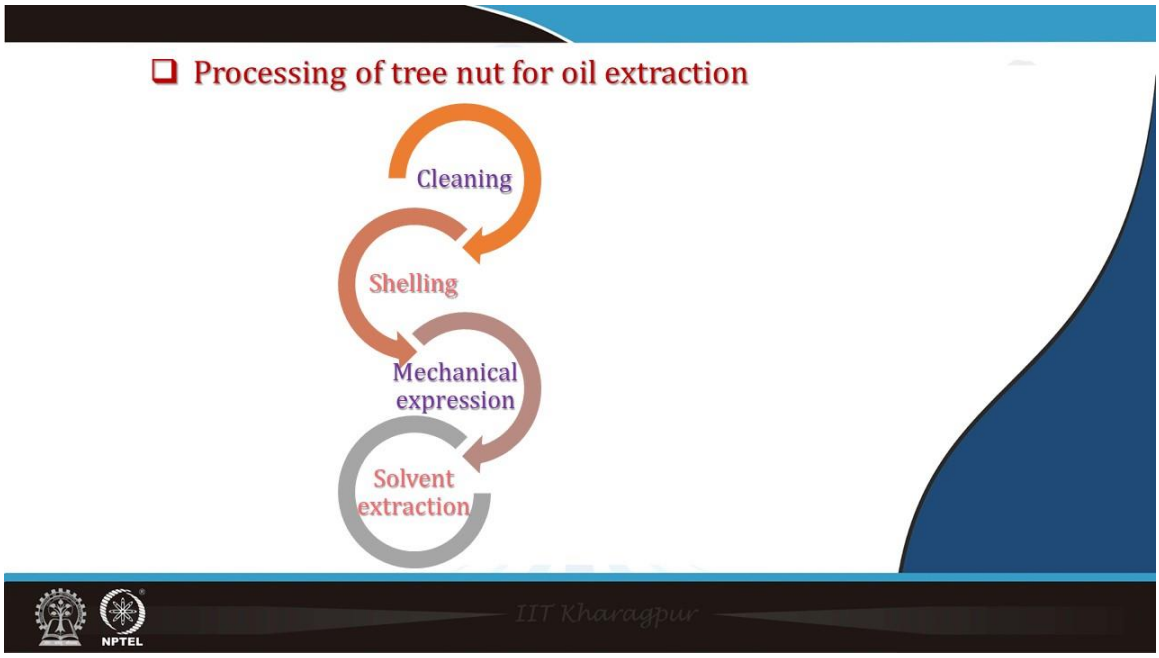
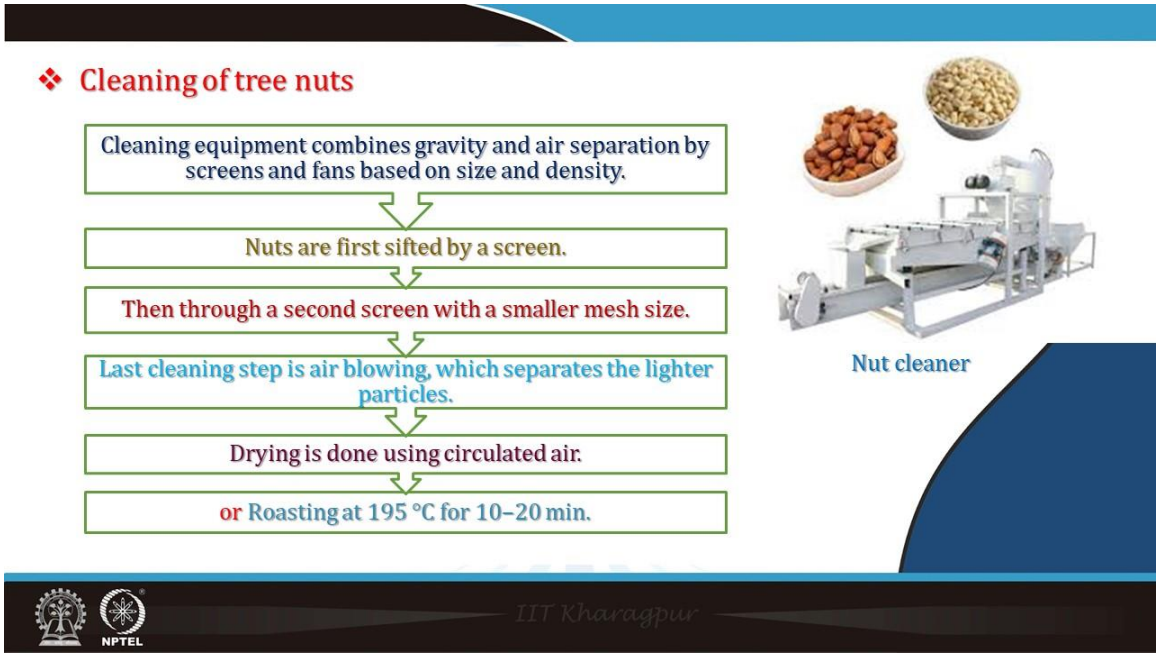
Then lipid class distribution that is the relative percentage of different fat compounds in the selective nuts is shown in the table. You can see that almonds have about 98 percent Triacylglycerols, contain around 0.53 percent Sphingolipids and other content like sterols 0.22 %, and the remaining content is much less. Similarly, Brazil nut has 96 percent triacylglycerol, hazelnut 98 percent. So, you can see from the data all these nuts contain around 96, 97, or up to 98 percent of the triacylglycerols and they are normally low in these other contents.



The composition of major free fatty acids which are found in these nuts includes as you see 18:1 is the oleic acid, it contained in almost all nuts. In the almond, it is around 69 percent, Brazil nut 29, cashew 57, hazelnut 79, macadamia 65 and 58 in pistachio and in walnut 21 percent. Similarly 18:2, that is omega 6 and it is present at about 42 percent in Brazil nuts, 57 percent in walnuts, 44 percent in pine nuts, and in others also it is in good quantity. Then, the iodine value if you see that almond oil has an iodine value of 97 whereas, walnut oil has 148. The pine nut oil also has an iodine value. So, this comparatively depends upon the saturation fatty acid unsaturated fatty acid that is the calculated iodine value is there. They also contain that is 16 there is 16:0 palmitic acid like 6 percent and 13 percent, a considerable amount of this palmitic acid is also present.

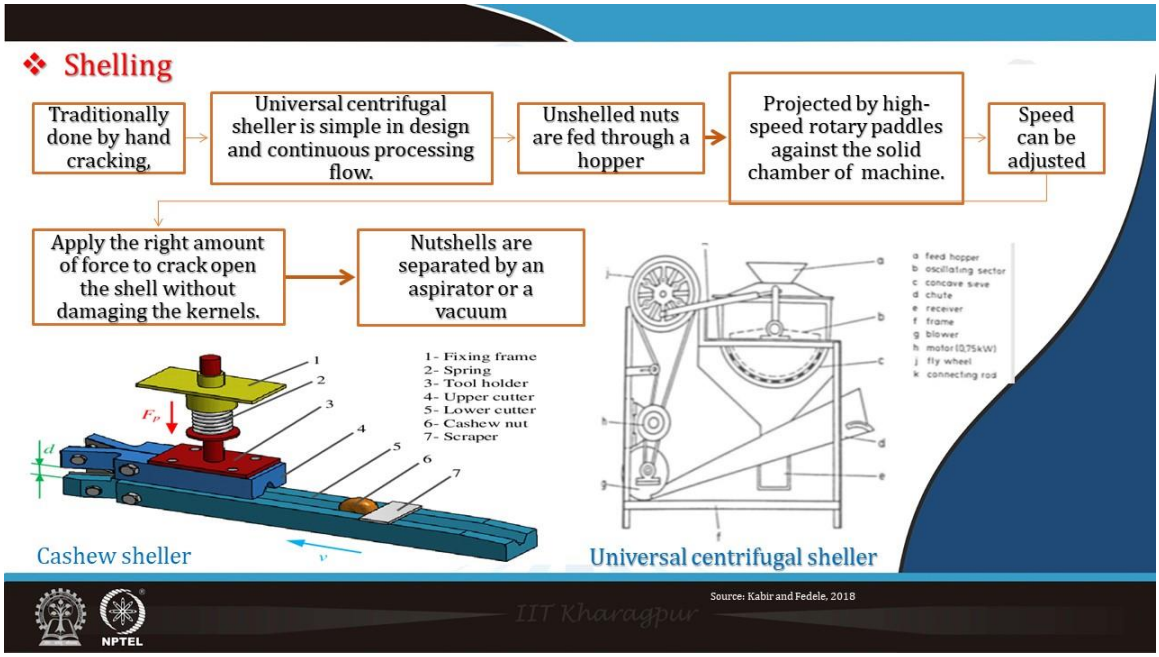


Then let us talk about the processing of tree nuts for oil extraction. This involves 4 major operations that is the tree nuts after they are obtained from the plants, need to be cleaned properly, their outer covering is removed by selling operations and then that is the deselled nuts are subjected to mechanical expression or solvent extraction for the extraction of or recovery of the oil.

