Food Oils and Fats: Chemistry and Technology
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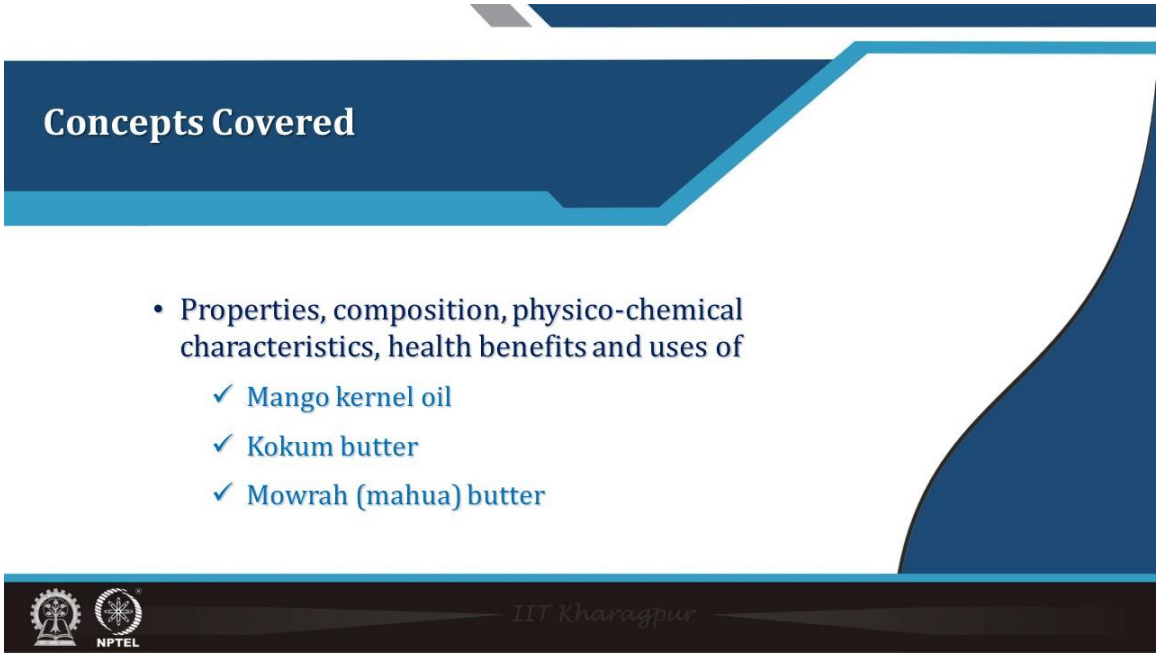
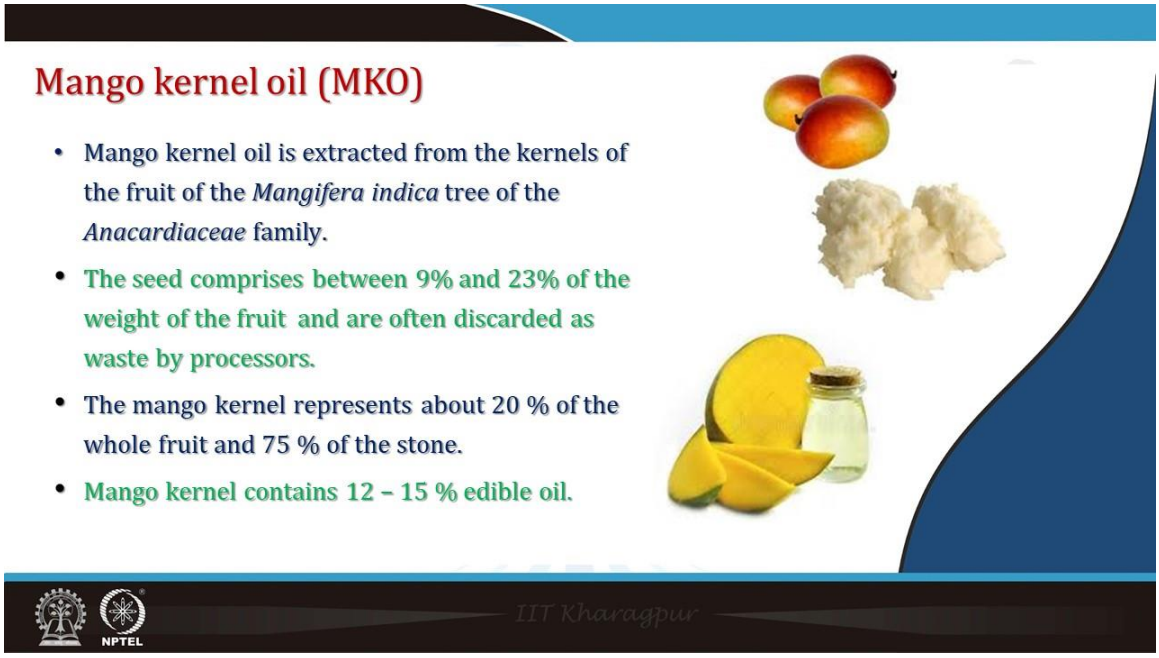
Indian Institute of Technology Kharagpur
Module 10 : Specialty Oils and Fats Products
Lecture 47 : Tropical Exotic Oils and Butter

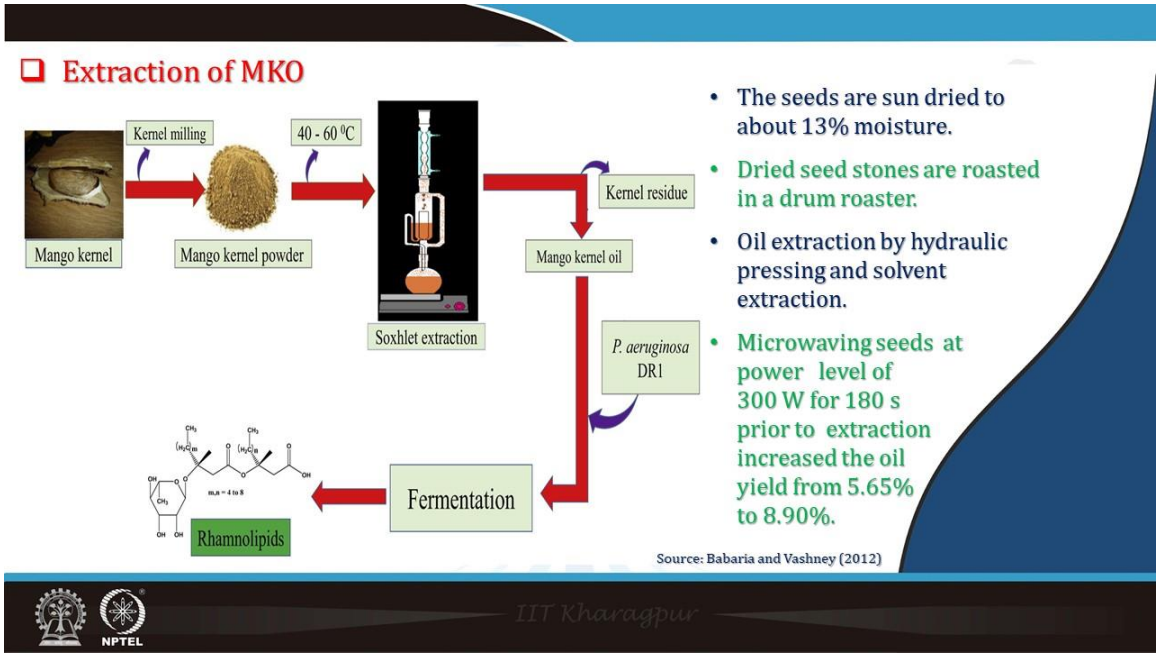


Hello everybody. Now, we are in the 47th lecture of the course and in this lecture in the next half an hour or so, we will talk about tropical exotic oils and butter. We will discuss the properties, composition, physicochemical characteristics, health benefits, and uses of

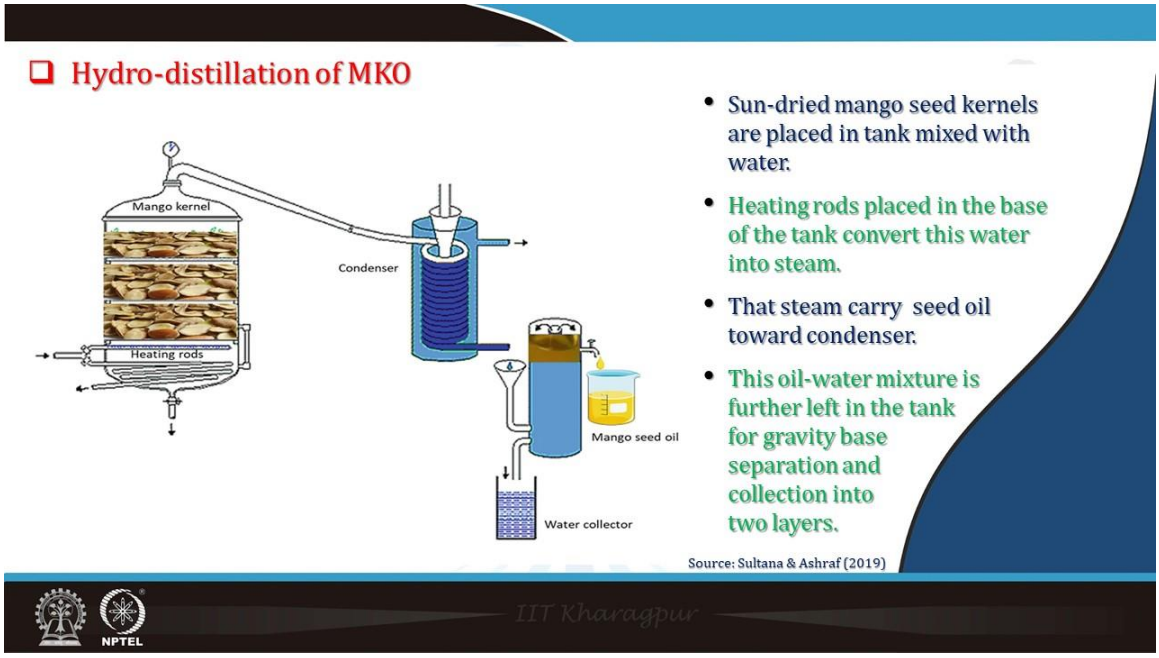
three major exotic butter like mango kernel oil and butter, kokum butter and mowrah or mahua oil and butter.



