Food Oils and Fats: Chemistry & Technology
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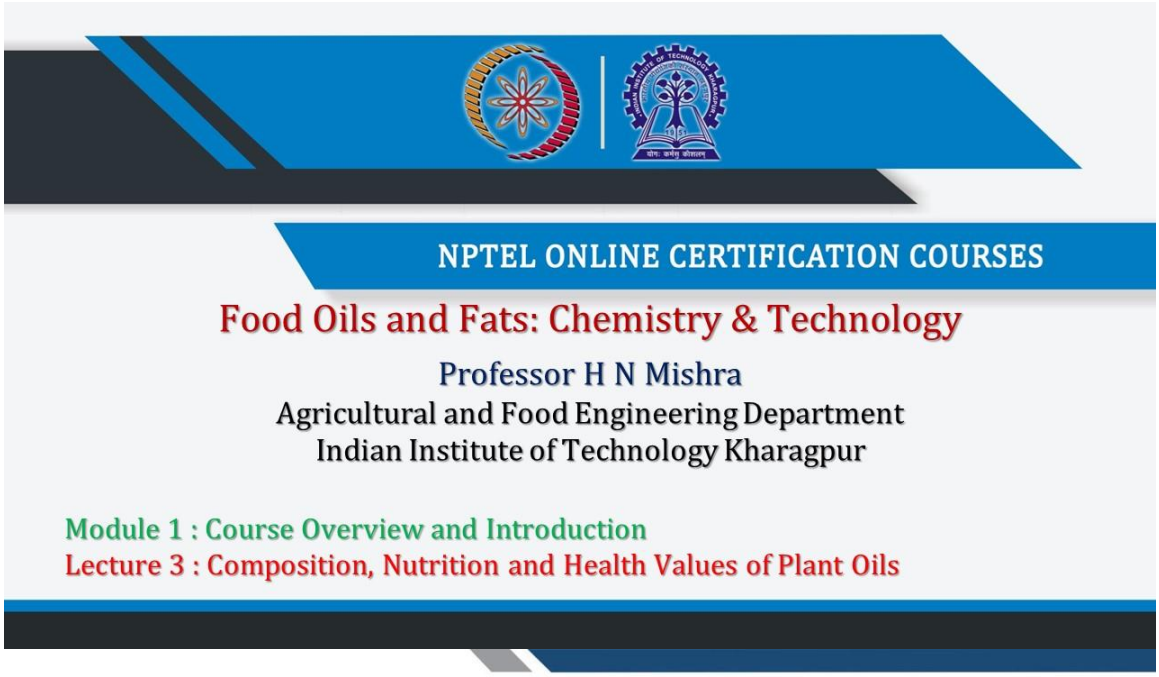
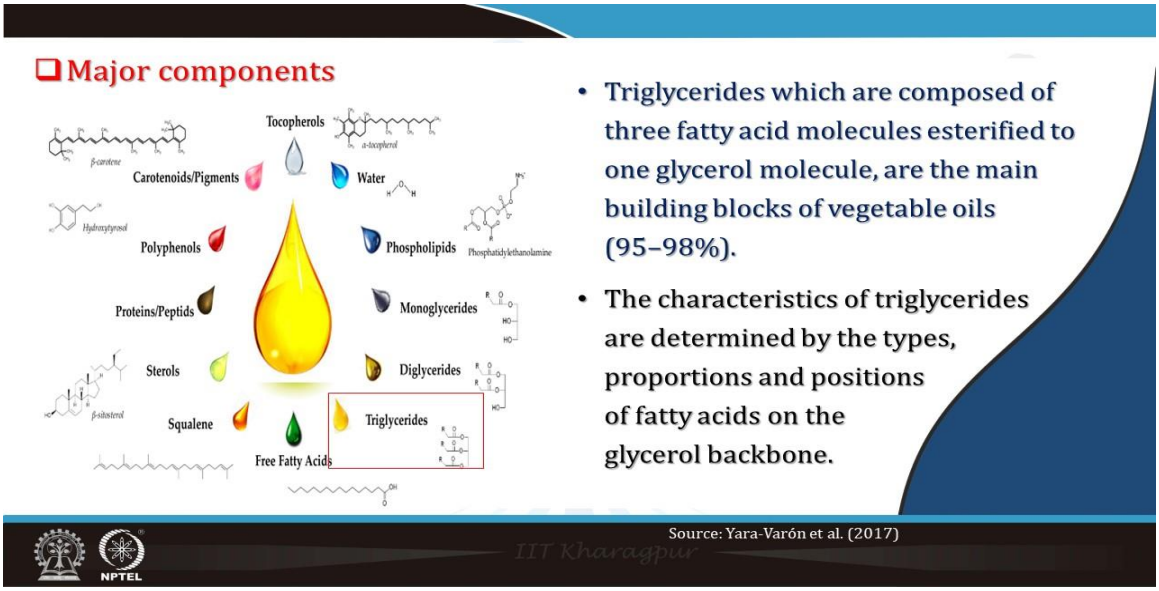
Week 1: Course Overview and Introduction
Lecture 3: Composition, Nutrition, and Health Values of Plant Oils



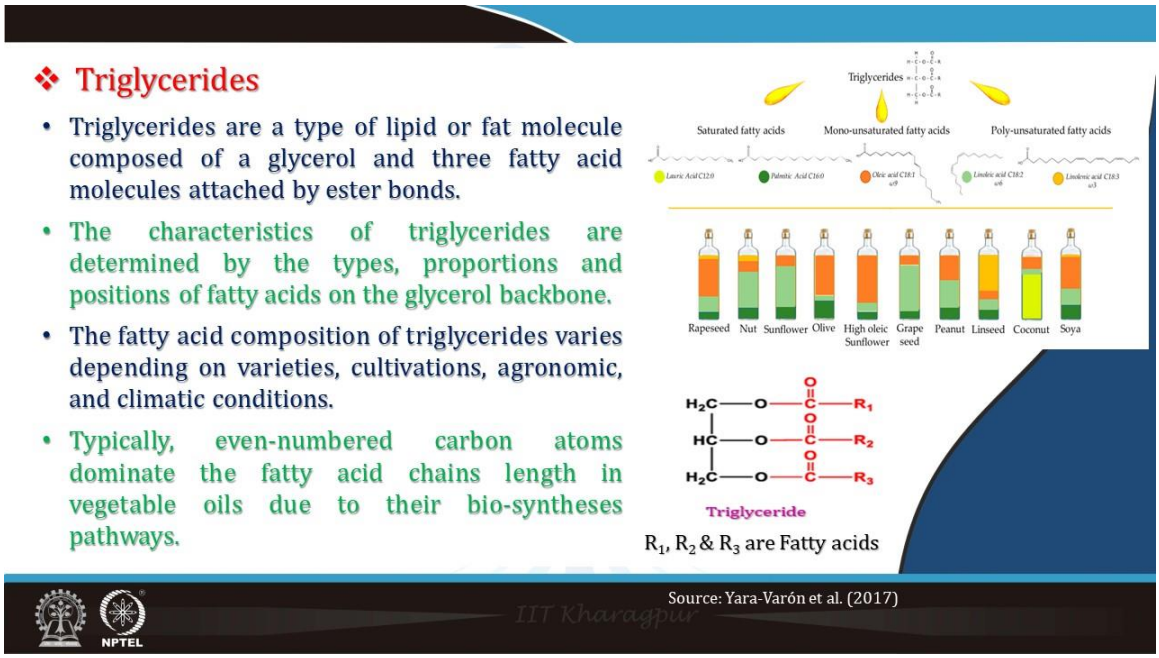
Hello everybody. Namaskar. Welcome to this third lecture of module 1 of this NPTEL course on Food Oils and Fats: Chemistry and Technology. In this lecture today, we will discuss about composition, nutrition, and health value of plants and oils. The concepts

which are covered in today's lecture include the composition of vegetable oils, what are the major components and minor components present in various vegetable oils, fatty acid profiles of vegetable oils, total phenolic and flavonoid content, and finally, we will also take up a summary of the nutritional and health benefits of plant oils.

So let us see the composition of vegetable oils. You know that vegetable oils play an important role in our diet. They are consumed directly in refined or virgin forms or via many food products. Vegetable oils are usually produced from plant seeds, nuts, or fruits like for example, rapeseed, sunflower, olives, etc. are used for extraction of oils and these oils are extracted from these sources either simply by pressing or by solvent extraction, or sometimes by both processes. They are considered non-polar and lipophilic systems whose composition is highly variable and complex depending upon their origin, quality, and producing methods. That is what is the source of these plant oils and fats, how they are extracted by which method towards the end of this lecture I will also give you some overview that how the various methods of extraction influence the composition of oils and fats, particularly the fatty acid profile or other minor components.