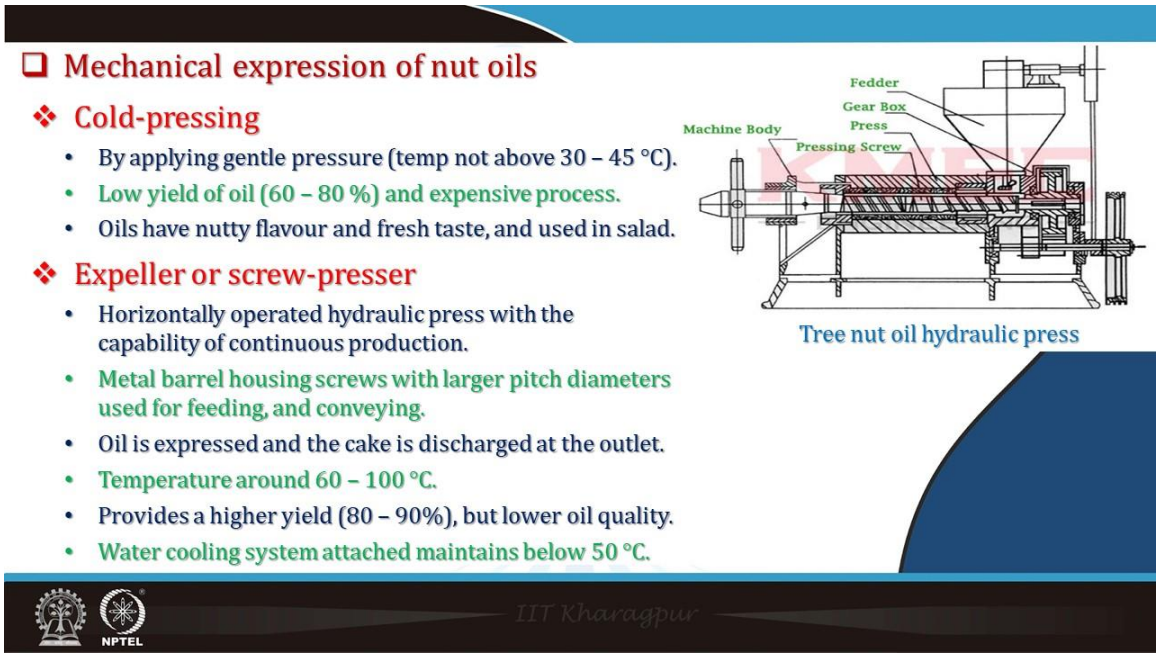


So, depending upon the nut that is the cleaning operation normally involves cleaning equipment that combines gravity and air separation by screens and fans based on the size and density. The nuts are first shifted by a screen to remove any unwanted material then

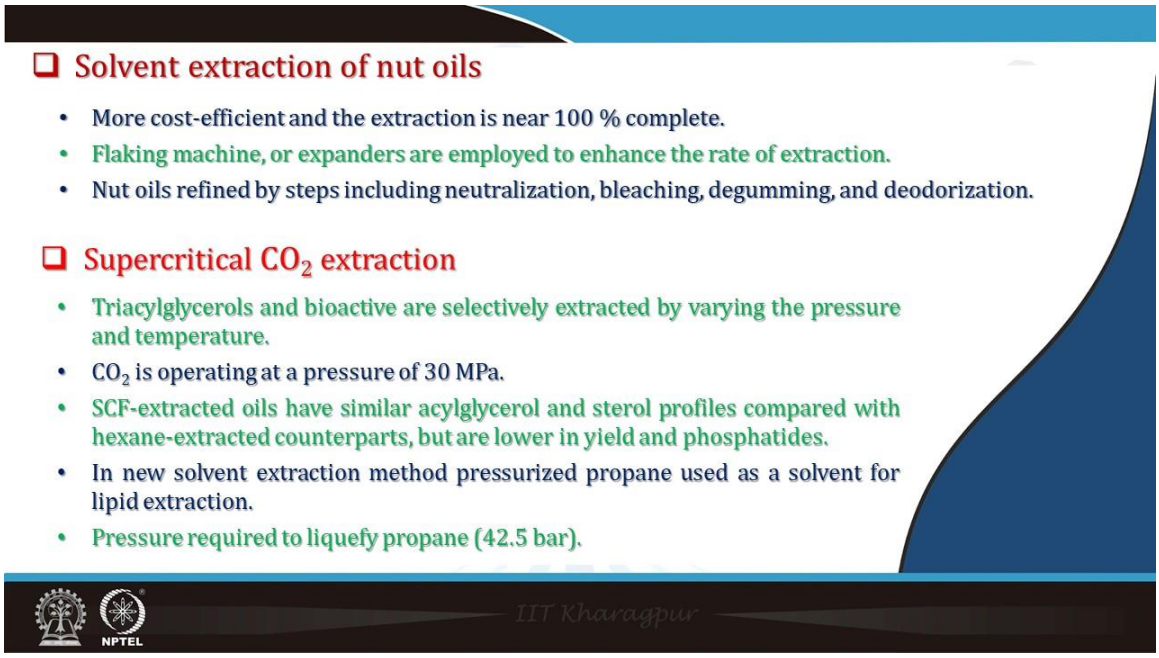
through a second screen with a smaller mesh size. The last clearing step is the air blowing which separates the lighter particles. Finally, these nuts are dried using circulated air or sometimes they can be roasted at 195 degrees Celsius for 10 to 20 minutes. And this drying or roasting that is the condition it is used to facilitate the further peeling or removal of the outer covering after the cleaning



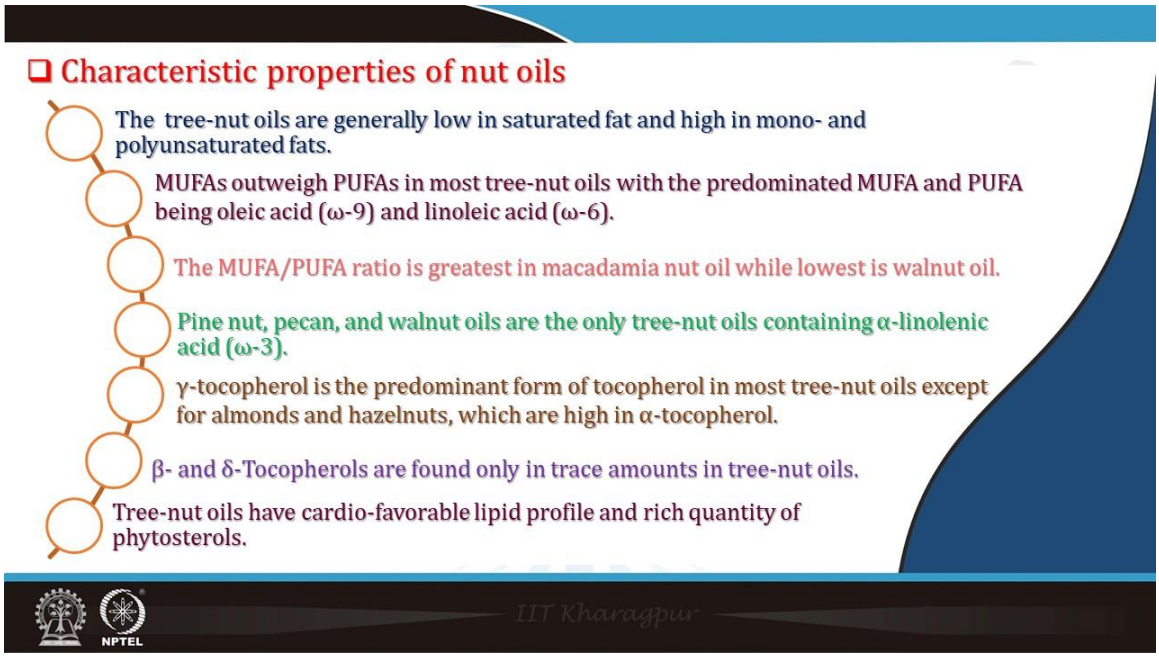
Then there is the selling which is the removal of the outer cover. It is traditionally done by hand cracking, but the universal centrifugal sheller is simple in design and it is used for continuous processing flow. Unshelled nuts are fed through a hopper where that is you can see that they are projected by high-speed rotary paddles against the solid chamber of the machine and then speed can be adjusted depending upon the nut. Then apply the right amount of force to crack open the shell without damaging the kernel. So, that is basically where it is done by using this machine the shell is broken that is kernel is broken without damaging the internal material and then these nuts shells are separated by the aspirator or in a vacuum that is by vacuum flying or by any suitable methods these shells are blown and the undamaged kernels are recovered. These kernels are a source of the oil, they are further sent for the process.