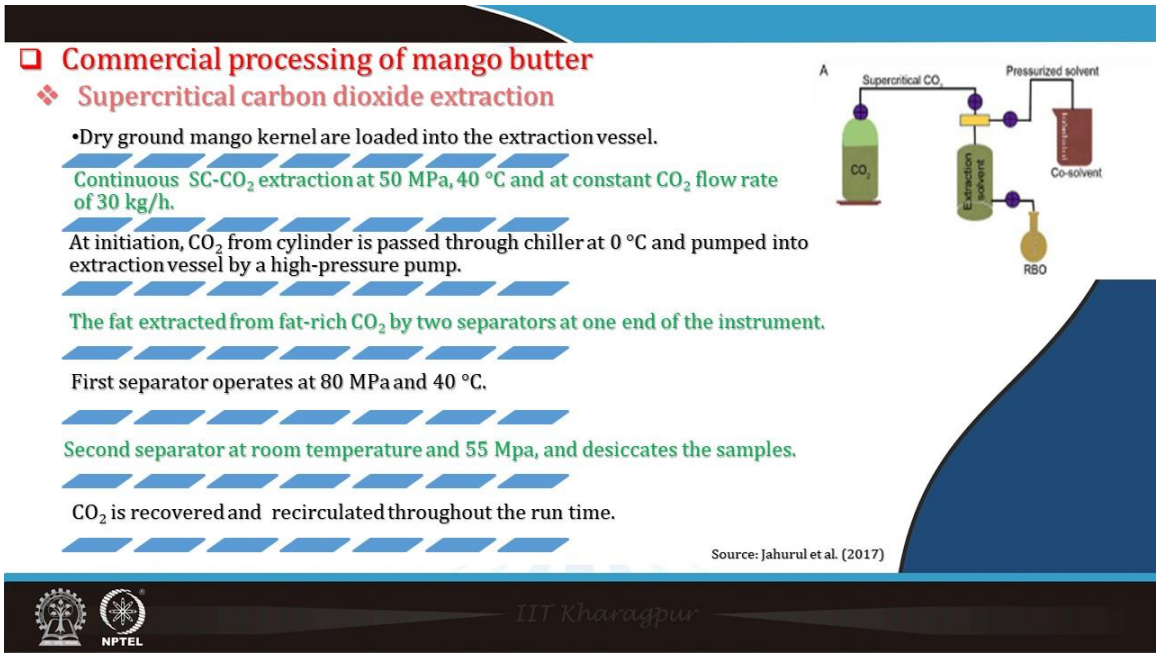
So, first let us talk about mango kernel oil. Mango kernel oil is extracted from the kernels of the fruit of the Mangifera indica tree of the Anacardiaceae family. The seed comprises between 9% and 23% of the weight of the fruit and are often discarded as waste by processors. The mango kernel represents about 20 % of the whole fruit and 75 % of the stone. Mango kernel contains 12 – 15 % edible oil.



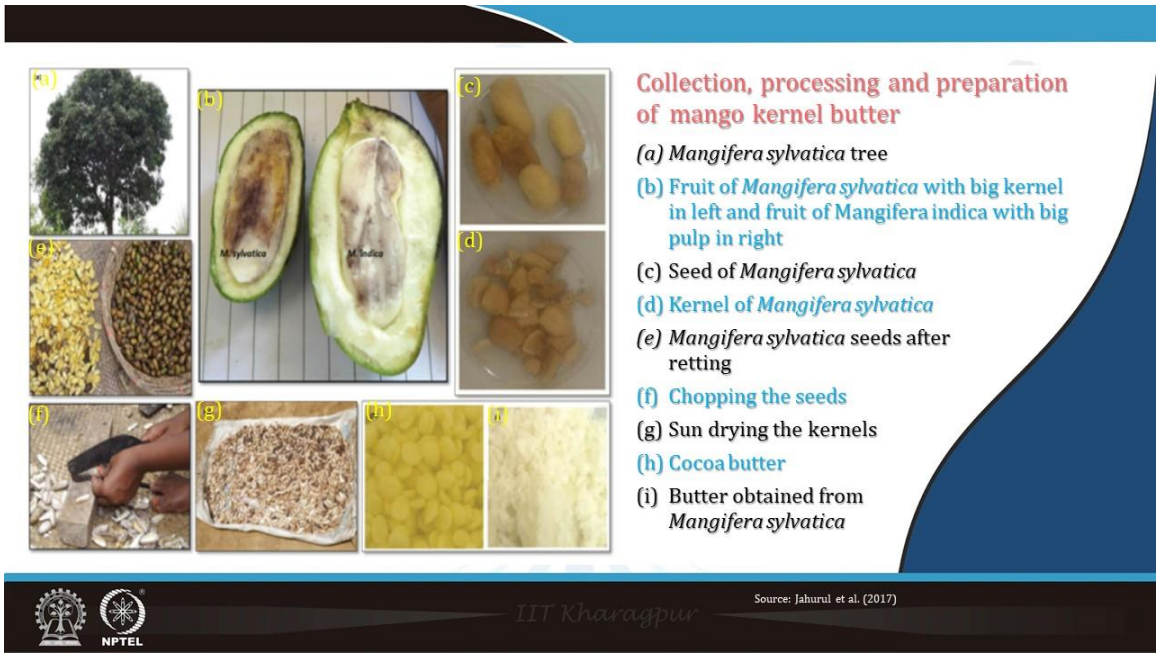
So, for extraction of mango kernel oil, the seeds that are after the pulping the mango seeds are sun dried to around 13 percent moisture content and these dried seeds stones are roasted in a drum roaster or suitable equipment. After roasting they are broken and kernels are obtained then kernels may be converted into powder and then it is subjected to hydraulic pressing or solvent extraction. It gives the mango kernel oil. Microwaving seeds at power level of 300 W for 180 s prior to extraction increased the oil yield from 5.65% to 8.90%. Mango kernel oil then maybe subjected to fermentation and you get rhamnolipids in it.



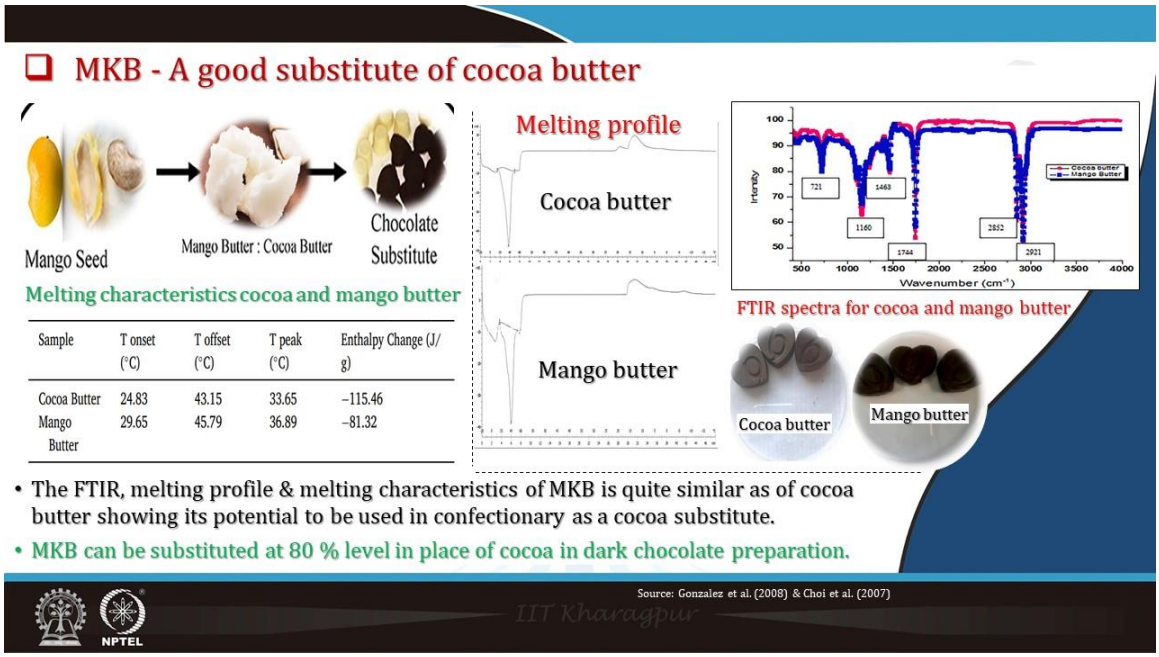
A different method which can be used is hydro distillation of mango kernel oil. The mango kernel that is in the water is heated using heating rods, there is a conductor that condenses the water, and mango kernel oil is obtained. Sun-dried mango seed kernels are placed in a tank mixed with water. Heating rods placed in the base of the tank convert this water into steam. That steam carries seed oil toward the condenser. This oil-water mixture is further left in the tank for gravity base separation and collection into two layers and the top layer is the mango kernel oil.



The commercial pressing of the mango butter can be done by a super-critical carbon dioxide process. It has been found to be very effective in this case that dry ground mango kernels are loaded into the extraction vessel then continuous supercritical carbon dioxide extraction at 50 mega Pascal pressure at 40 degrees Celsius temperature and at a constant carbon dioxide flow rate of 30 kg per hour. So at initiation carbon dioxide from the cylinder is passed through the chiller at 0 degrees Celsius and then pumped into the extraction vessel by a high-pressure pump. The fat is extracted from fat-rich CO2 by two separators at one end of the instrument. The first separator operates at 80 mega Pascal pressure and 40 degree Celsius temperature and the second separator operates at room temperature and 55 mega Pascal and desiccates the sample. Then carbon dioxide is finally recovered and recirculated throughout the run time.

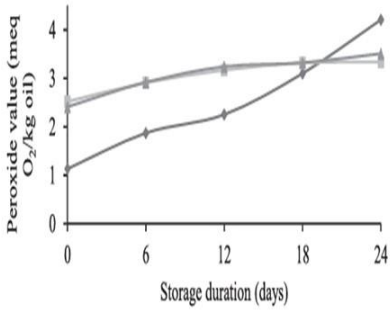


So, you can see here that is the different pictures are shown here is collection, processing and preparation of mango kernel butter. From the mango tree you get mango and the fruits *Mangifera sylvatica* with the big kernels in left and the fruit of *Mangifera indica* with the pulp in right as seen in 'b', 'c' is the seed of *Mangifera sylvatica*. Then the seed is broken and the kernel is obtained, that is the kernel is received by suitable method and then chopping of the seed is done. The kernel is sun dried kernel. And this kernel basically here which is shown in picture is subjected to that extraction of butter or oil. You can see here a comparison, this is the cocoa butter and this is the butter obtained from the mango kernel.