The components in vegetable oils and fats as I told you there is triglycerides which are composed of three fatty acid molecules esterified to one glycerol molecule. They are the main component, main building blocks of vegetable oils. These triglycerides constitute up to 95 to 98 percent. The characteristics of triglycerides are determined by the type, proportions, and positions of the fatty acid in the glycerol backbone. The details of the chemistry of these triglycerides and how the various fatty acids that as saturated fatty acids, long chain fatty acids, short chain fatty acids, etc., influence the characteristics we will take up again in the separate other classes. Today our concern is just to tell you what the various components present in oils and fats, particularly vegetable oils.



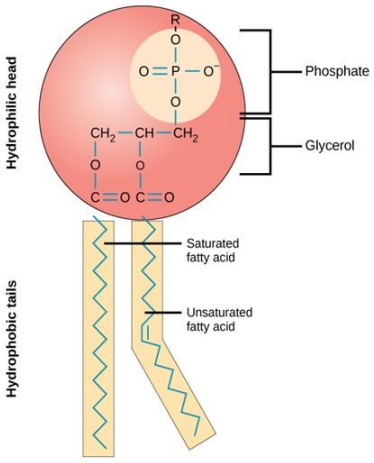
So you can see here triglycerides that is they are a type of lipid or fat molecules which are composed of as I told you a glycerol and three fatty acids molecules attached by ester linkage that is you can see here that is here is the glycerol which has three alcoholic group. So each alcoholic group and this fatty acid has a COOH carboxylic group. So from the alcoholic group OH and H from these two groups, they combine one molecule of water is released and a monoglyceride is formed. Similarly, when three fatty acids are joined with the glycerol molecule with three ester linkage that is called a triglyceride and these glycerides that is the triglycerides whether they are liquid, solid, etc., which depend upon their melting characteristics other properties will entirely depend upon the type of these fatty acids that are attached to them. That is where the proportion, positions, fatty acid chain length etcetera are.

The fatty acid composition of triglycerides varies depending upon the varieties, cultivation methods agronomical practices, and climatic conditions. Typically, even number of carbon atoms dominate the fatty acid chains and the fatty acid chain length in vegetable oil due to their biosynthetic part. That is every plant material has its physiological process and this governs that normally it has been seen that most of the fatty acids that are present in triglyceride, monoglyceride, or diglyceride contain an even number of carbon atoms.

Here in this figure, I have just shown you that what are the differences see that lauric acid is a saturated fatty acid, palmitic acid another saturated fatty acid which is C 18, palmitic acid is C 16, lauric acid is C 12, oleic acid is C 18 with one unsaturated bond then linoleic acid and linolenic acids are that saturated, polyunsaturated fatty acids with two and three double bonds respectively. So, in this figure rapeseed oil you can see here that it has more amount of oleic acid that is it has monounsaturated fatty acids. Nuts have more amounts of linoleic acids that is the two double-bond saturated fatty acid. Coconut oil you can see here has more amount of lauric acid than saturated fatty acids and that is why this coconut oil is solid at room temperature. It has been shown that grapeseed oil contains more amount of linoleic acid and so on.

Then apart from this major component the oils and fats are extracted depending upon the nature of the extraction how they are extracted method pressing solvent extraction etcetera. Other components are present in the plant materials they also get extracted along with the triglycerides. So, these are called minor components. So, the minor components maybe will be less than 5 percent they can be glycerolipids such as mono and diglycerides or phospholipids Even during the extraction process during the pressing process these various conditions may also hydrolyze the triglycerides. So, in the oil, there may be more amount of little less or more amount of free fatty acids and the generation of free fatty acids also causes the generation of formation of diglycerides monoglycerides etcetera.

❖ Phospholipids



- Phospholipids are considered polar lipids present in plant cell membranes, which co-extract with neutral triglycerides during squeezing or solvent extractions of both seeds and waste virgin oils using hexane.
- Most phospholipids are removed in the degumming step of the oil refining process in order to avoid foaming or browning during technological processing operations for edible oil uses.
- Phospholipids consist of a glycerol backbone, two fatty acids and one polar phosphate group associated itself with an amino alcohol (choline, ethanolamine, serine) or a sugar (inositol).

Composition of phospholipids in selected crude oil samples

Samples	Composition of phospholipids (%)			
	PC	PE	PI	PA
Soybean oil 1	29.7 ± 0.5	27.5 ± 1.3	9.3 ± 1.0	4.4 ± 0.2
Soybean oil 2	33.1 ± 1.2	22.3 ± 0.4	10.9 ± 0.5	5.5 ± 0.6
Soybean oil 3	37.4 ± 0.7	17.8 ± 0.2	12.6 ± 0.8	3.8 ± 0.6
Rapeseed oil	30.0 ± 0.7	20.8 ± 0.8	12.5 ± 0.4	7.2 ± 0.5
Rapeseed oil	40.3 ± 0.2	14.9 ± 0.6	15.6 ± 0.4	1.5 ± 0.3
Rapeseed oil	23.3 ± 0.3	20.5 ± 0.9	16.8 ± 1.1	12.4 ± 0.9
Rice bran oil	27.9 ± 0.9	22.7 ± 1.1	13.8 ± 0.7	6.9 ± 0.5
Camellia oil	28.6 ± 1.1	17.1 ± 0.5	11.3 ± 0.3	14.6 ± 0.8

PC: Phosphatidylcholine PE: Phosphatidylethanolamine
PI: Phosphatidylinositol PA: Phosphatidicacid

Source: Jiang et al. (2015)

Other phospholipids are also present these are the monoglycerides diglycerides and phospholipids glycerolipids and the glycerolipids that might be present in the oil in traces amount may be sterol, tocopherol, tocotrienol, free fatty acids, vitamins, pigments, proteins, phenolic compounds and so on. So, the mono and diglycerides as I told you in the triglycerides you have seen are when all the three alcoholic linkages are esterified with the fatty acids. So, similarly, when only one alcoholic linkage is esterified with one fatty acid you can see R 1 in this picture then it becomes monoglyceride. When two fatty acids, R 1 and R 2 you can see here when they are present in the glycerol backbone they become diglycerides. So, both monoglycerides and diglycerides are naturally present in

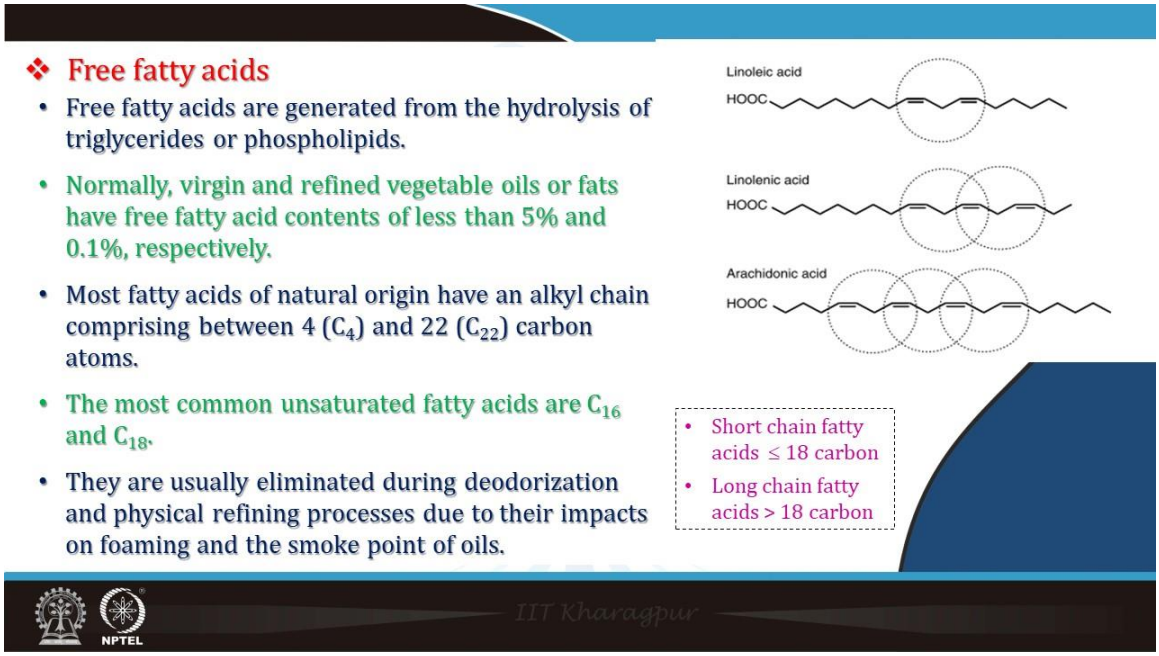
virgin oils due to the action of indigenous lipase in fruits or oil seeds as well as during the extraction that is the process parameters they may also influence as I told you earlier.