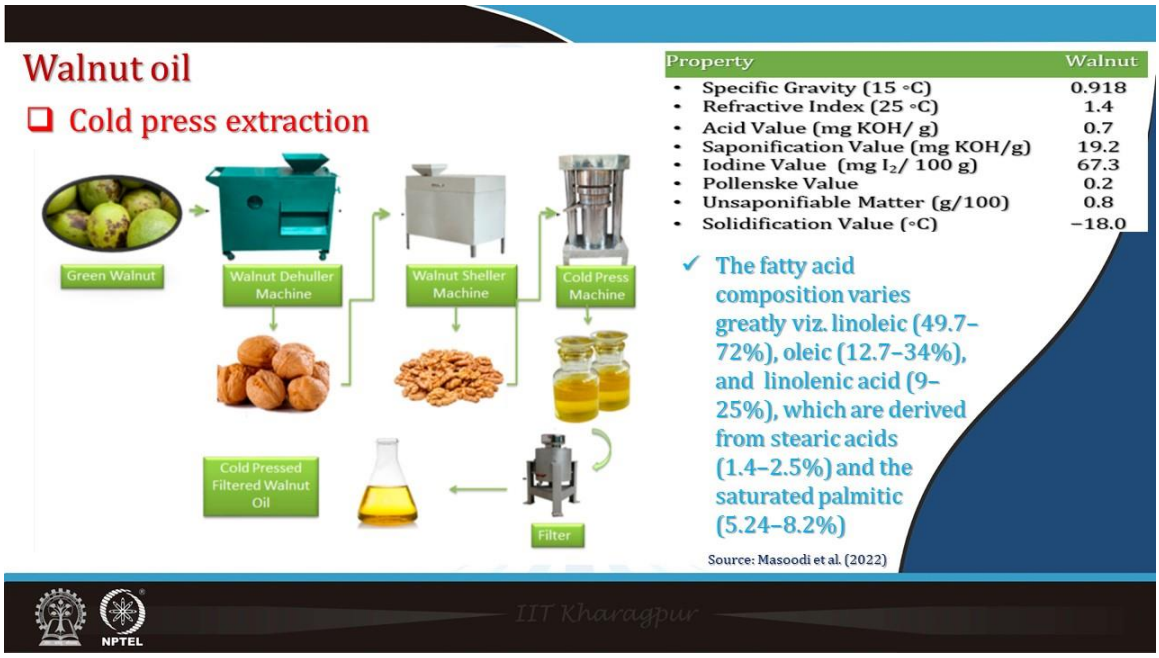
Now these cleaned and deshelled kernels are subjected to mechanical expression or solvent extraction. In the mechanical expression normally we have details we have discussed in the earlier classes principles of all these operations. So, here I will just tell specific things which are for these specific nuts. So, that is by applying gentle pressure at temperatures not above 30 to 40 degrees Celsius that is, there is a low yield of oil around 60 to 80 percent and it is an expensive process. These oils have a nutty flavor and fresh taste and they are used for salad making etcetera. Then expeller or screw presser, these horizontally operated hydraulic presses with the capability of continuous production. Metal barrel housing screws with larger pitch diameters are used for feeding and conveying. Oil is expressed and the cake is discharged at the outlet. Temperature around 60 – 100 °C. Provides a higher yield (80 – 90%), but lower oil quality. The water cooling system attached maintains below 50 °C.



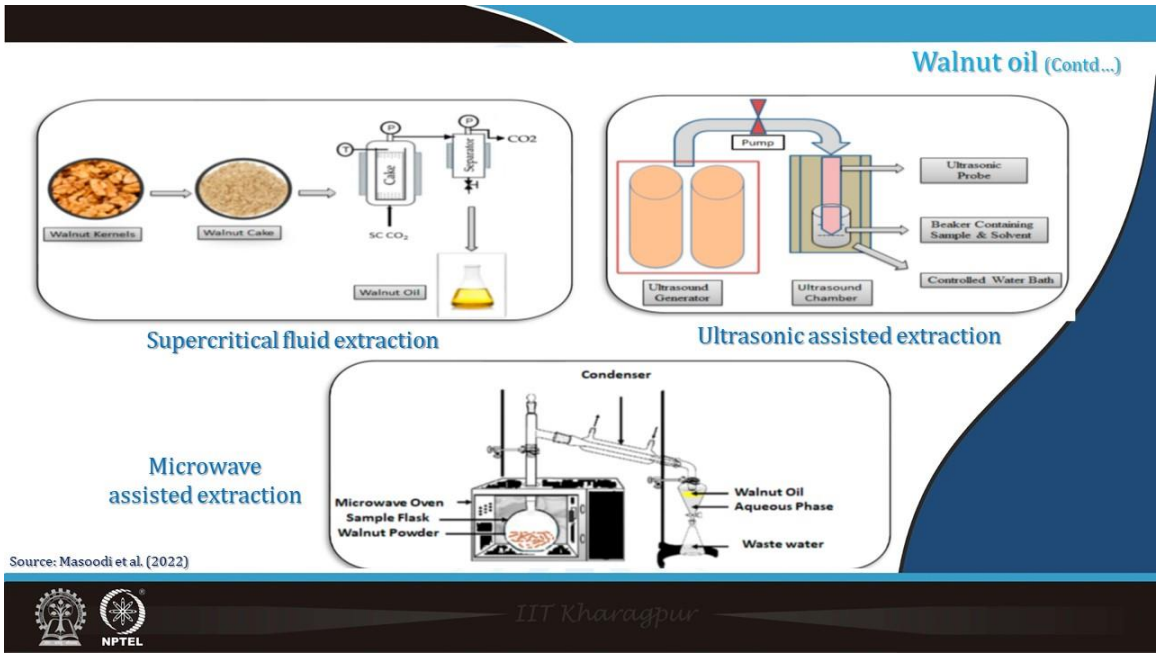
The solvent extraction method also can be used for the extraction of tree nut oils. More cost-efficient and the extraction is nearly 100 % complete. Flaking machines or expanders are employed to enhance the rate of extraction. Nut oils are refined by steps including neutralization, bleaching, degumming, and deodorization. Then supercritical CO2 extraction can also be used. Here triacylglycerols and bioactive are selectively extracted by varying the pressure and temperature. CO2 is operating at a pressure of 30 MPa. SCF-extracted oils have similar acylglycerol and sterol profiles compared with hexane-extracted counterparts but are lower in yield and phosphatides. In the new solvent extraction method pressurized propane is used as a solvent for lipid extraction. The pressure required to liquefy propane is around 42.5 bar.