Mango kernel butter is considered to be a good substitute of cocoa butter. If you see the melting characteristics of cocoa, it is used in confectionery or ice creams like products because of its melting profile. So, the melting profile of mango kernel butter is almost similar to the cocoa butter as you can see in these two figures. Similarly FTIR spectra of cocoa and mango butter are also shown and the chocolate prepared using mango butter and cocoa butter is shown in the figure. The melting characteristics of cocoa and mango butter mango seed see that the T onset for cocoa butter is 24.83 and mango butter is 29.64. And T offset in degrees Celsius 43 and 45, T peak 33 and 36 and enthalpy change is -115 or -81. So, almost the cocoa butter and mango kernel butter properties are very similar. So, it can be considered a good substitute for cocoa butter. The FTIR, melting profile & melting characteristics of MKB is quite similar as of cocoa butter showing its potential to be used in confectionary as a cocoa substitute. MKB can be substituted at 80 % level in place of cocoa in dark chocolate preparation.

Effect of accelerated storage on MKB

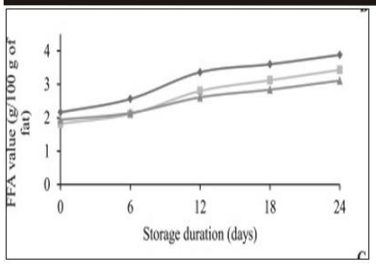


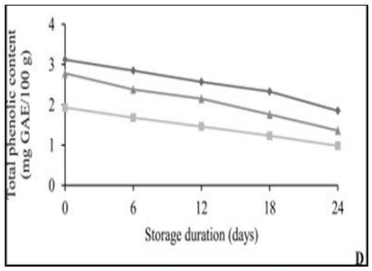
Mango seed fat (-◇-) and its blend with palm oil mid-fraction (POMF) at proportions 80 g/100 g (-□-) and 85 g/100 g (-△-) upon accelerated storage.

- ✓ Blend 1 (MKB/POMF; 80/20)
  Blend 2 (MKB/POMF; 85/15)
- ✓ Storage at 65 °C for 24 days, where 1 day of storage represents 1 month of storage at room temperature
- Contains high degree of unsaturated fatty acids which are susceptible to oxidation
- The fresh MKB, and blends 1 and 2 showed PV of 1.1 ± 0.0, 2.5 ± 0.1, and 2.4 ± 0.1 meqO_2/kg oil, respectively.
- The PV was found to be slightly high.
- Heat used for extraction of MSF by solvent, might have caused fat oxidation.

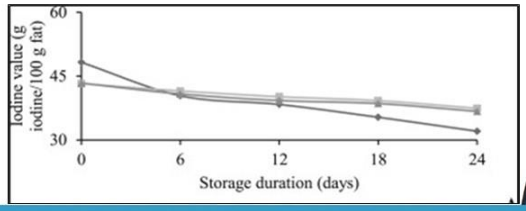
Source: Jahurul et al (2017)

Here some studies show the effect of accelerated storage conditions on mango kernel butter that is there are two blends were used. Blend 1 contains mango kernel butter and palm oil mid-fraction (POMF) 80 to 80 ratio, and blend 2 is 85 percent mango kernel and 15 percent POMF. Storage conditions are 65 degree Celsius for 24 days where one day of storage represent one month of storage at room temperature because it is accelerated storage. The lines here are mango seed oil and palm oil mid-fraction mixture and it shows how the peroxide value increases with storage. So, these both contain a high degree of unsaturated fatty acids which are susceptible to oxidation. The fresh MKB, and blends 1 and 2 showed PV of 1.1 ± 0.0, 2.5 ± 0.1, and 2.4 ± 0.1 meqO2/kg oil, respectively. The PV was found to be slightly high. Heat used for extraction of MSF by solvent might have caused fat oxidation.





- The FFA values increased significantly during the storage.
- At 12 days of storage, the FFA values of all fats increased dramatically. On the last day of storage, MSF showed the highest FFA value
- The total phenolic contents in MSF and MSF/POMF blends decreased in 6 days of storage. The phenolic contents decreased significantly upon storage.
- The iodine values decreased significantly during storage.
- The decrease of iodine values from day 0 to day 24 of storage were observed to be higher in MKB .



Source: Jahurul et al (2017)

That is the free fatty acids this shows that similar conditions affect free fatty acids, the total phenolic content, and the iodine number that changes during storage. The FFA values increased significantly during the storage. At 12 days of storage, the FFA values of all fats increased dramatically. On the last day of storage, MSF showed the highest FFA value. The total phenolic contents in MSF and MSF/POMF blends decreased in 6 days of storage. The phenolic contents decreased significantly upon storage. The iodine values decreased significantly during storage. The decrease of iodine values from day 0 to day 24 of storage was observed to be higher in MKB.

Physicochemical characteristics of MKO

FFA %	0.22
Colour	Light white to yellowish
Moisture %	0.21
Iodine value, (g iodine/100 g fat)	54.6
Melting point (°C)	35.2
Insoluble matter %	1.68
PV (meqO_2/kg)	0.65
pH	5.9
Refractive index	1.476
Density (g/cm^3)	0.911
Saponification value (mg KOH/g)	162.69

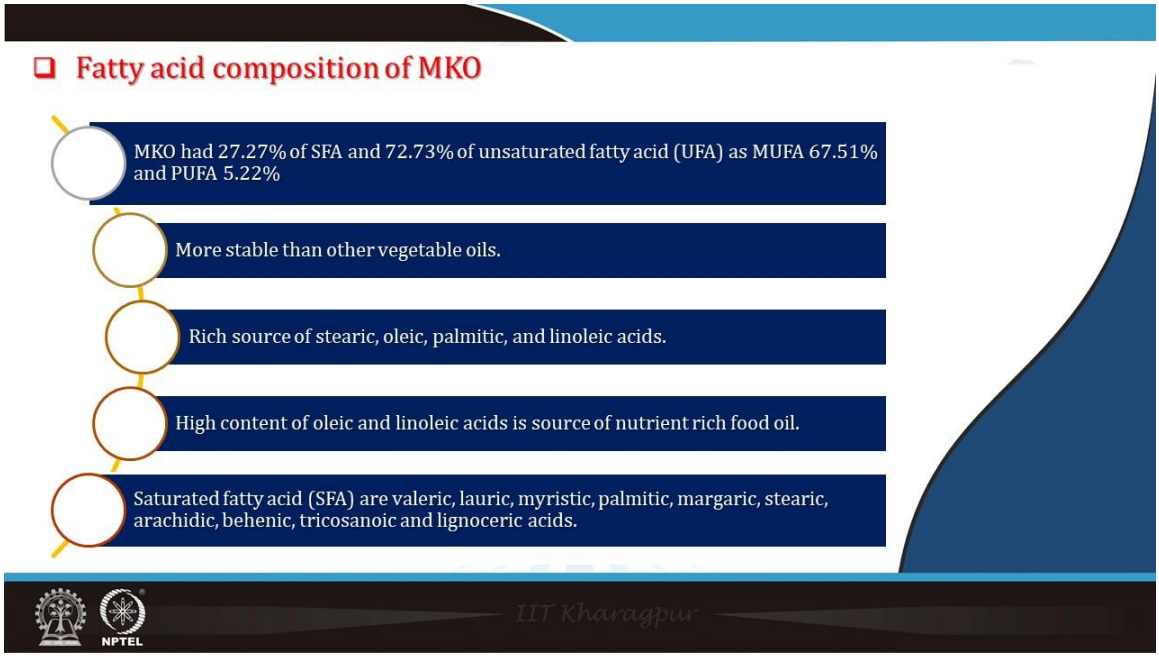
Proximate composition of oil cake

Moisture	19.80
Crude protein %	38.0 - 47.3
Crude fat %	12.8 - 26.1
Ash content %	3.7 - 5.7
Crude fiber %	4.69
Carbohydrates %	40.50

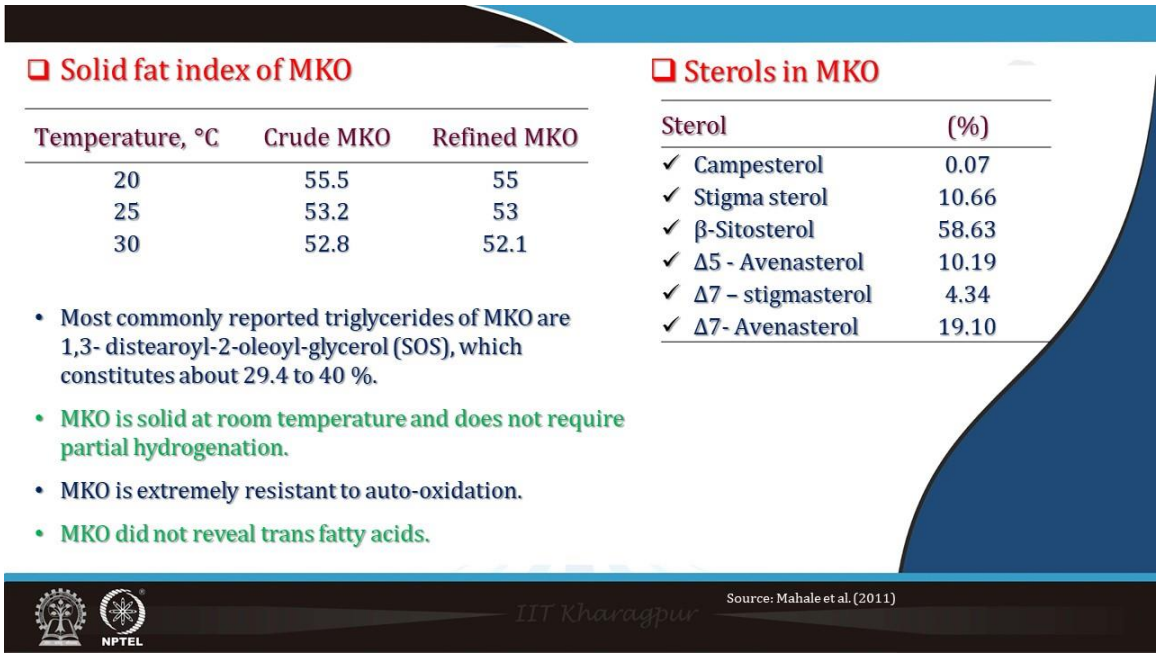
- **Yellow color** and had non-offensive odour.
- Oil ceases to flow on increased temperature.
- The **high saponification** indicative for use in cosmetic industry.