The enzymatic hydrolysis leads to the formation of both partial glycerides and free fatty acids in which partial glycerides account for 1 to 6 weight percent depending on the oil type. For example, the concentration of glycerides ranges from 1 to 2.8 percent in virgin olive oil and monoglycerides are present as much as lower as lower as less than 0.25 percent. Now, let us see what phospholipids are triglycerides you have seen in the last slides that there are three molecules of fatty acid present. Now, here in the phospholipids, they are also very very important components present in the oil and they get extracted from the seeds or other material however most of these poly phospholipids are removed during the degumming step they are also known as gums.

So, in the oil refining process the phospholipids are removed, and some phospholipids like lecithin, etc., are then further refined and characterized for further use in food processing. They are used in food processing as an emulsifier they are a very important commercial product and they are byproducts of oil refining plants. So, the phospholipids are considered polar lipids present in the plant cell membranes which coextract with neutral triglycerides during squeezing or solvent extraction of both seeds and waste virgin oils. So, they consist of a glycerol backbone like triglyceride, but the only difference between triglyceride and phospholipids is that which of course causes this difference causes the major difference in their properties these here there are two fatty acids, and the third one is attached with a phosphoric acid molecule and which in turn attached with various other components like amino alcohol side chains i.e. choline, ethanolamine, serine, or a sugar molecule inositol, and accordingly these phospholipids may be named as phosphatidylcholine, phosphatidyl ethanolamine, phosphatidyl serine, or phosphatidyl inositol. So, these phospholipids have one hydrophobic tail As you can see here these are the fatty acids that may be saturated and unsaturated fatty acids and they have a hydrophilic head hydrophilic head has the glycerol backbone and then phosphoric acid attached. , which is why that is they have both hydrophobic as well as hydrophilic components These phospholipids that is they have emulsifying actions that is they when they are in between which are the polar and nonpolar groups. So, they keep together that is they create or form a sort of bridge between these compounds and keep them together and it is the phospholipids you can say lecithin which help make the milk fat remain intact in the water component in the serum that is milk the fat is present in the form of that oil in water emulsion and that emulsifier is the lecithin. So, here you see the composition of different phospholipids in selected crude oils and there are three types of soyabean oil, three types of rapeseed oil, rice bran oil, and camellia oil.

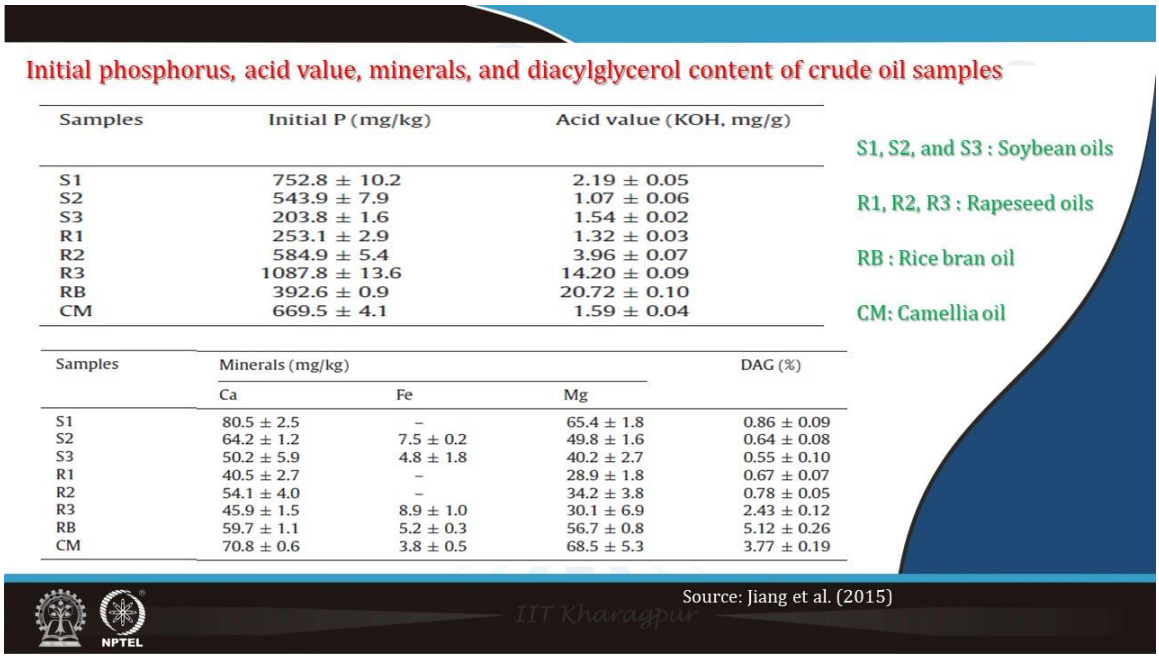
So, in this, you can see there is that phosphatidylcholine, phosphatidyl-ethanolamine, phosphatidyl-inositol, and phosphatidic acid are content. So, if you see the rice bran oil

contains about twenty-seven to twenty-eight percent phosphatidylcholine, twenty-three percent phosphatidyl-ethanolamine, about thirteen point eight percent phosphatidyl-inositol and it has comparatively less amount of phosphatidic acid. So, you see that even the phosphatidic acid they are comparatively less in almost all the oils except for that in the camellia oil which contains around fourteen point six percent of the total phospholipids present, but at the same time, you see the soybean has the maximum amount of phosphatidylcholine, phosphatidyl-ethanolamine and even also it has a good amount of phosphatidyl-inositol. So, you see in all these oils at least the major phospholipids present is phosphatidylcholine.



Now, the other thing in the free fatty acids is the chemistry of free fatty acids again we will be taking it up separately in the next module, but here I have told you that in the glycerol these fatty acids are attached. So, I have told you that either by the hydrolysis or by the enzymatic action or by some other factors when these triglycerides come in contact with these various conditions during extraction, during storage, during processing etcetera then these ester linkages get broken and the free fatty acids are released from the triglycerides. So, in the oil finally, you get a mixture of triglyceride, monoglyceride, diglyceride, and free fatty acid depending upon the extent of hydrolysis or enzymatic action. Normally virgin and refined vegetable oils or fats have free fatty acid content of less than 5 percent and 0.1 percent respectively and that is why the free fatty acid content is regulated as per the law. If you have more amount of free fatty acid content in the oil in the triglyceride then its properties and characteristics get changed even 1 percent free fatty acid in vegetable oil seriously reduces the smoke point that it is a frying characteristic, cooking characteristic etcetera These aspects we will take up in the other

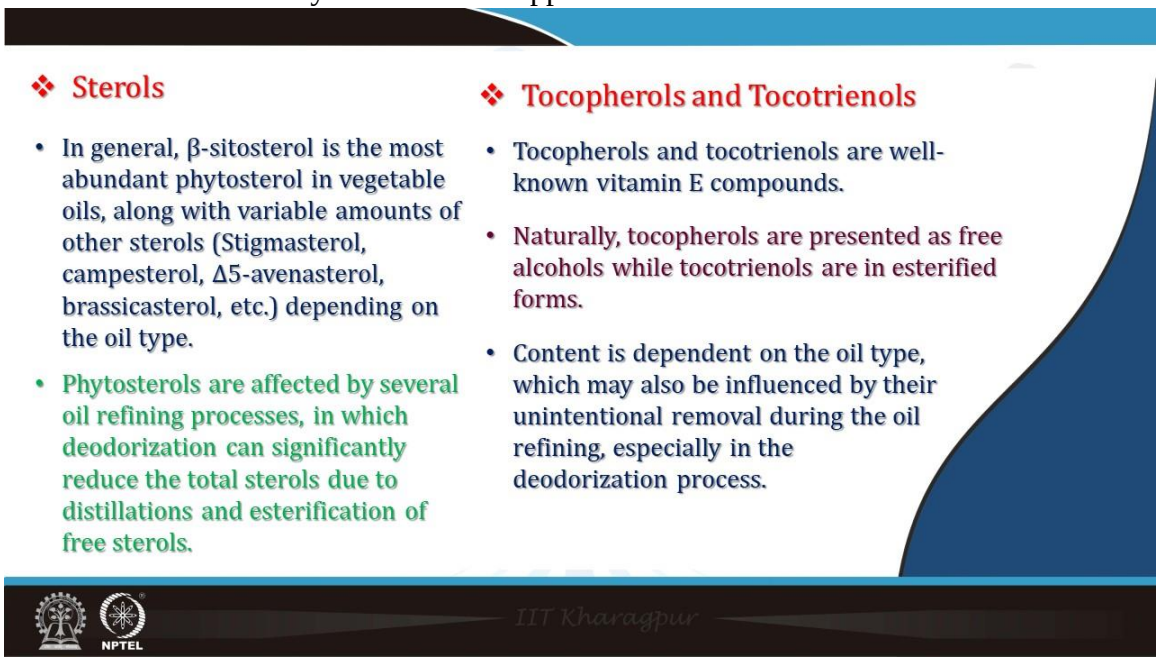
classes. Most fatty acids of natural origin have an alkyl chain comprising between C4 and 22 carbon atoms. The most common unsaturated fatty acids are C16 and C18. They are usually eliminated during deodorization and physical refining processes due to their impact on foaming and the smoke point of the oils.