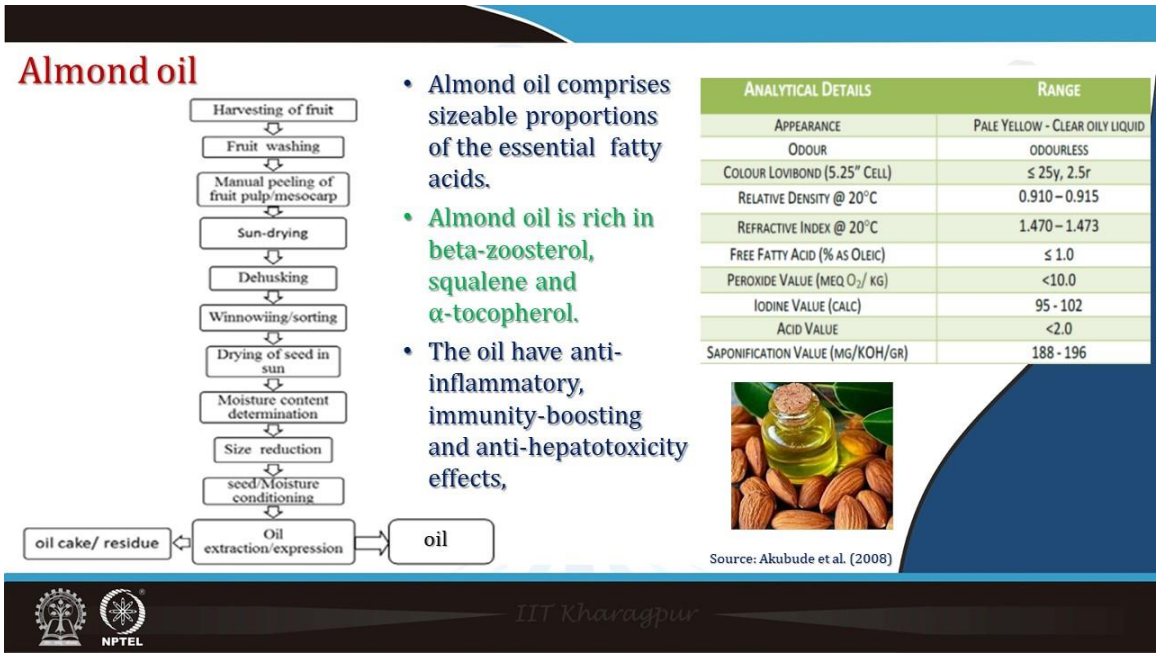
The characteristic properties of nut oils are as follows. The tree-nut oils are generally low in saturated fat and high in mono- and polyunsaturated fats. MUFAs outweigh PUFAs in most tree-nut oils with the predominated MUFA and PUFA being oleic acid (ω-9) and linoleic acid (ω-6). MUFA PUFA ratio is very important as far as the healthy aspects health aspects of the oil are concerned. The MUFA/PUFA ratio is greatest in macadamia nut oil while the lowest is walnut oil. Pine nut, pecan, and walnut oils are the only tree-nut oils containing α-linolenic acid (ω-3). γ-tocopherol is the predominant form of tocopherol in most tree-nut oils except for almonds and hazelnuts, which are high in α-tocopherol. β- and δ-Tocopherols are found only in trace amounts in tree-nut oils. Tree-nut oils have a cardio-favorable lipid profile and a rich quantity of phytosterols.



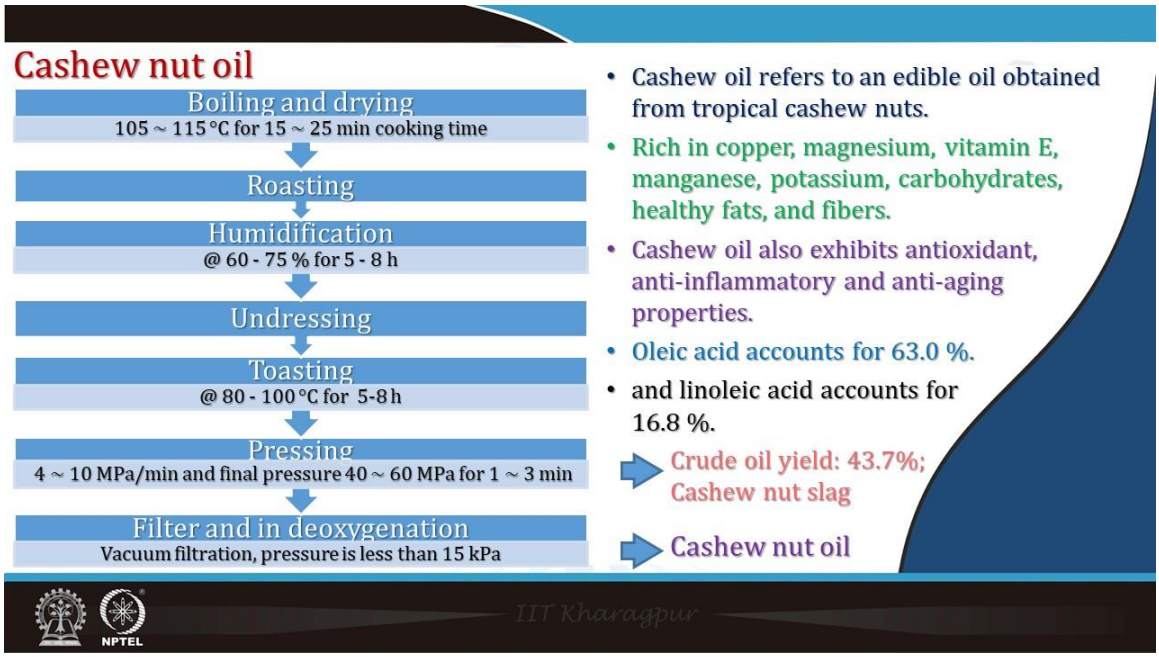
So, now let us see specific characteristics and extraction of specific oils. For walnut oil as you can see here, normally cold press is used. Green walnuts are taken then passed through the walnut dehuller machines, from where the dehulled walnut is passed through walnut sheller machine, that is they shell and the shells are blown. The deshelled walnut obtained is subjected to cold pressing by a simple cold press machine. The oil extracted is filtered and you get cold pressed filtered walnut oil. And its property that is it has a specific gravity at 15 degree Celsius about 0.918, refractive index at 25 degree Celsius is 1.4, acid value is 0.7 milligram KOH per gram, saponification value is 19, iodine value is 67, it has a Pollenske value of 0.2 and saponifiable matter 0.8 g/100g and saponification value is - 18 degree Celsius. The fatty acid composition of walnut oil varies greatly viz. linoleic (49.7–72%), oleic (12.7–34%), and linolenic acid (9–25%), which are derived from stearic acids (1.4–2.5%) and the saturated palmitic (5.24–8.2%).