Source: Abdel-Razik et al. (2012)

This table gives the physicochemical properties of mango kernel oil that is free of fatty acid 0.22 percent, it is light yellow to white in color, the moisture content is 0.21 percent. It has an iodine value of 54 g iodine/100 g fat and a melting point of 35.2 degrees celsius. It has a refractive index of 1.476, a density of 0.911 grams per cubic centimeter, and a saponification value of 162 milligrams KOH per gram. It contains around 1.65 percent insoluble matter and its melting point is around 35 that is it melts in the hand like this. So, the proximate composition of mango oil cake is crude protein 38 percent, but fat 12 percent, ash content 3.7, fibre 4.9, and carbohydrate 40 percent. It has a yellow color and has a non-offensive odor. Oil ceases to flow at an increased temperature. The high saponification is indicative of use in the cosmetic industry.

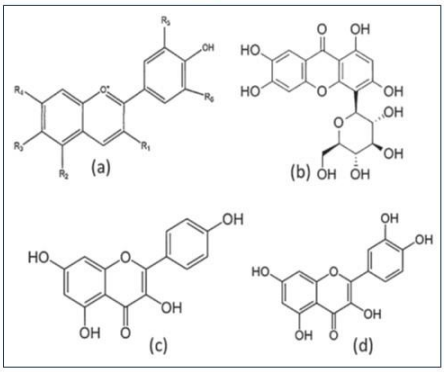


Fatty acid composition of mango kernel oil is 27.27% of saturated fatty acids and 72.73% of unsaturated fatty acid (UFA) as MUFA 67.51% and PUFA 5.22%. These are more stable than other vegetable oils. They are rich source of stearic, oleic, palmitic, and linoleic acids. High content of oleic and linoleic acids is source of nutrient rich food oil. Saturated fatty acid (SFA) present are valeric, lauric, myristic, palmitic, margaric, stearic, arachidic, behenic, tricosanoic and lignoceric acids.

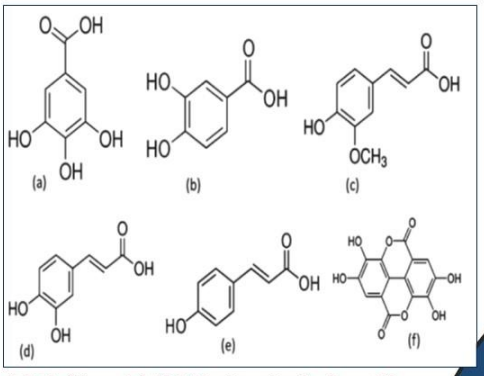


Solid fat index of mango kernel oil at 20 degree celsius for crude is 55.5, refined is 55 and at 30 degree Celsius crude mango kernel oil has a solid fat index of 52.8 and refined fat oil has a solid fat index of 52.1. Most commonly reported triglycerides of mango kernel oils are 1, 3-distearoyl-2-oleoyl-glycerol (SOS) which constitute about 29.4 to 40 percent. Mango kernel oil is solid at room temperature and does not require partial hydrogenation. Mango kernel oil is extremely resistant to auto oxidation. It did not reveal any trans fatty acids. It also has a good quantity of sterols like beta-sitosterol is 58 percent, stigma-sterol is 10 percent, delta 5 avenasterols is 10 percent, delta 7 avenasterol is 19.1 percent.

❑ Bioactive compounds in MKO



(a) Anthocyanin, (b) Isomangiferin,
(c) Kaemferol, and (d) Quercetin



(a) Gallic acid, (b) Protocatechuic acid,
(c) Ferulic acid, (d) Caffeic acid,
(e) Coumaric acid, and (f) Ellagic acid

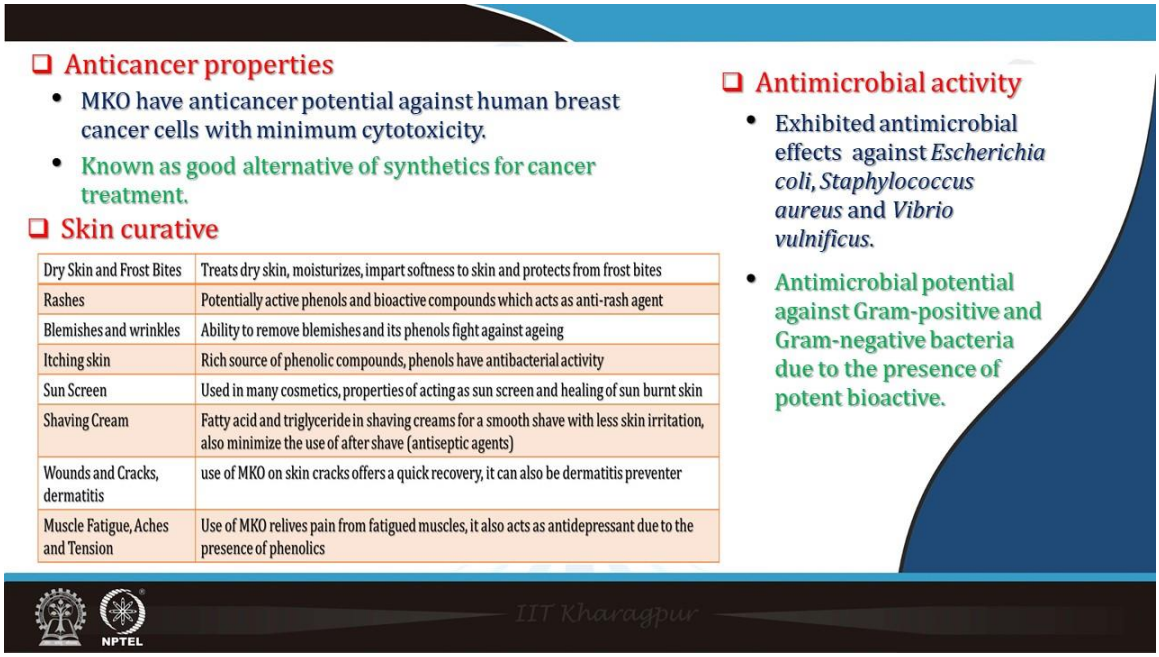
Bio-active compounds here their structures are shown in the mango kernel oil. It contains anthocyanins, isomanggiferin, kaemferol and quercetin, gallic acid, protocatechuic acid, ferulic acid, caffeic acid, coumaric acid and ellagic acid. So, these are the various bio-active components which are found in mango kernel oil.

❑ Antioxidant capacity of MKO

- Highest degree of free-radical scavenging and tyrosinase-inhibition activities.
- Contained different phenolic compounds and consisted of stable fat rich in SFA.
- Phenolic compounds inhibit lipid peroxidation of human LDL in-vitro.
- Antioxidant property is attributed to SFA and MUFA as well as fractions of tocopherols, sterols, their esters and other phenolic compounds present as unsaponifiable matter.
- Can be used as antioxidant in edible oil.
- Comparison of the PV showed that addition of crude MKO reduced the oxidation process.
- Gallic acid present as an anti-inflammatory, anti-mutant and antioxidative agent.

Accordingly, the bio-actives give a good antioxidant capacity. Highest degree of free-radical scavenging and tyrosinase-inhibition activities. Contained different phenolic compounds and consisted of stable fat rich in SFA. Phenolic compounds inhibit lipid peroxidation of human LDL in-vitro. Antioxidant property is attributed to SFA and

MUFA as well as fractions of tocopherols, sterols, their esters and other phenolic compounds present as unsaponifiable matter. It can be used as antioxidant in edible oil. Comparison of the peroxide value showed that addition of crude MKO reduced the oxidation process. Gallic acid present as an anti-inflammatory, anti-mutant and antioxidative agent.



Mango kernel oil is reported to have anti-cancer properties. MKO has anticancer potential against human breast cancer cells with minimum cytotoxicity. It is known as good alternative of synthetics for cancer treatment. It has a lot of skin curative properties like it treats dry skin, moisturizes the skin, it is potentially active phenol and bioactive compound which act as anti-rash agent on the skin. It has the ability to remove blemishes and its phenols fight against aging. The use of mango kernel oil relieves pain from fatigued muscles. It also acts as anti-depressant due to the presence of phenolics. It exhibited antimicrobial effects against Escherichia coli, Staphylococcus aureus and Vibrio vulnificus. It has antimicrobial potential against Gram-positive and Gram-negative bacteria due to the presence of potent bioactive mainly owing to the presence of various bioactive compounds.

Kokum butter

- Obtained from the fruit of the kokum tree (Botanical name: *Garcinia indica*)
- Native plant of the western coastal area of the Indian subcontinent
- Fruits have seeds containing 32–40% fat
- Permitted for use as vegetable fats according EU chocolate directive

❑ Kokum fruit

- The fruit contains 5–8 brown kidney-shaped, flattened, 1–2 cm long and up to 1 cm broad seeds.
- The pericarp contains a secretion container, and the embryo contains the distinctly crystalline fat and several aleurone grains.