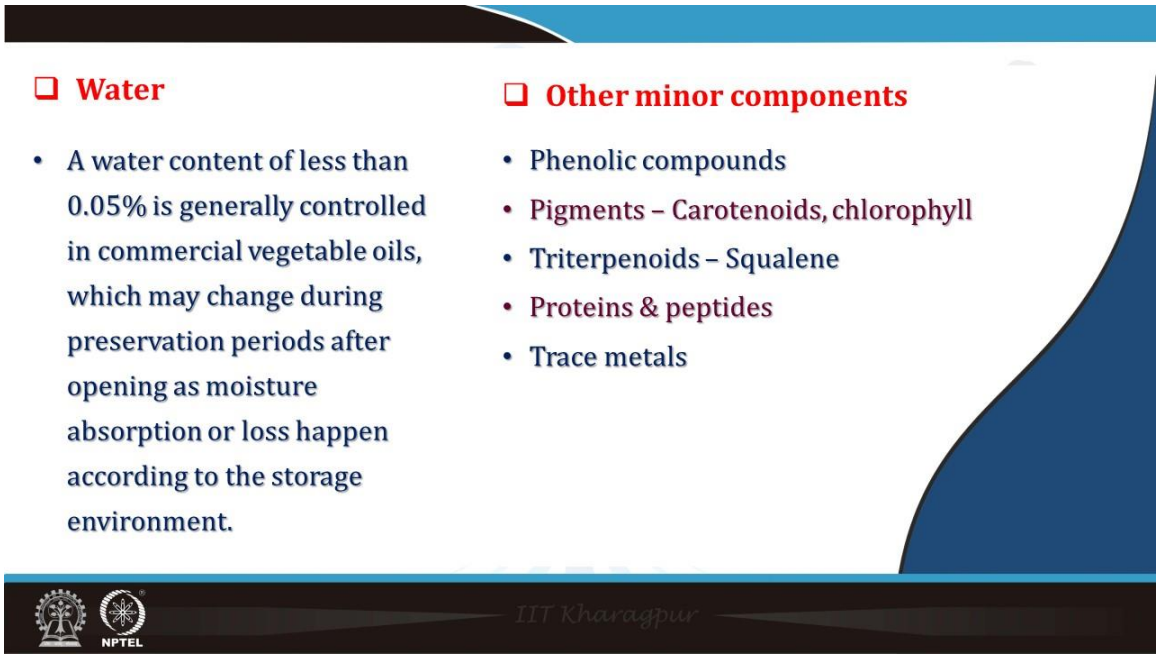


In this table, I have again tried to give you the content of the minor compounds like phosphorous, acid value, minerals, diacylglycerols etcetera in various crude oils. Again the crude oil samples are 3 soyabean oil samples, 3 rapeseed oil samples, rice bran oil, and camellia oil. So, you can see that the initial phosphorous content is much higher in rice than in rapeseed oil. So, soyabean oil also contains a significant amount of camellia oil, but in the rice bran oil that is initial phosphorous is comparatively less than the other oils that are presented here. So, here acid value you can see here acid value that is the koh milligram per gram, Rice bran oil has more acid value and then followed by your rapeseed oil. Similarly, the mineral content of calcium, ferrous, magnesium, etc., and diacylglycerol percentages are given in this table you can take. So, even these values speak about the characteristics of triglyceride and accordingly their usefulness in various operations and their health values.

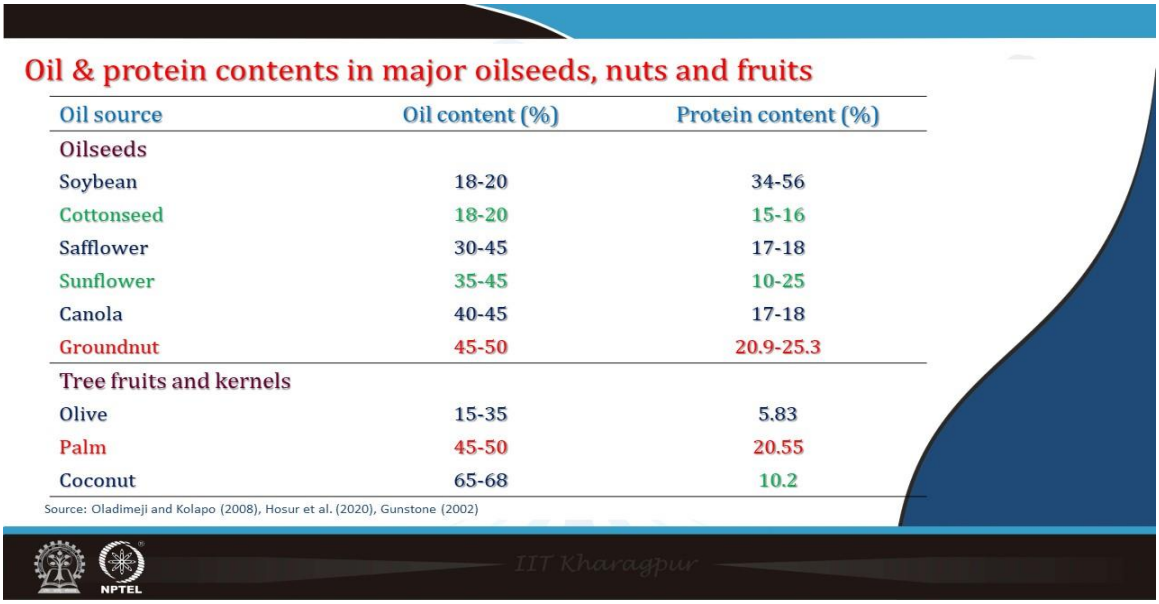
Another important minor component in vegetable oils is sterols that are beta-sitosterol is the most abundant phytosterol in vegetable oils along with a variable amount of other sterols like campesterol, avenasterols, brassicasterol etcetera depending upon the oil type. Phytosterols are affected by several oil refining processes in which deodorization can significantly reduce the total sterols due to the distillations and esterification of the sterols. It is well known you must be knowing that Tocopherols and trocotrienols which

are the other types of plant sterols are well known for their vitamin E or anti-oxygen property or vitamin properties. Naturally, tocopherols are present as free alcohols while tocotrienols are esterified the content of these tocotrienols or trocopherols depends upon the oil type which may also be influenced by their unintentional removal during the oil refining especially in the deodorization processes. And it is the antioxidant properties of these tocopherols and tocotrienols which help keep the vegetable oils for comparatively a longer period. Of course, while doing this they are performing their antioxidant action, and their vitamin activity is somewhat suppressed.