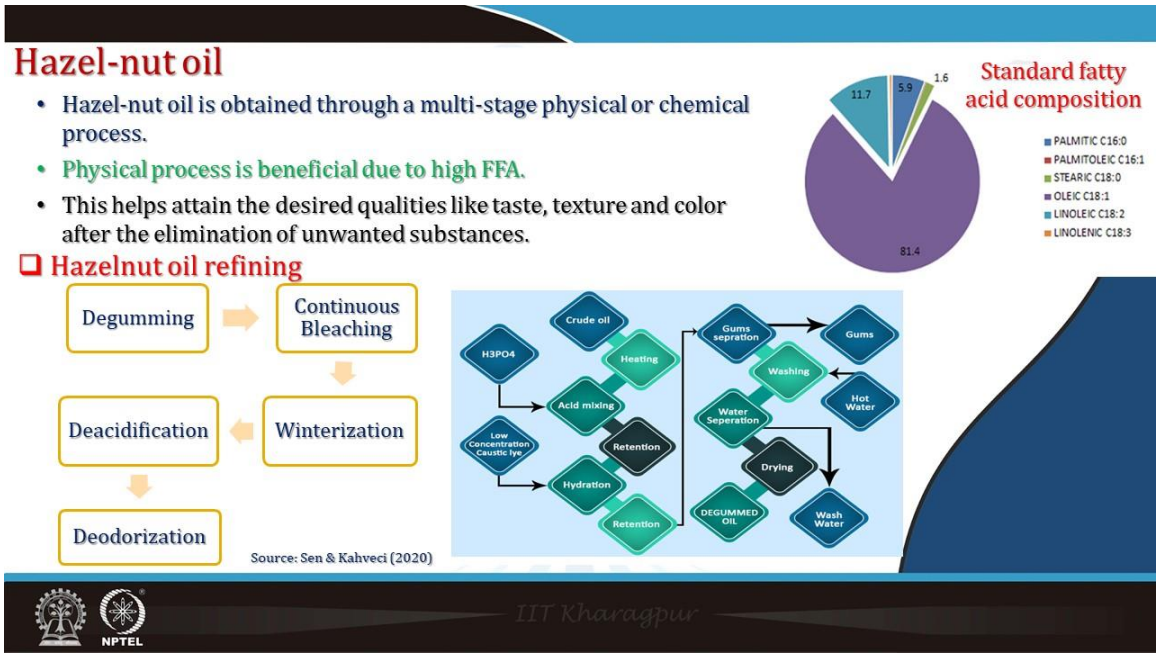
And then supercritical fluid extraction, ultrasonic-assisted extraction, and microwave-assisted extraction also have been tried by researchers who have worked for the extraction of walnut oil, because these emerging novel technologies where there much not much temperature is involved are always considered to be a better process for the extraction of this high-quality super specialty oils like nut oil, fruit oil, olive oil etcetera. So, this is simple, the material is the walnut kernels, they are made into powder or into paste and then subjected to the supercritical extraction chamber where supercritical carbon dioxide is part and oil is extracted. Similarly in microwave-assisted extraction, you see here, inside the microwave oven walnut powder is kept and given microwave treatment and then it goes to the solvent extraction.



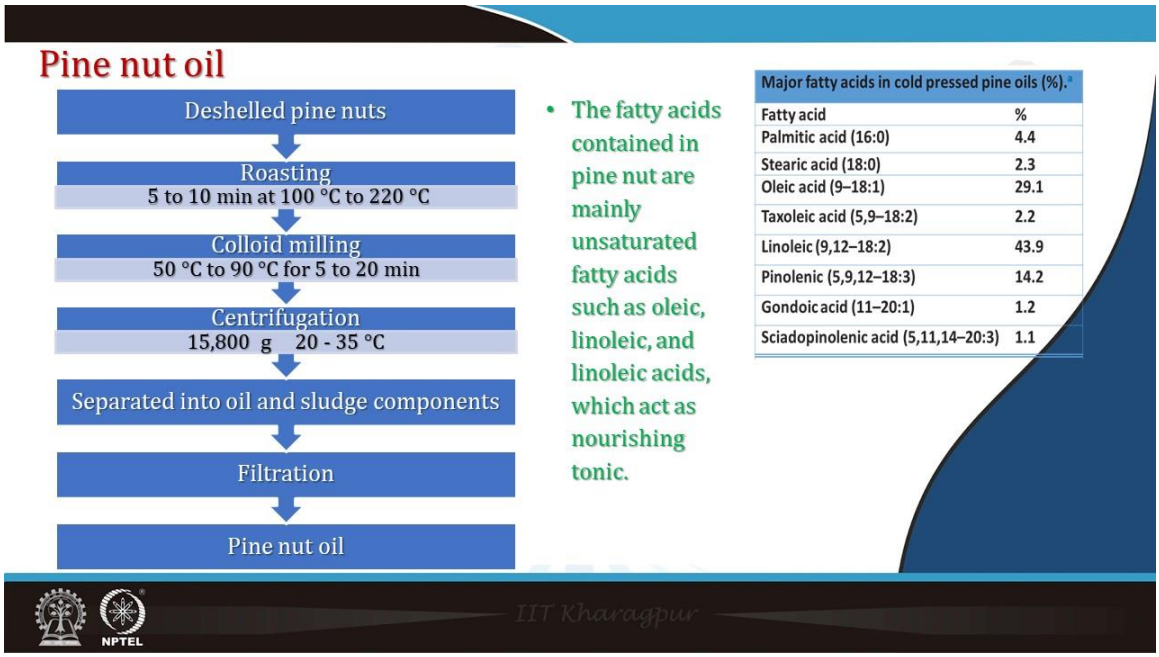
Then almond oil, you see harvesting the fruit, fruit washing, manual peeling of the fruit pulp/ mesocarp, sun drying, dehusking, and then winnowing/sorting, drying of seeds in the sun, and then moisture content determination for moisture adjusting, after that size reduction and we get the almond seed of a particular moisture content. These seeds are conditioned to get a better recovery of the oil. Then it is either extracted by solvent extraction or by expression, and the oil and the oil cake or residue are obtained. So, these are the treatments given to the almond oil and then using a standard process the oil is extracted. Almond oil comprises sizeable proportions of essential fatty acids. Almond oil is rich in beta-zoosterol, squalene, and α-tocopherol. The oil has anti-inflammatory, immunity-boosting, and anti-hepatotoxicity effects. Its appearance is pale yellow or clear oily liquid and it is odorless. Its refractive index at 20 degrees Celsius is 1.47 to 1.473. Its free fatty acids as percent oleic acid are normally less than or equal to 1, the peroxide value is less than 10, the iodine value is in the range of 95 to 102, and its saponification value is 188 to 196. So, it these are the properties and characteristics of the almond oil.



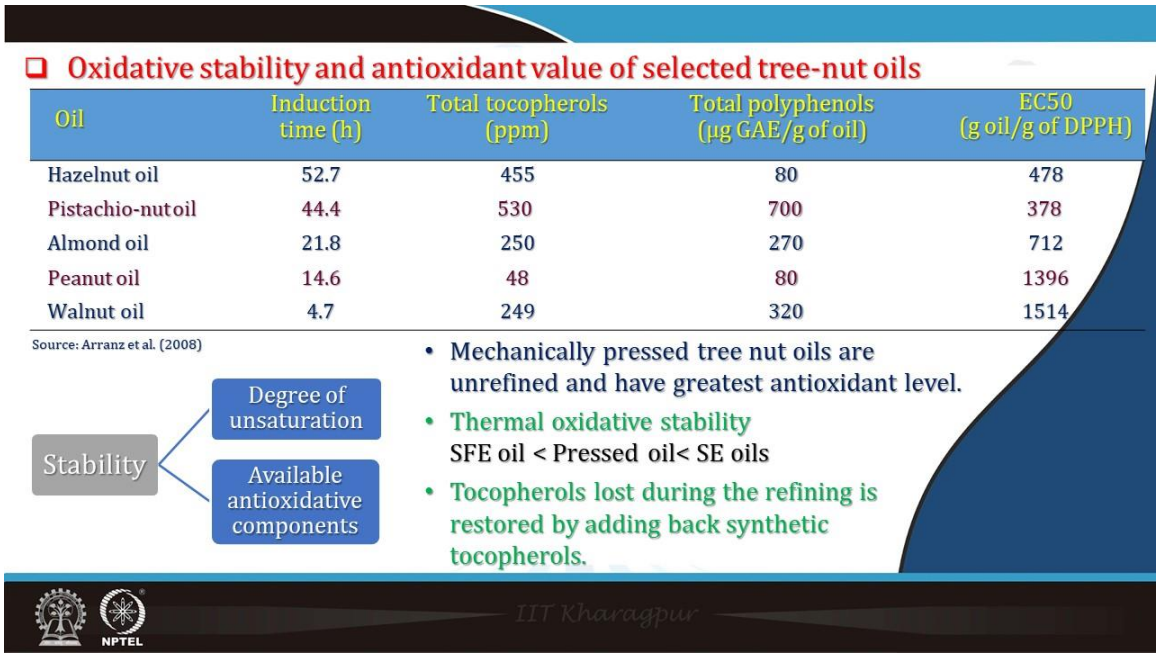
Now let us talk about cashew nut oil as it is another very important nut oil. So, basically, cashews are boiled and dried at around 105 to 115 degrees Celsius for 15 to 25 minutes of cooking time. Then it is roasted and kept under humid conditions that are in a humidity environment of 60 to 75 percent for 5 to 8 hours. Then it is undressed and finally, the cashew is toasted. Toasting is done at around 80 to 100 degrees Celsius for 5 to 8 hours and then finally, it is subjected to pressing that is where 4 to 10 mega Pascal pressure per minute is used, and a final pressure of about 40 to 60 mega Pascal per 1 to 3 minute might be required to get the better recovery of the oil. Then this oil is filtered and deoxygenated using vacuum filtration and here the pressure is less than 15 kilo Pascal. So, the cashew by this pressing gives an oil yield of about 43.7 percent and there is a cashew nut slag. Cashew oil refers to an edible oil obtained from tropical cashew nuts. Rich in copper, magnesium, vitamin E, manganese, potassium, carbohydrates, healthy fats, and fibers. Cashew oil also exhibits antioxidant, anti-inflammatory, and anti-aging properties. Oleic acid accounts for 63.0 %. And linoleic acid accounts for 16.8 %.