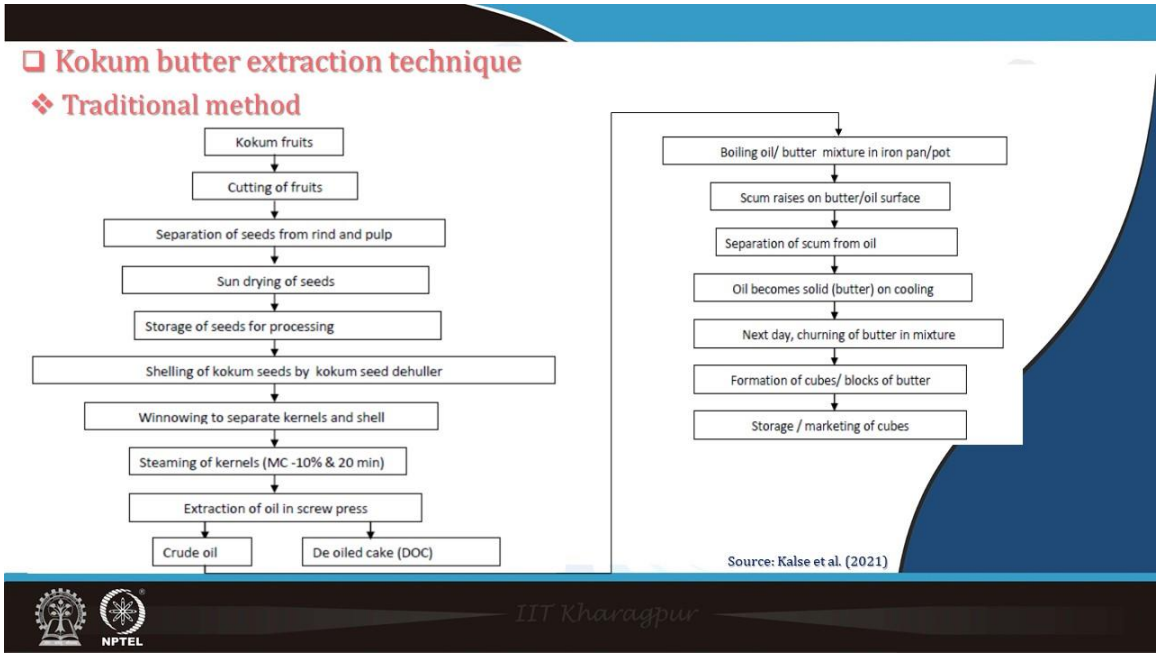
Let us talk briefly about the kokum butter. This kokum butter is obtained from the fruit of the kokum tree. It is native plant for the western coastal area of the Indian subcontinent. Fruits have seed containing around 32 to 40 percent fat. It is permitted for use as vegetable fat according to the European Union chocolate directive. Kokum fruit contains 5 to 8 brown kidney shaped flattened 1 to 2 centimeter long and up to 1 centimeter broad seeds. The pericarp contains a secretion container and embryo contains the directly crystalline fat and several aleurone gains.

❑ Physical and chemical characteristics of Kokum butter (KB)

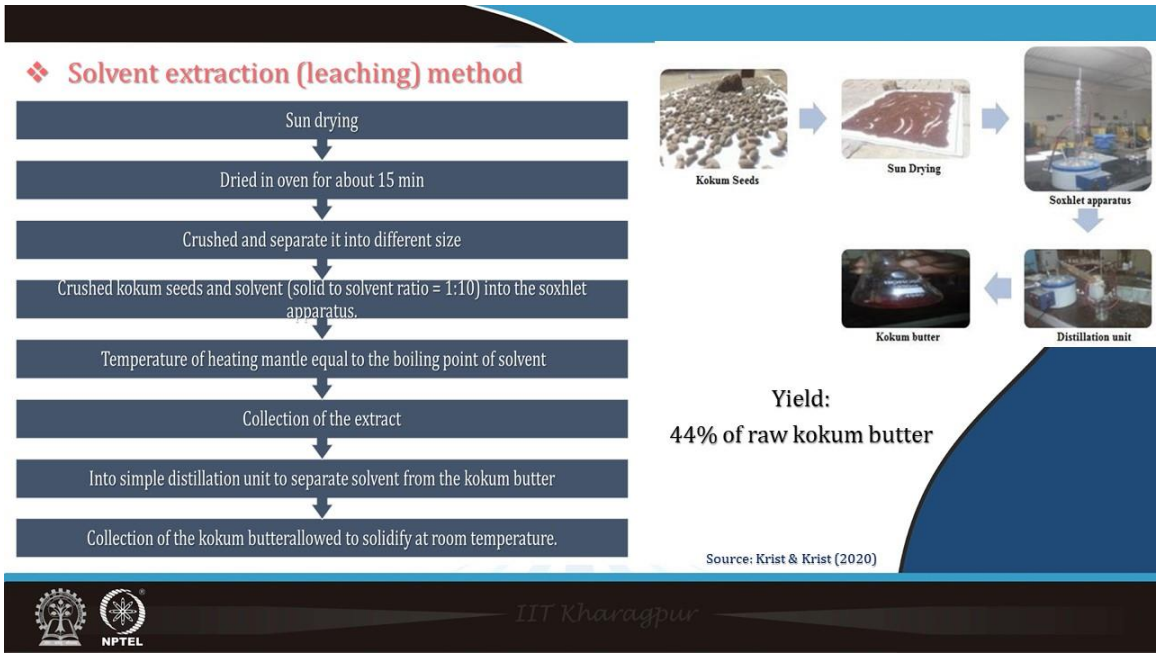
✓ Colour	✓ Yellowish-white to yellowish light-grey
✓ Odour	✓ Fresh, light smell similar to cocoa butter
✓ Flavour	✓ Mild taste
✓ Shelf life	✓ Up to 1 year

▪ Refractive index at 20 °C	▪ 1.452 to 1.496
▪ Saponification number	▪ 186 – 190 mg KOH/g
▪ Iodine number	▪ 35 – 37 g Iodine/100 g
▪ Acid number	▪ 4.0 mg KOH/g
▪ Unsaponifiable matter	▪ 1 – 2 %
▪ Melting range	▪ 39 – 42 °c

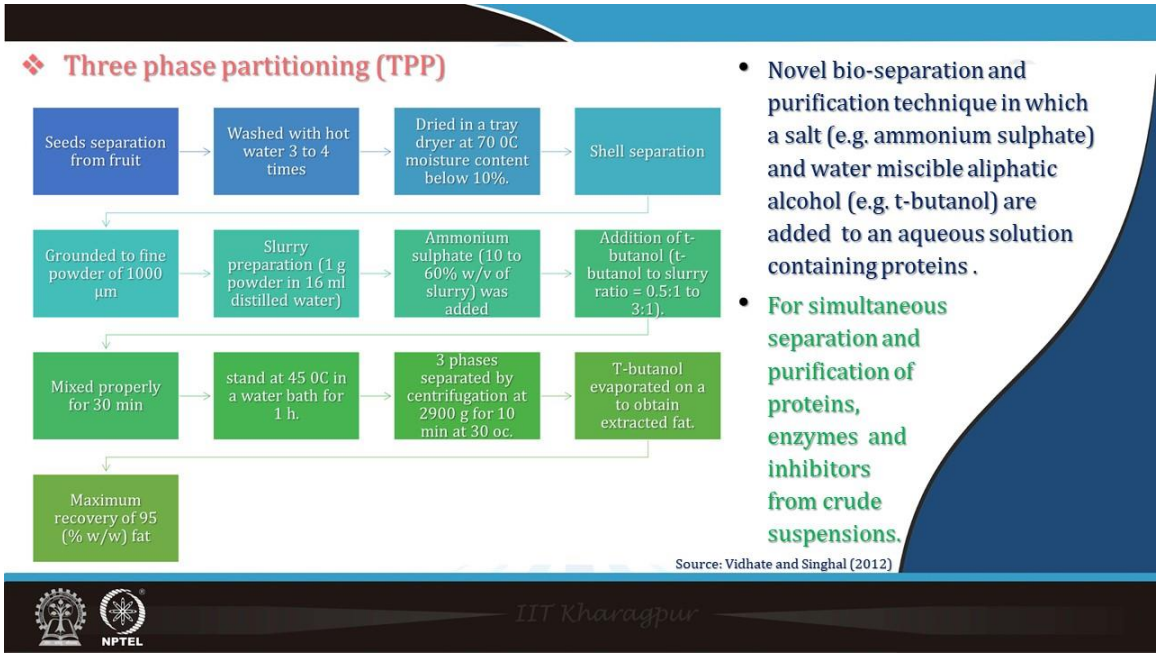
The physical and chemical characteristics of kokum butter are, it is yellowish to white to yellowish light-grey in color. It has fresh, light smell similar to the cocoa butter. It has a mild taste and shelf life is very good upto 1 year. Its reffective index at 20 degree Celsius is 1.452 to 1.469. Its iodine value is 35 to 37 gram iodine per 100 gram, acid value is 4 milligram KOH per gram. It has around 1 to 2 percent unsupponifiable matter and its melting range 39 to 42 degree Celsius.



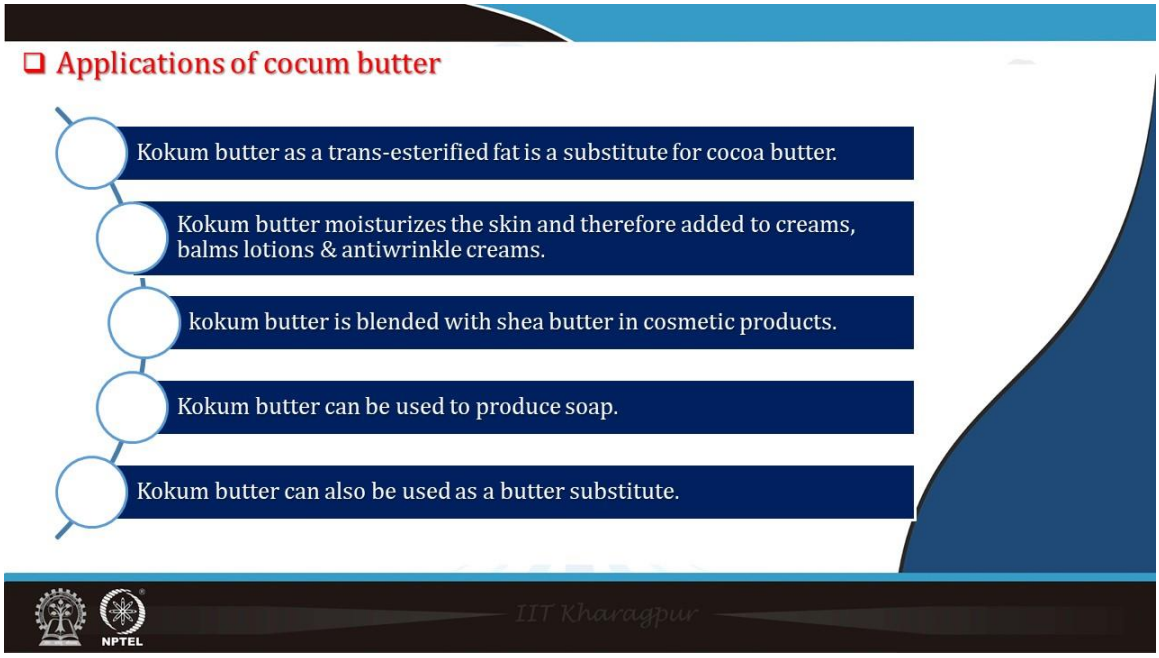
For the extraction of the kokum butter, the traditional extraction method is cutting of kokum, then separating of seed from the rind and pulp. The seeds are then sun dried and the seeds after sun drying are stored for processing or for extraction. There is shelling of the kokum seed by dehuller, winnowing to separate the hulls and the kernels. The kernels are steamed at around 10 percent moisture content for 20 minutes and then steamed kernels are subjected to oil extraction either by screw pressing or sometime the solvent extraction. The crude oil which is obtained is boiled to a butter mixture in iron pans. Scum rises on the butter/oil surface, then separation of the scum from oil. Oil becomes solid butter on cooling. Next day churning of butter is done in mixture then formation of cubes or blocks of butter and it is stored or marketed in cubes.