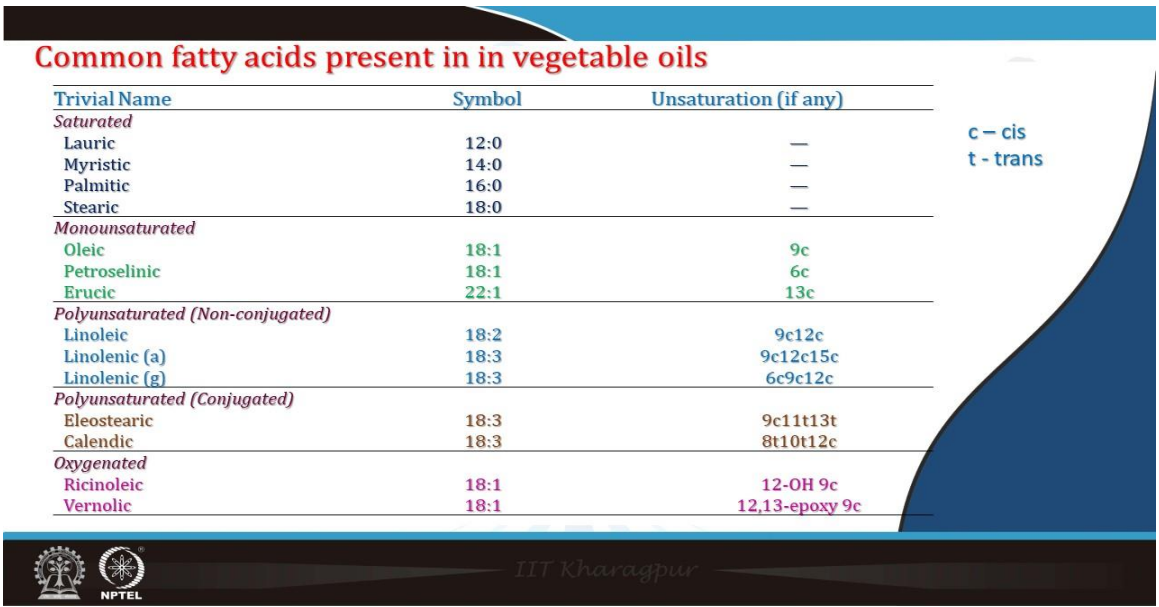




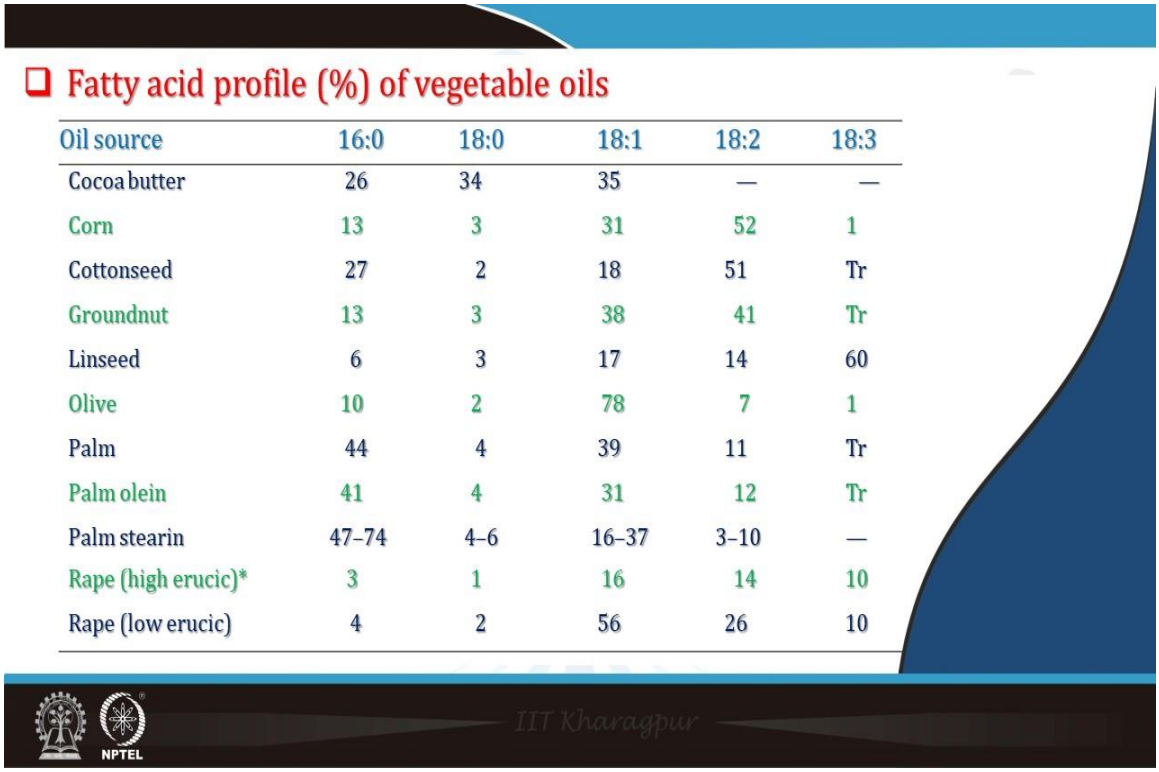
Then water, there is a water content of less than 0.05 percent is generally controlled in commercial vegetable oil because if there is an oil it will create problems, and the stability may result in hydrolysis etcetera. So its content is carefully controlled. Then other minor components are phenolic compounds, pigments like carotenoids, chlorophylls etcetera which may get extracted during the extraction process. Then triterpenoids are like squalenes, protein peptides, or even some trace metals that may also get extracted along with the triglycerides.



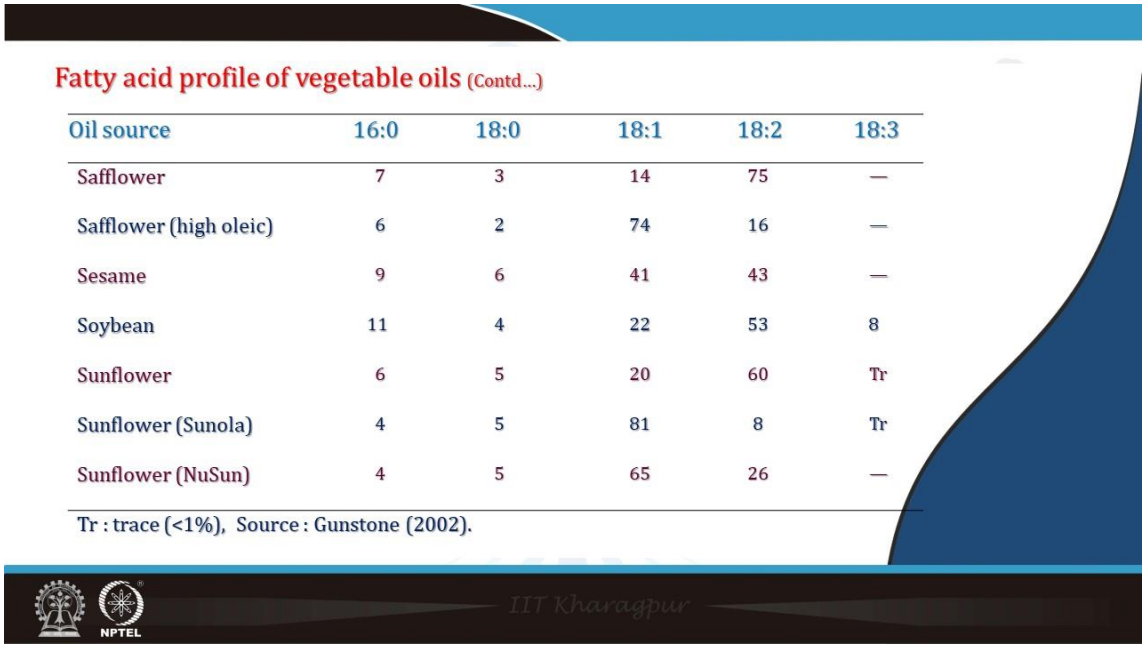
So here in this slide, I have tried to give you the oil and protein contents of the major oil seeds. You can see here ground nut oil and palm oil if you see that palm kernel and ground nut kernels are almost the same both contain around 45 to 50 percent oil content and around 21 percent protein content. The other oil seed which has high oil content and also significantly high protein content is the canola. Canola has again 40 to 45 percent oil about 17 to 18 percent protein. Coconut has around 65 to 68 percent oil and also about 10 percent protein. The protein quantity of the coconut is almost equal to the wheat flour. So it is again a very important valuable source of both oils and proteins. Sunflower oil again you see here has around 30 to 45 percent oil and 17 to 18 percent protein.