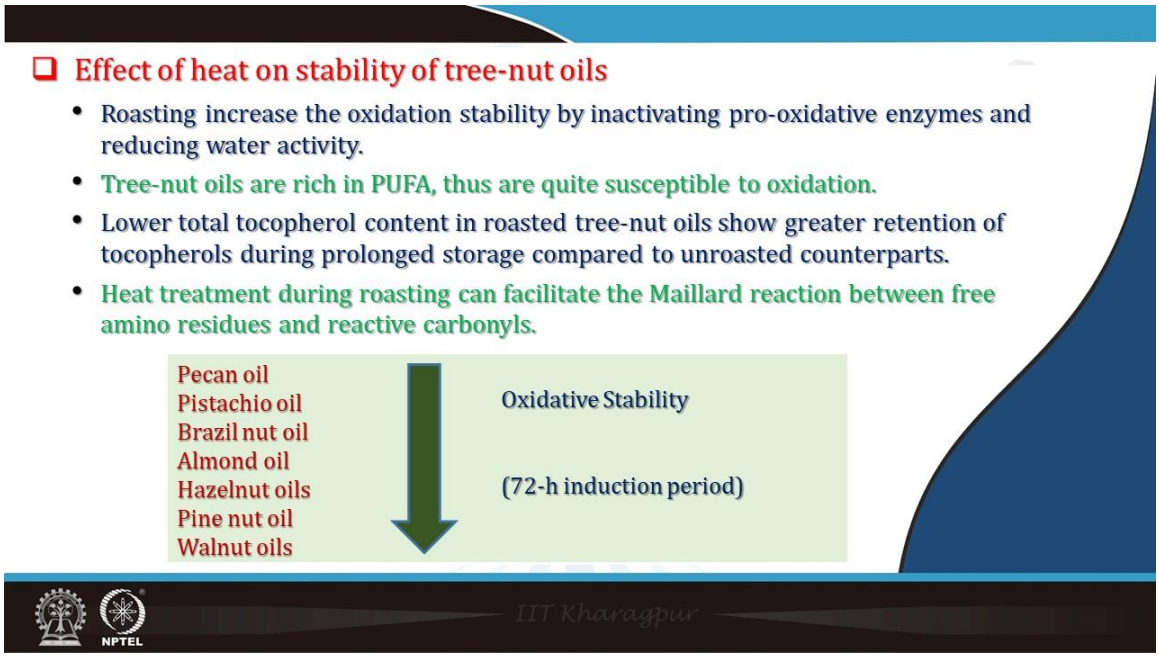
Hazelnut oil is obtained through a multi-stage physical or chemical process. The physical process is beneficial due to high FFA. This helps attain the desired qualities like taste, texture, and color after the elimination of unwanted substances. Hazelnut oil refining includes degumming, continuous bleaching, winterization, deacidification and deodorization finally refined oil is obtained. You can see, that the crude oil is heated, then acid mixed, then degummed, then neutralization, and finally dried. The standard fatty acid composition in crude oil is, you can see C 18:1 is around 81 percent, linoleic acid is C 18:2 is around 11 percent. Linolenic acid is comparatively in less amount and palmitic acid is around 5.9 percent or so given here, but the major acid is the oleic acid here in hazelnut oils.



Then pine nut oil again there is deshelled pine nuts, are roasted for 5 to 10 minutes at 100 degrees Celsius to 220 degrees Celsius. Then the roasted pine nuts are subjected to colloid milling at 50 degrees Celsius to 90 degrees Celsius for 5 to 20 minutes and then centrifugation is done at 15,800-gram force for 20 to 35 degrees Celsius, where it is separated into oil and sludge components. The oils obtained are filtered to get pine nut oil. The fatty acids contained in pine nuts are mainly unsaturated fatty acids such as oleic, linoleic, and linoleic acids, which act as a nourishing tonic. See that palmitic acid is 4.4 percent, linoleic acid is around 43.9 or 44 percent pinolenic acid is 14.2 percent and even oleic acid is around 29 percent.



As the tree nuts oil have varying amount of unsaturated fatty acid, this will cause instability, but as it contains various antioxidant it gives oxidative stability also. The oxidative stability and antioxidant value of selected tree nut oils are given in this table induction time hours for hazelnut is 52 hours and then almond oil is 21.8 hours, peanut oil is 14.6 hours and walnut oil is 4.7 hours, it has comparatively less stability, less stable to oxidation and then the hazelnut oil it has a maximum stable because of this unsaturation value of all these oils. But at the same time, you see that the total tocopherols ppm in hazelnuts is more. So, because the antioxidant content is more total polyphenol also is around 80 µg GAE/g of oil. Then pistachio nut oil has an induction time of 44.4 hours, total tocopherol is 530 ppm, total polyphenol is 700 µg GAE/g of oil, and EC50 value is 378 g oil/g of DPPH. Similarly, pine nut oil also has an EC50 value of 1396 g oil/g of DPPH and its total polyphenol content is 80 mu µg GAE/g of oil. The stability of the oil is because of the degree of unsaturation and available antioxidant components. Although unsaturation leads to instability, antioxidants are polyphenolic compounds and they provide stability against oxidation. Mechanically pressed tree nut oils are unrefined and have the greatest antioxidant level. Thermal oxidative stability SFE oil < Pressed oil< SE oils. Tocopherols lost during the refining are restored by adding back synthetic tocopherols.



As far as the effect of heat on the stability of the tree nut oils is concerned roasting increases the oxidation stability by inactivating pro-oxidative enzymes and reducing water activity. Tree-nut oils are rich in PUFA and thus are quite susceptible to oxidation. Lower total tocopherol content in roasted tree-nut oils shows greater retention of tocopherols during prolonged storage compared to unroasted counterparts. Heat treatment during roasting can facilitate the Maillard reaction between free amino residues and reactive carbonyls. So, if you see that oxidative stability that is 72 hours incubation period, we find that it decreases in the order of pecan oil, pistachio oil, brazil nut oil, almond oil, hazelnut oils, pine nut oil, and walnut oils.

Health benefits of tree-nut oils

- Reductions in serum total and low-density lipoprotein (LDL)-cholesterol.
- Suppresses appetite, enhances satiety, and limits the consumption of foods.
- Reduce the glycemic impact of carbohydrate-rich foods.
- Associated negatively with stroke, dementia, cardiovascular-disease and gallstones.
- Reduce blood pressure and reduce the levels of very low density lipoprotein (VLDL)-triglycerides and LDL-cholesterol.
- Omega-3 ALA (alpha-linolenic acid) and the omega-6 LA(linolenic acid), essential for healthy skin.
- Reduce inflammation.