Solvent extraction yields 44 percent of the raw kokum butter. In this process, kokum seed is sun-dried, then extracted in soxhlet apparatus and separated in distillation unit. After sun drying, the kokum seed are dried in an oven for 15 minutes, crushed and separated into different sizes. Crushed kokum seeds and solvents in the solids to solvent ratio of 1:10 is taken in the Soxhlet apparatus. The temperature of the heating mantle was maintained equal to the boiling point of the solvent. The extract was collected into a simple distillation unit to separate solvent from the kokum butter. The kokum butter collected is allowed to solidify at room temperature.

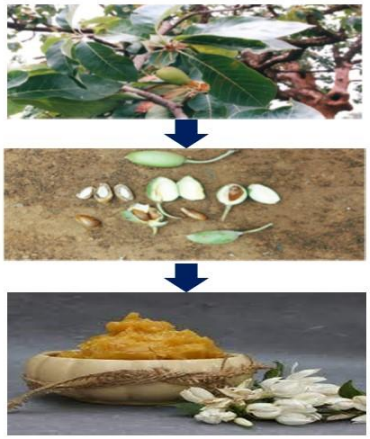


Then there is another method that is three phase partitioning. It is a novel bio-separation and purification technique in which a salt (e.g. ammonium sulphate) and water miscible aliphatic alcohol (e.g. t-butanol) are added to an aqueous solution containing proteins. For simultaneous separation and purification of proteins, enzymes and inhibitors from crude suspensions. This method involves seed separation from the fruit, washed with hot water 3 to 4 times, then dried in a tray at around 70 degree Celsius the moisture content of the seed is brought to a 10 percent, and subjected to shell separation. The shelled seeds are grounded into fine powder of 1000 micron, then it is prepared into a slurry, that is 1 gram powder in 16 ml distilled water. Then ammonium sulphate that is 10 to 60 percent weight by volume of the slurry is added and addition of t-butanol like t-butanol to slurry ratio is maintained 0.5 to 1 or 3 to 1. Then it is properly mixed for 30 minutes and it is allowed to stand at 45 degree Celsius of in a water bath for about 1 hour. The 3 phases were separated by centrifugation at 2900 gram for 10 minutes at 30 degrees Celsius. The T-butanol is evaporated to obtain the extracted fat and then maximum recovery of the fat is almost about 95 percent.



As far as the application of kokum butter is concerned, Kokum butter as a trans-esterified fat is a substitute for cocoa butter. Kokum butter moisturizes the skin and therefore added to creams, balms lotions & antiwrinkle creams. kokum butter is blended with shea butter in cosmetic products. It can be used to produce soap and can also be used as a butter substitute.

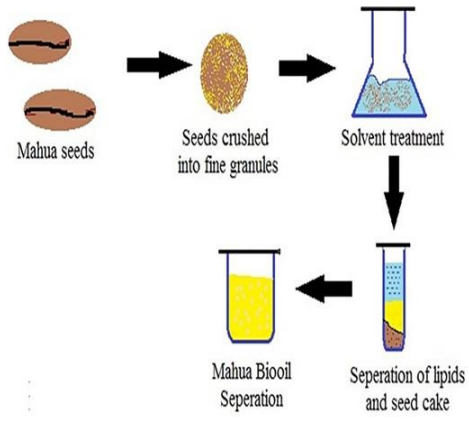
Mowrah (mahua) butter



- *Madhuca longifolia* fruit seeds contain 60% lipids, but it is under-utilized for oil production.
- Seeds of *Madhuca longifolia* show a good commercial potential as a source of vegetable oil.
- Commercially known as mahua or mowrah butter which is pale yellow in color and remains as a semi-solid under the tropical temperature conditions.
- High oil content indicates suitability of mahua seeds for industrial use as it reduces production cost.

Then we come to the mowrah or mahua butter that is *Madhuca longifolia* fruit seeds contain 60% lipids, but it is under-utilized for oil production. The seeds of *Madhuca longifolia* show a good commercial potential as a source of vegetable oil. It is commercially known as mahua or mowrah butter which is pale yellow in color and remains as a semi-solid under the tropical temperature conditions. Its high oil content indicates suitability of mahua seeds for industrial use as it reduces production cost.

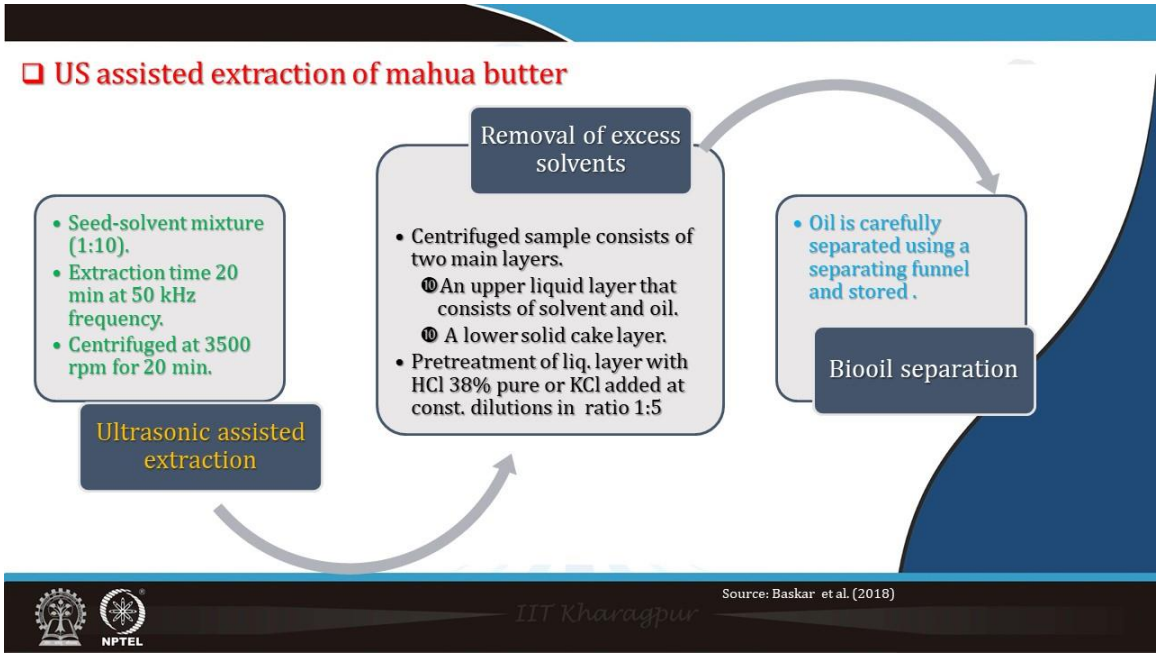
Extraction of mowrah butter



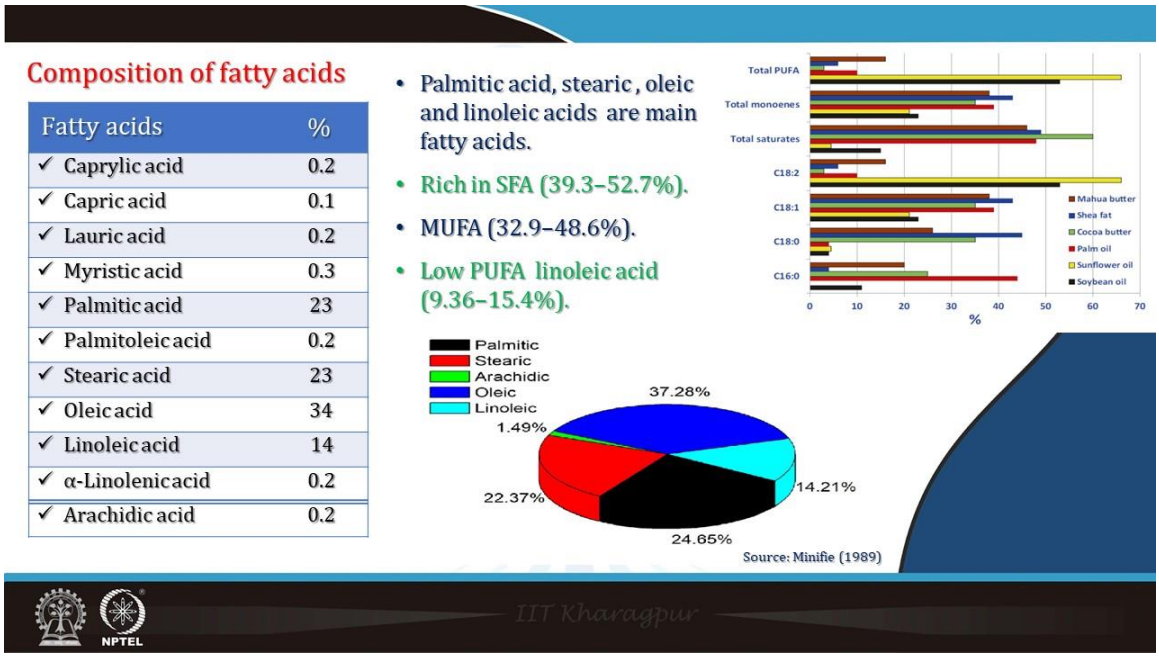
- Mahua seeds are sun dried for a week and then kernel is separated.
- Kernels are oven dried at 60 °C for 72 h to remove excess moisture and then grounded.
- Ground mahua seed is mixed with solvent (1:10 ratio) & allowed to react for 10 min at 37 °C.
- Heterogenous solvents prepared as a mixture of diethyl ether $(C_2H_5)_2O$ and ethanol (C_2H_5OH) in 3:1 ratio are used.
- After reaction time the material is centrifuged at 3500 rpm for 20 min.