So here the common fatty acids that are present in vegetable oils that are they are saturated fatty acids lauric, myristic, palmitic, and stearic and their symbol is the normal 4, 12, 14, 16, 18, 0 means that is there is no unsaturation they are all saturated fatty acids and here 12, 14 this indicate the number of the carbon atoms. So you can see here there is no unsaturation. Then monounsaturated fatty acids include oleic, pesto-selenic, and erucic they are 18:1, 18:1, and 22:1. So they are 18 carbon-containing and 22 carbon-containing, but one unsaturated linkage at the position of the unsaturated bond is that 9, 6 and 13 respectively and CE means cis forms they are the cis position means that is both the there is an OH group are in the same side. Then polyunsaturated nonconjugated fatty acids present in vegetable oil commonly include linoleic acid, linolenic acid, and linolenic acid (g) which is 18:2, 18:3 18:3 and here that is the only difference between linolenic (a) and linolenic (g) is in the position of the saturated bond and also that is it contains 9, 12 and 15 and whereas, the linolenic (g) is the 6, 9 and 12, but they are all 3 unsaturated linkages 18:3. Then polyunsaturated conjugated fatty acids are allosteric and calendic both of them are 18:3 and here that is in addition to cis there is also a T linkage that is the transform that is 9c, 11t and 13t are 8t, 10t and 12c. So, at 12 position it is cis form and at 8 and 10th position it is the trans form in calendic acid. Oxygenated fatty acids include Ricinolic and vernolic that is 18:1, and 18:1 both of them, and here 12 OH, 9 C and 12, 13 epoxy, 9 C these are the unsaturation levels. So, this gives you a fairly good idea about how that cis position and trans position are there what are the saturation values and these are the commonly found vegetable that is the fatty acids present in the vegetable oil.



Here some data that is what is the percentage of the fatty acid that is the fatty acid profile of common vegetable oil that is 16:0, 18:0, 18:1, 18:2, and 18:3. If you look at the data that cocoa butter has about 26 percent 16:0 whereas, it has 34, 35 percent of 18:0 and 18:1 of course, almost negligible amount of 18:2 and 18:3. Similarly, you see that rapeseed although it has a high erucic content rapeseed then it has around 3 percent of that 16:0, 1 percent 18:0, but it has a higher amount of 18:1, 18:2, and 18:3. Even lower erucic rapeseed oil can has a significantly higher amount of 18:1, 18:2 and 18:3 like 18:1 is oleic then 18:2 is the linoleic and 18:3 is the linolenic acid. So, you see it has your groundnut oil again it has more amount about 38 percent 18:1 and 41 percent 18:2, but traces of the 18:3. So, this gives that is the yes that is the which are the oil and normally if they have more amount of polyunsaturated fatty acid obviously, they should be considered better.



So, here again, the same data for safflower oil, sunflower oil, and sesame oil and you can see that sunflower oil is all these they have oils they have high in monounsaturated and polyunsaturated fatty acids like 18:1 and 18:2.

Then here is the fatty acid profile of rice bran oil especially if you see it has a total of about 98.8 percent that is they are 98.8 grams per 100 grams of fatty acid triglycerides that is the fatty acids are proper. Then saturated fatty acids are about 20.5 percent in rice bran, monounsaturated fatty acids 41.9 and polyunsaturated fatty acids 36.4 percent.

❖ Fatty acid profile of rice bran oil

Fatty acid	g/100 g
C12:0 Lauric acid	0.2
C14:0 Myristic acid	0.4
C16:0 Palmitic acid	16.9
C16:1 Palmitoleic acid	0.2
C17:0 Heptadecanoic acid	-
C17:1 Heptadecenoic acid	-
C18:0 Stearic acid	2.3
C18:1 Oleic acid	41.4
C18:1 Vaccenic acid	0.1
C18:2 Linoleic acid	34.9
C18:3 Linolenic acid	1.5

Fatty acid	g/100 g
C20:0 Arachidic acid	0.4
C20:1 Eicosanoid acid	-
C22:0 Behenic acid	0.2
C22:1 Erucic acid	0.1
C24:0 Tetracosanoic acid	0.1
C24:1 Tetracosenoic acid	0.1
Total	**98.8**
Saturated	20.5
Monounsaturated	41.9
Polyunsaturated	36.4

Fatty acid profile of tree nut oils

Nut type/processing	C16:0	C18:0	C20:0	C16:1 ω7	C18:1 ω9	C20:1 ω9	C18:2 ω6	C18:3 ω3
Almond								
Pressed	6.52	1.51	0.09	0.03	65.34	0.09	24.33	0.15
Solvent extracted	6.00–6.45	1.47–2.10	–	0.40–0.43	65.70–67.62	–	24.03–24.80	trace
Roasted	6.3	1.9	–	0.5	66.50	–	24.00	trace
SFE	6.6–8.4	1.5–2.1	–	0.50–0.62	69.10–73.00	–	18.00–20.20	–
Brazil nut								
Pressed	14.24	11.19	–	–	36.26	–	37.53	0.08
Solvent extracted	12.63–14.71	9.79–11.63	–	0.29	29.76–38.36	–	36.84–45.17	0.074
Roasted	–	–	–	–	–	–	–	–
SFE	14.04–14.94	10.63–10.23	–	0.02	34.55–35.55	–	40.15–40.51	0.08–0.09
Cashew								
Pressed	–	–	–	–	–	–	–	–
Solvent extracted	10.31–11.14	9.08–9.83	0.68–0.74	0.34	56.87–60.57	0.19	17.03–22.22	0.21
Roasted	10.21	9.57	0.67	0.34	61.33	0.19	16.79	0.22
SFE	–	–	–	–	–	–	–	–
Hazelnut								
Pressed	5.1–6.33	2.47–2.83	0.10–0.20	0.04–0.2	76.42–82.6	0.02–0.2	8.5–11.83	0.2
Solvent extracted	5.02–5.78	1.89–2.36	0.12–0.18	0.16–0.19	79.57–79.64	0.15–0.16	11.78–12.72	0.08
Roasted	5.41–5.53	1.84–2.4	0.18	0.22	80.97–83.05	0.16	8.67–9.76	0.06–0.4
SFE	5.99–6.01	2.17–2.19	0.08	0.15–0.2	79.34–82.65	0.14	8.42–11.45	0.09
Macadamia								
Pressed	8.1	3.6	2.7	18.1	54.6	2.4	3.3	0.4
Solvent extracted	8.04–8.78	2.34–3.74	1.96–2.88	17.95–20.8	54.1–60.08	2.62–2.53	2.32–3.74	–
Roasted	–	–	–	–	–	–	–	–
SFE	–	–	–	14.37	50.68	1.65	1.16	–
Pecan								
Pressed	5.40–6.20	2.23–2.30	–	0.10	52.50–69.60	0.31	22.6–31.32	0.71

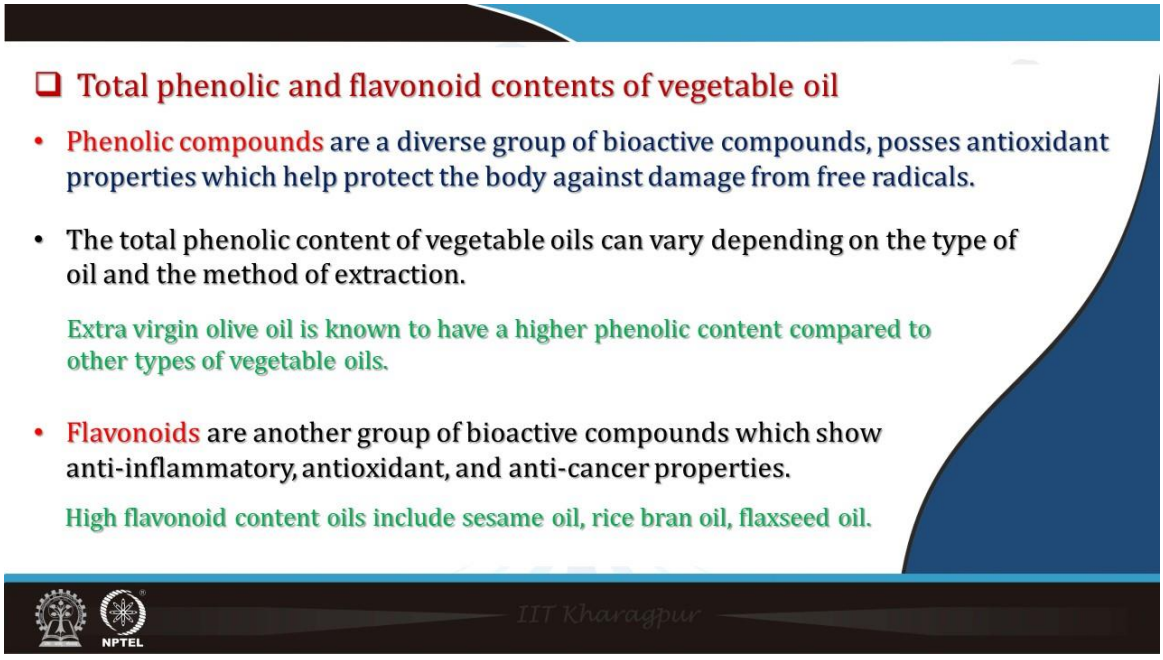
So, here again, that is the fatty acid profiles of various tree nut oils and tree nut oil here almond, brazil nut, cashew nut, hazelnut, macadamia and in this also some idea has been given that is the pressed oil, solvent extracted, roasted and supercritical fluid extracted oil. So, here it also shows that in this tree nut oils whether you are extracting the oil after roasting or before roasting whether it is a by the supercritical fluid extraction, solvent extraction, or by that also influences the amount of that the fatty acid present in them

particularly the omega fatty acids and polyunsaturated fatty acids you can see the content of 18:1 omega 9, 21 omega 9, 18:2 omega 6, 18:3 omega 3 etcetera they are content.