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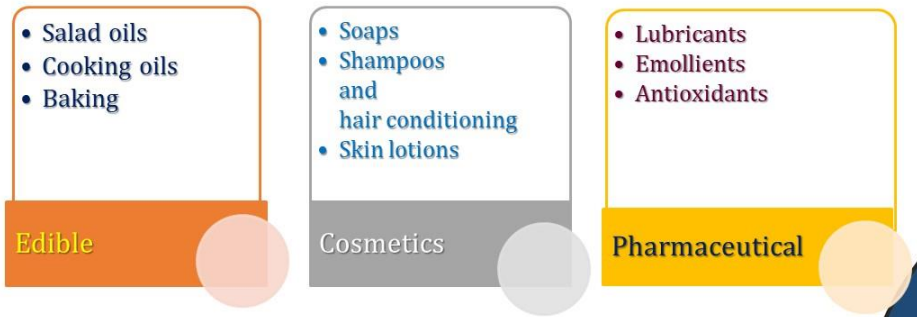
The health benefits of tree nut oils are due to the reductions in serum total and low-density lipoprotein (LDL)-cholesterol. They suppress appetite, enhance satiety, and limit the consumption of foods. Reduce the glycemic impact of carbohydrate-rich foods. Associated negatively with stroke, dementia, cardiovascular disease, and gallstones. Reduce blood pressure and reduce the levels of very low-density lipoprotein (VLDL)-triglycerides and LDL-cholesterol. Omega-3 ALA (alpha-linolenic acid) and omega-6 LA(linolenic acid), are essential for healthy skin. They are also shown to reduce inflammation.

Edible and nonedible applications of tree nut oils



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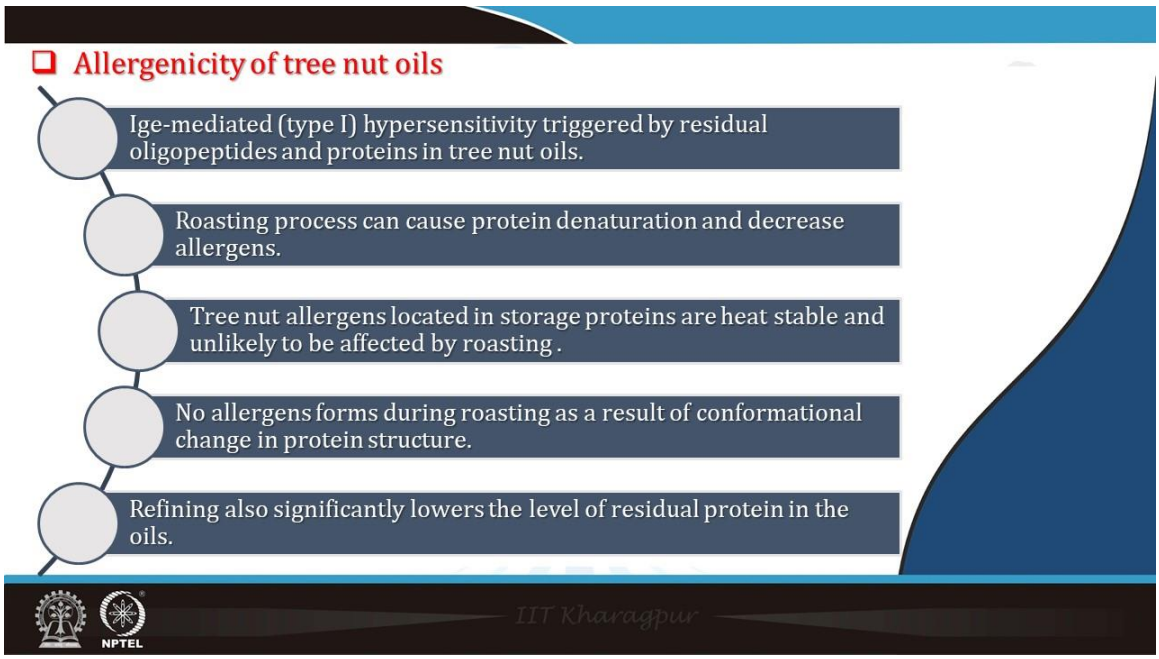
The edible and non-edible applications of tree nut oils are, in edible uses, it can be used for salad oils, cooking oils, and baking oils, but in cooking oils, because these are very costly and so, it can be sometimes used for low-temperature cooking it may give a better flavor to the product, but normally for salad oil it is good. Then in cosmetics, it is used for soap manufacturing, in shampoos and in hair conditioning, and even in skin lotions it can be used for their skin-beneficial property. In pharmaceuticals, it is used as lubricants, emollients, and antioxidants.



Although they are very good quality oil some of the tree nuts are reported to have allergenicity, that is the Ige-mediated (type I) hypersensitivity triggered by residual oligopeptides and proteins in tree nut oils. The roasting process can cause protein denaturation and decrease allergens. Tree nut allergens located in storage proteins are heat-stable and unlikely to be affected by roasting. No allergens form during roasting as a result of conformational change in protein structure. Refining also significantly lowers the level of residual protein in the oils.

Nut allergens

Nut	Major allergens
Almonds	Pru du 2S albumin (2S albumin, seed-allergic protein 1, accession # P82944) Pru du conglutin (conglutin γ, seed-allergic protein 2, accession # P82952) Pru du 4 (profilin, accession # Q8GSL5) Pru du amandin (11S legumin, seed-allergic protein)
Brazil nuts	Ber e 1 (2S albumin, accession # PO4403), Ber e 2 (11S globulin-like protein, accession # Q84ND2)
Cashew nuts	Ana o 1 (7S globulin, vicilin-like protein, accession # Q8L5L5) Ana o 2 (11S globulin-like protein, accession # Q8GZP6) Ana o 3 (2S albumin, accession # Q8H2B8
Hazelnuts	Cor a 1 (PR-10 (Bet v 1 homologous), accession # Q9FPK2/3/4) Cor a 2 (profilin) Cor a 8 (PR-14, lipid-transfer protein) Cor a 9 (11S globulin-like protein, accession # Q8W1C2)
Macadamia nuts	Allergy established but allergen(s) not characterized
Pecan nuts	Car i 1 (putative allergen 11, accession # AAO32314)
Pine nuts	(17 kDa vicilin-like protein)
Pistachio nuts	Pis v 3 (vicilin-like protein, accession # ABO36677)
Hazelnuts	Cor a 1 (PR-10 (Bet v 1 homologous), accession # Q9FPK2/3/4) Cor a 2 (profilin) Cor a 8 (PR-14, lipid-transfer protein) Cor a 9 (11S globulin-like protein, accession # Q8W1C2)
Walnuts	Jug r 1 (2S albumin, accession # P93198) Jug r 2 (vicilin-like protein, accession # Q9SEW4) Jug r 3 (PR-14, lipid-transfer protein) Jug r 4 (11S globulin-like protein)

Sources: Robotham et al. (2005) & Jin et al. (2008).