For the mowrah butter extraction, the mahua seeds are taken, the seeds are crushed into fine granules then subjected to solvent extraction and separation of lipid and seed case is

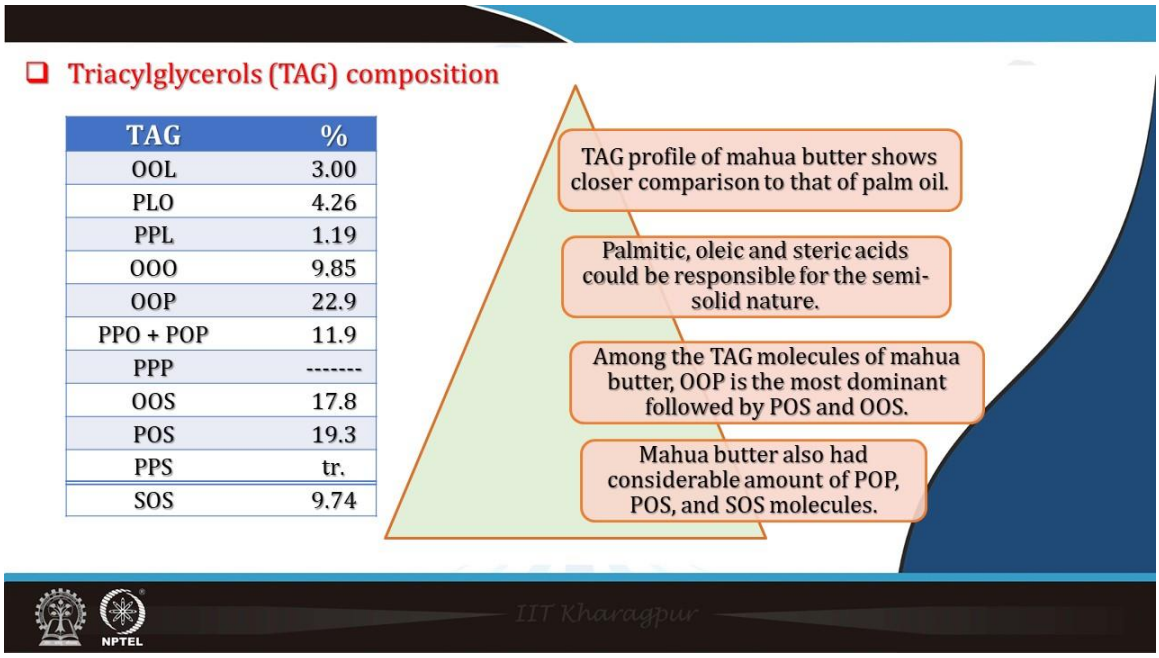
done and you get mahua bio-oil separation as shown in the figure. Mahua seeds are sun dried for a week and then kernel is separated. Kernels are oven dried at 60 °C for 72 h to remove excess moisture and then grounded. Ground mahua seed is mixed with solvent (1:10 ratio) & allowed to react for 10 min at 37 °C. Heterogeneous solvents prepared as a mixture of diethyl ether (C2H5)2O and ethanol (C2H5OH) in 3:1 ratio are used. After reaction time the material is centrifuged at 3500 rpm for 20 min.



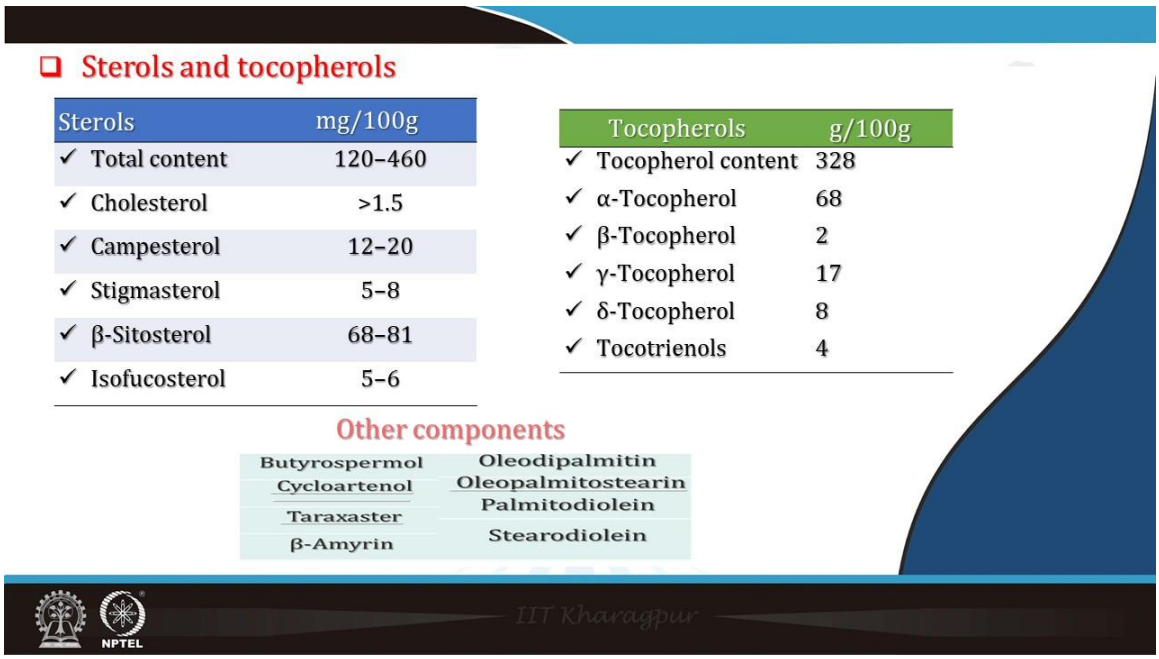
In ultrasound assisted extraction of mahua butter has been also proved beneficial. Seed to solvent ratio used is 1:10, the extraction time is 20 minutes at 50 kilohertz frequency and they are finally, and centrifuged at 3500 rpm for 20 minutes. And after this the removal of excess solvent is done that is the sample is centrifuged. The centrifuged sample consists of two main layer, an upper layer liquid layer that consists of solvent and oil and lower layer is that of the solid cake. So, pretreatment of liquid layer with 38% HCL PURE or KCL is added at a constant dilution ratio of 1:5. Then finally, oil is carefully separated using a separating funnel and stored in appropriate containers.



The composition of fatty acids of mahua oil is around 23 percent palmitic acid, 34 percent oleic acid, 14 percent linolenic acid and 23 percent stearic acid and some small amount of caprylic, capric, lauric and alpha linolenic acid. You can see from the data here that palmitic, stearic, oleic and linolenic acid are the main fatty acids of the mahua oil. They are rich in the saturated fatty acid like 39 to 52 percent that mahua saturated fatty acids contain ranges from 32 to 48 percent of MUFA and low PUFA, that is the polyunsaturated fatty acid such as linolenic acid are comparatively lower around 9 to 15 percent. You can see here that is in the about 24 percent is the palmitic acid, about 22 percent stearic acid, around 14 percent is linoleic acid, 37 percent is oleic, and 14 percent is linolenic acid. Arachidic is very at about 1.49 percent. Here also in the bar diagram, a comparison between the total poly total pufa, total monomers, total saturated fats such as C 18:2, C 18:1, C 18:0 and C 16:0 of major oil like mahua butter, shea fat, cocoa butter, palm oil, sunflower oil and soya bean oil is given. You can see the sunflower oil total pufa is maximum, but in other cases that mahua butter almost meets the cocoa butter and they are close by in the values.

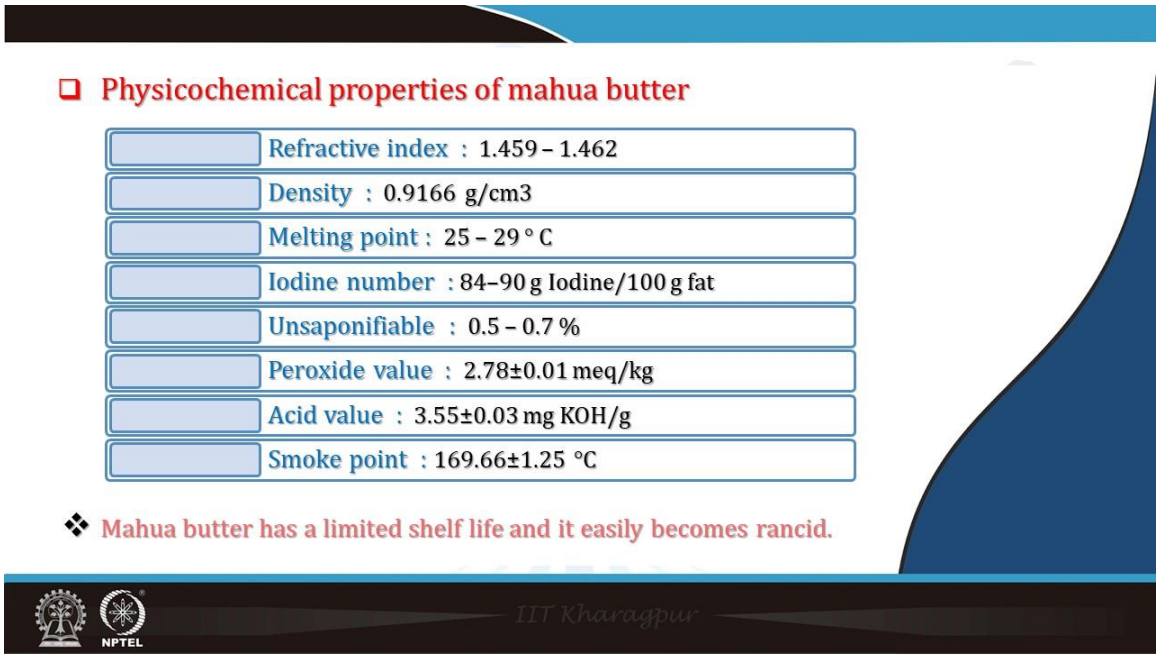


TAG composition in the it is given that is PPO plus POP 11.9 and PPL 1.19, OOO that is trioline you can say 9.85. TAG profile of mahua butter shows closer comparison to that of palm oil. Palmitic, oleic and steric acids could be responsible for the semi-solid nature. Among the TAG molecules of mahua butter, OOP is the most dominant followed by POS and OOS. Mahua butter also had considerable amount of POP, POS, and SOS molecules.