Similarly, others like pine nuts, walnuts etcetera this type, and this data says that even the processing method extraction method also significantly the amount of various fatty acids present or the fatty acid profile of the oils plant oils.

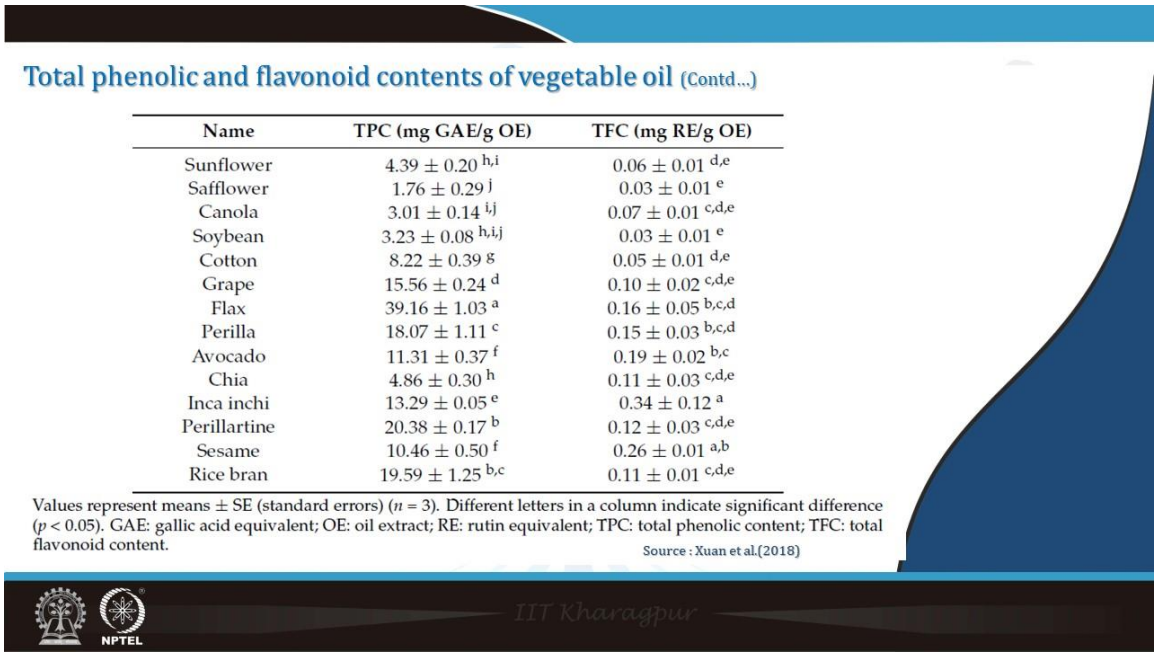
Fatty acid profile of tree nut oils (Contd...)

Nut type/processing	C16:0	C18:0	C20:0	C16:1 ω7	C18:1 ω9	C20:1 ω9	C18:2 ω6	C18:3 ω3
Solvent extracted	6.15	2.54	–	–	62.36	–	27.69	1.25
Roasted[g]	5.89	2.19	–	0.12	54.24	0.41	28.48	1.52
SFE	5.65	2.45	–	–	66.20	–	24.70	1.05
Pine nut[h]								
Pressed	4.81	2.77	0.37	0.14	24.7	1.16	46.01	19.23
Solvent extracted	4.08–5.22	2.36–2.78	0.41–0.42	0.08	24.82–27.67	1.32–1.38	45.02–46.41	19.28
Roasted	–	–	–	–	–	–	–	–
SFE	5.84	2.87	–	–	28.49	1.99	41.79	15.62
Pistachio[i]								
Pressed	13.12	2.78	0.17	2.04	50.65	0.32	29.76	0.59
Solvent extracted	9.17–11.79	1.23–1.5	–	1.07	55.11–56.75	–	28.56–29.45	0.33–0.37
Roasted	17.10	–	3.00	–	46.90	–	28.10	2.80
SFE	9.46	1.36	–	–	54.73	–	29.06	0.37
Walnut[j]								
Pressed	6.98–7.12	2.27–2.60	0.08	0.06	14.51–28.3	0.20	50.10–60.22	12.30–13.39
Solvent extracted	6.00–7.11	2.00–2.72	0.07	0.07	14.80–16.96	0.19	58.64–63.10	11.67–13.43
Roasted	4.70–6.20	2.10–3.10	trace	trace	14.60–15.40	–	62.70–70.00	7.2–13.00
SFE	6.26–8.5	2.13–3.02	0.10	0.07–0.10	15.91–23.5	0.19	50.6–56.46	13.16–13.7

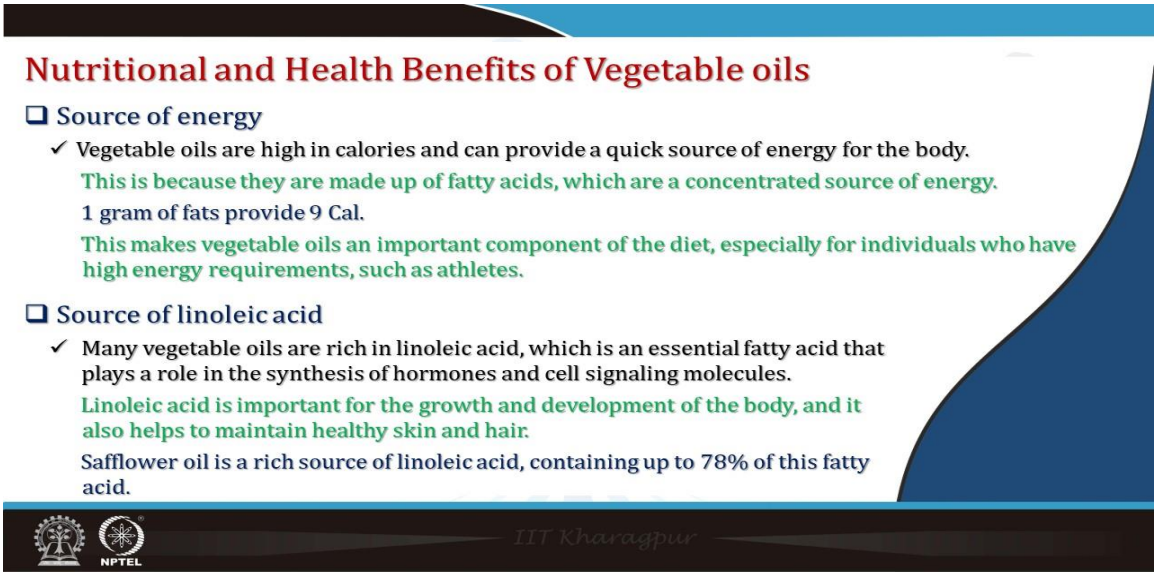


As far as the total phenolic and flavonoid contents of the vegetable oils are concerned, these phenolic compounds I hope you know are a diverse group of bioactive compounds. They possess antioxidant properties that help protect the body against damage from free