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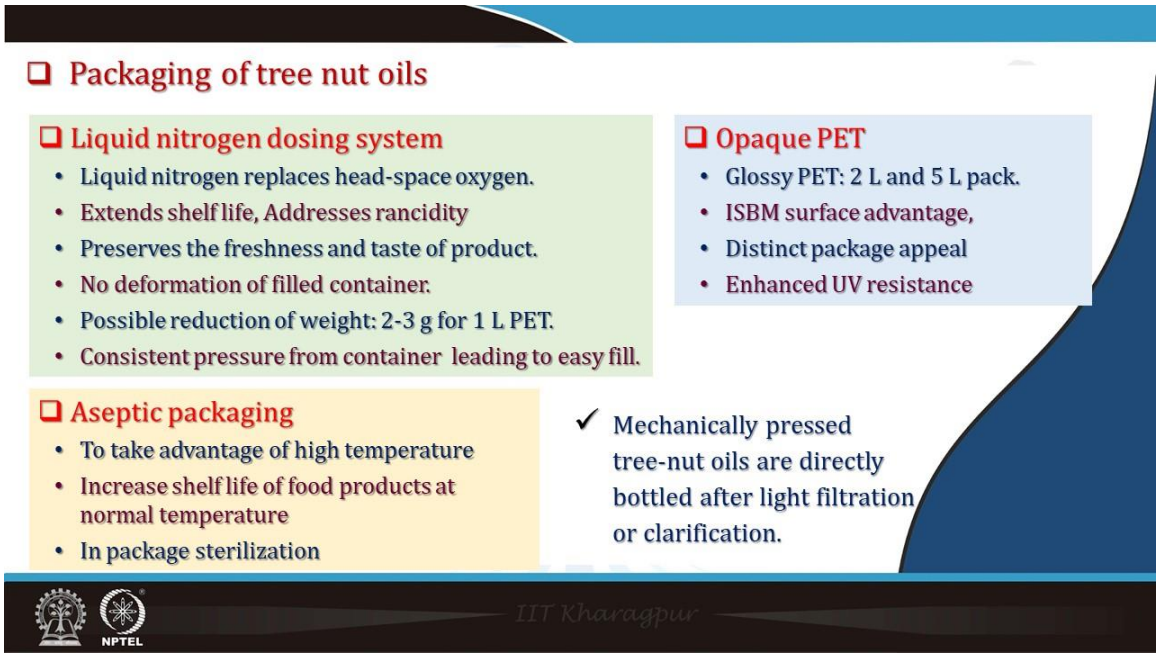
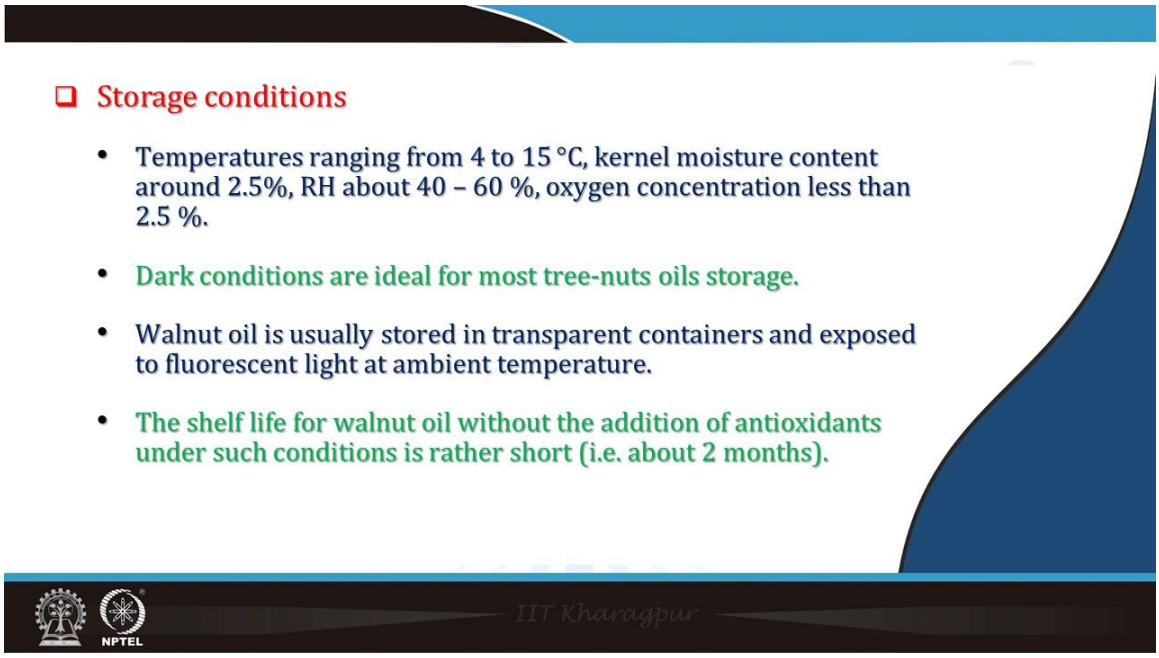
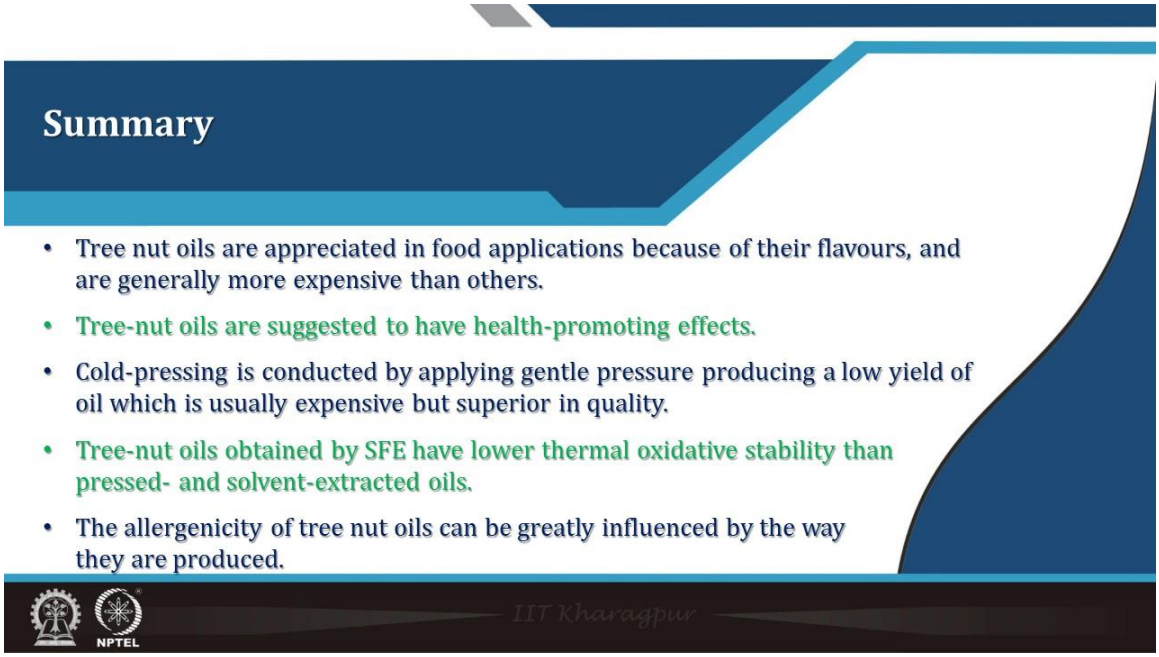
In this table, the data of major nuts and major allergens found in them are provided. In almonds, there is 2 S albumin, seed allergic protein 1, accession, conglutin, etc. The common allergens reported in brazil nuts are 2 S albumin, 11 S globulin-like protein, in cashewnut 7 S globulin, 11 S globulin-like protein, 2 S albumin, in hazelnut it is PR-10 Bet V 1 homologous, profilin, lipid-transfer protein, 11 S globulin-like protein. In macadamia nuts allergy is established but allergens are not well characterized so far. In pecan nut that is putative allergen 11, in hazelnut is PR 10, profiling, 11 S globulin-like protein, and in walnut 2 S albumin, vicilin-like protein, 11 S globulin-like protein. etc. So, these are some of the reported allergens found in the nuts.



Then in the packaging of the tree nut oil like any oil that is, can use a liquid nitrogen dosing system because liquid nitrogen replaces the head space oxygen and extends the shelf life, it addresses the rancidity. It preserves the freshness and taste of the products, there is no deformation of the filled container. There is a possible reduction of weight that is 2 to 3 grams for 1 liter PET packet and consistent pressure from the container leading to easy filling. Then aseptic packaging can be used here to take advantage of high temperatures and increase the shelf life of products at a normal temperature and even in package sterilization is possible in aseptic packaging. Normally form, fill, and seal machines are used that is packaging materials are sterilized and then oil is packed. Then opaque PET, there is 2 litre and 5 litre glossy pet packs are used. It has an ISBM surface advantage. They give a distinct package appeal and there is an enhanced UV resistance. The mechanically pressed tree nut oils are sometimes directly bottled after just light filtration or clarification.



For storage of tree nut oils, temperatures ranging from 4 to 15 °C, kernel moisture content around 2.5%, RH about 40 – 60 %, oxygen concentration less than 2.5 %. Dark conditions are ideal for most tree-nuts oils storage. Walnut oil is usually stored in transparent containers and exposed to fluorescent light at ambient temperature. The shelf life for walnut oil without the addition of antioxidants under such conditions is rather short (i.e. about 2 months).



So, with this I will summarize this course that tree nut oils are appreciated in food applications because of their flavours, and are generally more expensive than others.

Tree-nut oils are suggested to have health-promoting effects. Cold-pressing is conducted by applying gentle pressure producing a low yield of oil which is usually expensive but superior in quality. Tree-nut oils obtained by SFE have lower thermal oxidative stability than pressed- and solvent-extracted oils. The allergenicity of tree nut oils can be greatly influenced by the way they are produced.

So, these are the references that were used to make this lecture with this. Thank you very much for your patience here. Thank you.