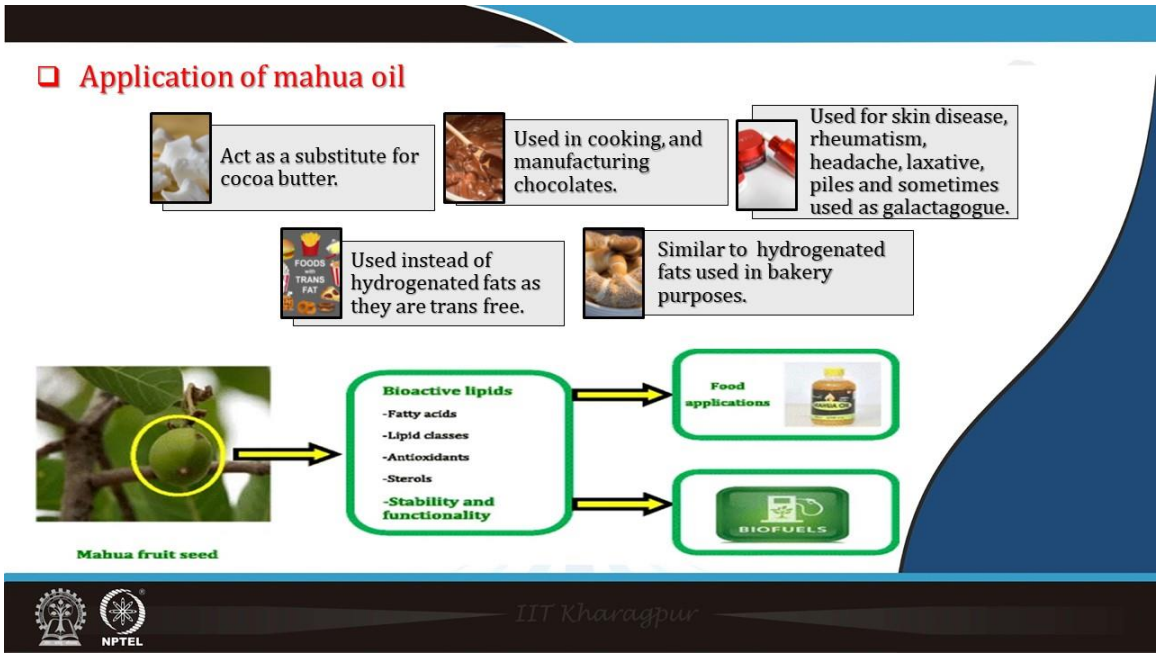


In sterols and tocopherols, total content of the sterols is around 120 to 460 milligram per 100 gram. It contains beta-Sitosterol 68 to 81 milligram per 100 gram, campesterol 12 to 20 milligram per 100 gram and also significant amount of stigma sterols and

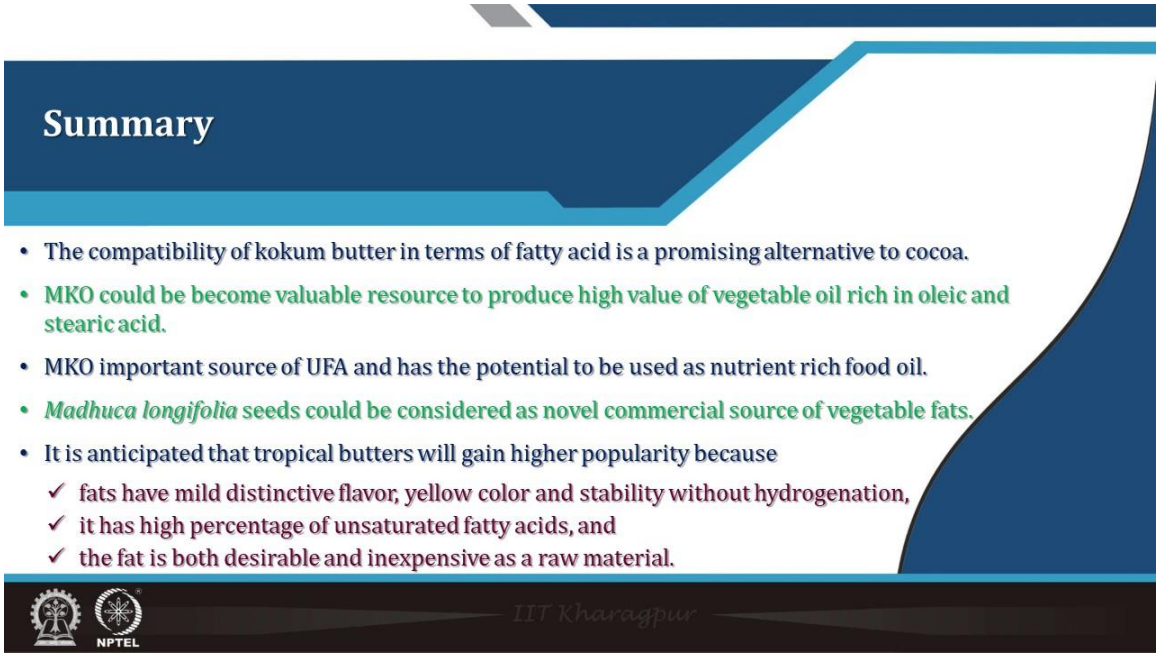
isofucosterols. Tocopherols content is 328 gram per 100 gram where alpha tocopherol is maximum 68 and followed by gamma tocopherol 17 and trocotrienol is 4, less quantity. Other components which are present in mahua oil include butyrospermol, oleodipalmitin and cycloartenol, taraxaster, beta Amyrin, oleodipalmitin, palmitodolein and so on.



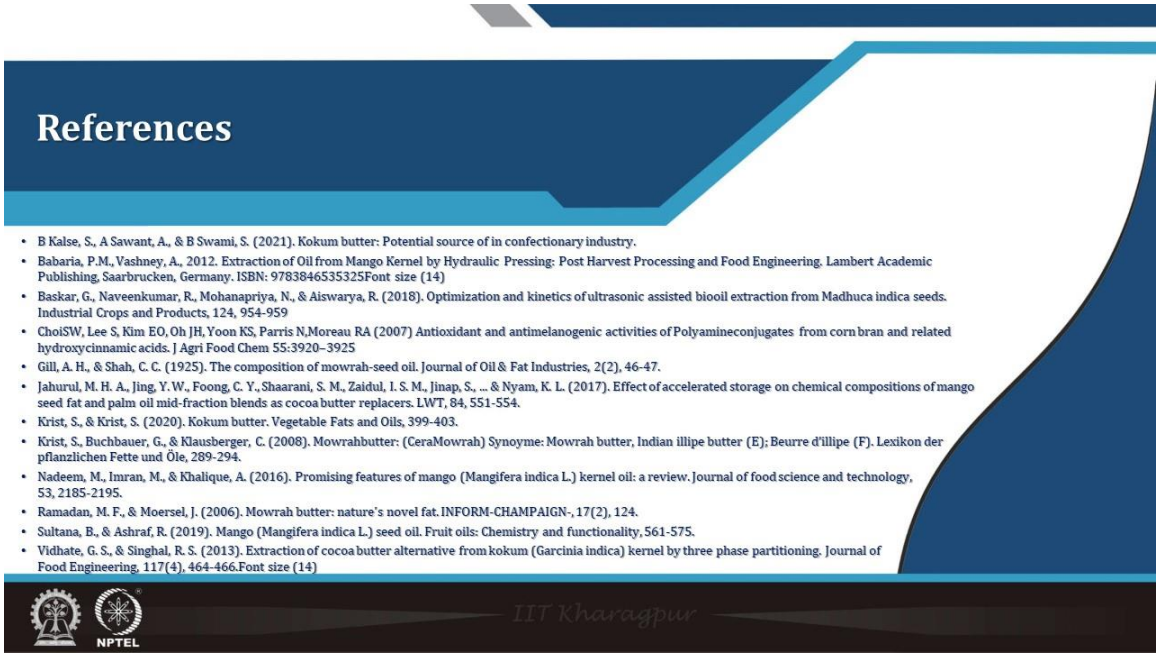
Physico-chemical properties of the mahua butter are as follows. Its refractive index is in the range of 1.459 to 1.462, density 0.9166 gram per cubic centimeter, melting point 25 to 29 degree Celsius, its iodine value is 84 to 90 g iodine per 100g fat, it peroxide value 2.78 meq per kg, acid value 3.55 mg KOH per kg and its smoke point is 169.66 degrees Celsius, that is it can be heated up to 169 degrees Celsius. It can be used for cooking operations up to this temperature. So, mahua butter has a limited shelf life and it easily becomes rancid. So, it need to be kept under proper conditions.



Applications of mahua oil are that it can be used as a substitute for cocoa butter, it is used for cooking and all manufacturing of chocolates, it can be used for skin diseases, and remedy for several other health issuea. It is used instead of hydrogenated fat as they are trans free, they are similar to hydrogenated fats and they are used with the bakery purposes. So, they have various these mahua fat series, they have very good bioactive lipids and their stability and functionality are good. So, they are used in food applications and of course, for the stability and functionality also they are sometimes used for bio fuel generation.



Finally, I will summarize this lecture by saying that the compatibility of kokum butter in terms of fatty acid is a promising alternative to cocoa. MKO could be become valuable resource to produce high value of vegetable oil rich in oleic and stearic acid. MKO important source of UFA and has the potential to be used as nutrient rich food oil.Madhuca longifolia seeds could be considered as novel commercial source of vegetable fats. It is anticipated that tropical butters will gain higher popularity because fats have mild distinctive flavor, yellow color and stability without hydrogenation, it has high percentage of unsaturated fatty acids, and the fat is both desirable and inexpensive as a raw material. So, this gives that a positive strength through this oil, but of course, this mahua oil etcetera is underutilized, but it has a great potential to be used as a food source and cocoa butter.



These are the references that were used in this lecture. With this thank you very much for your patience here. Thank you.