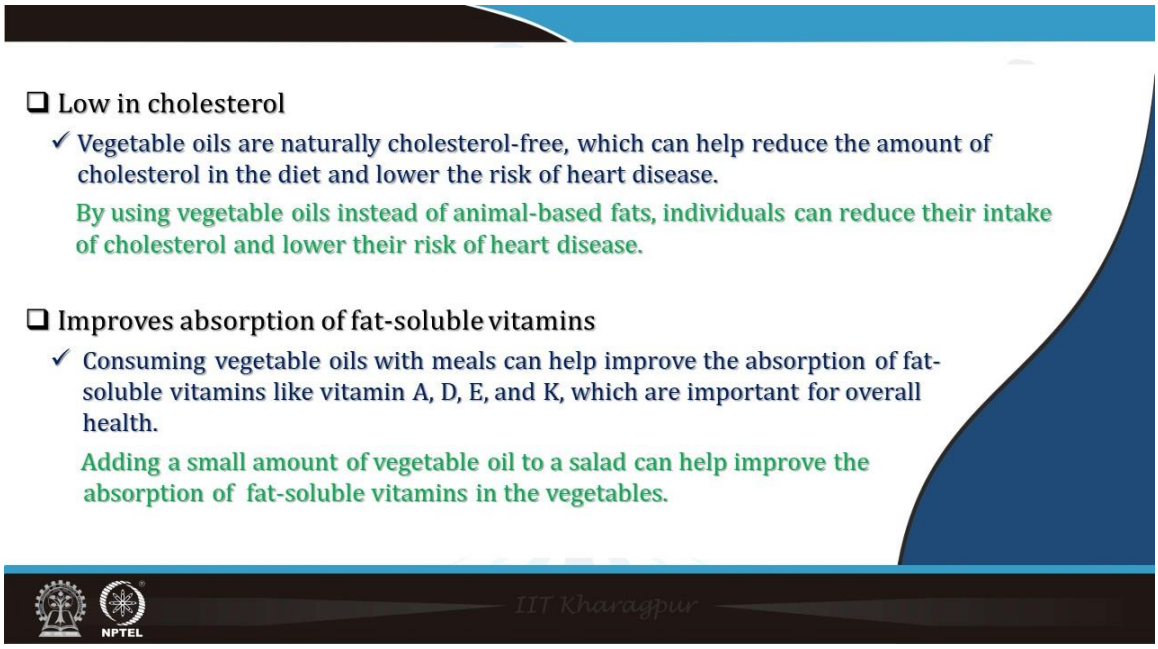
radicals. The total phenolic content of vegetable oils can vary depending on the type of oil and the method of extraction. Extra virgin olive oil is known to have a higher phenolic content compared to other types of vegetable oil. Flavonoids are another group of bioactive compounds that show anti-inflammatory, antioxidant, and anticancer properties. High-flavonoid content oils include sesame oil, rice bran oil, and flaxseed oil.



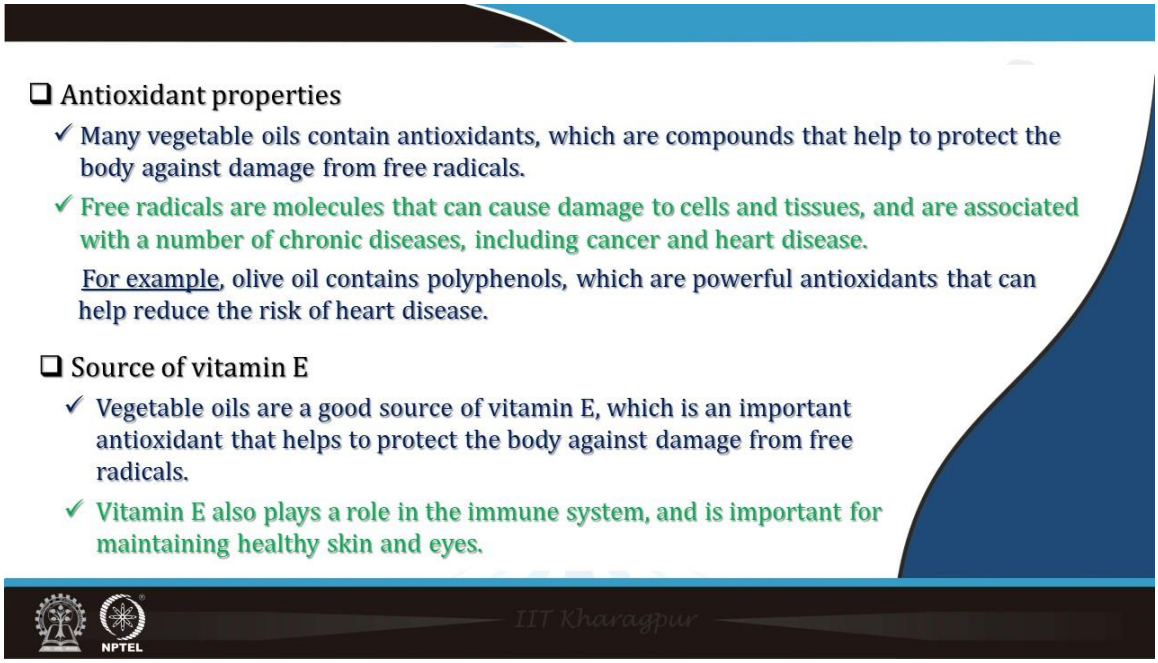
So, here in this slide, I have tried to give you the total phenolic and flavonoid content of the vegetable oils and you can see that the different oils that is they have that accordingly that is indicated the TPC value or TFC value that is which is a good indication of the antioxidant properties of this oil. So, the soybean oil you can see here particularly the sunflower and rice bran oil see that rice bran oil is having a TPC value of 19.59. Even perillartine oil has a TPC value of 20.38, a grape oil TPC value of 15.56. So, these oils are to be considered that they have a good amount of antioxidant potential.



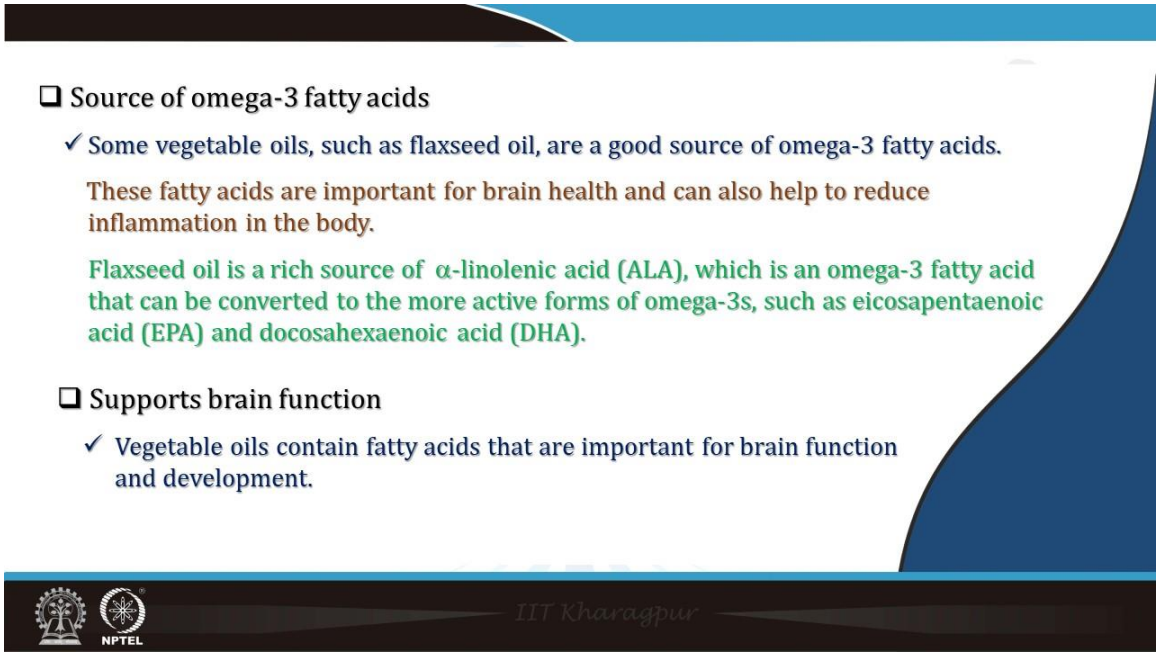
Now, let us discuss the nutritional and health benefits of vegetable oil and most of these points have been covered in the earlier lecture in general when we were talking about the health impact of these oils and fats. But here in this oil exclusively I will be covering the health benefits of plant-based oils that is yes they are a rich source of energy. That is one gram of fat or oil provides 9 kilo calorie heat energy upon complete oxidation and this makes vegetable oils an important component in the diet, especially for individuals who have high energy requirements like athletes etcetera. These vegetable oils and plant oils are considered good sources of linoleic acid. Linoleic acid is important for the growth and development of the body and it also helps to maintain healthy skin and hair. Safflower oil is a rich source of linoleic acid it contains around 78 percent of these fatty acids.



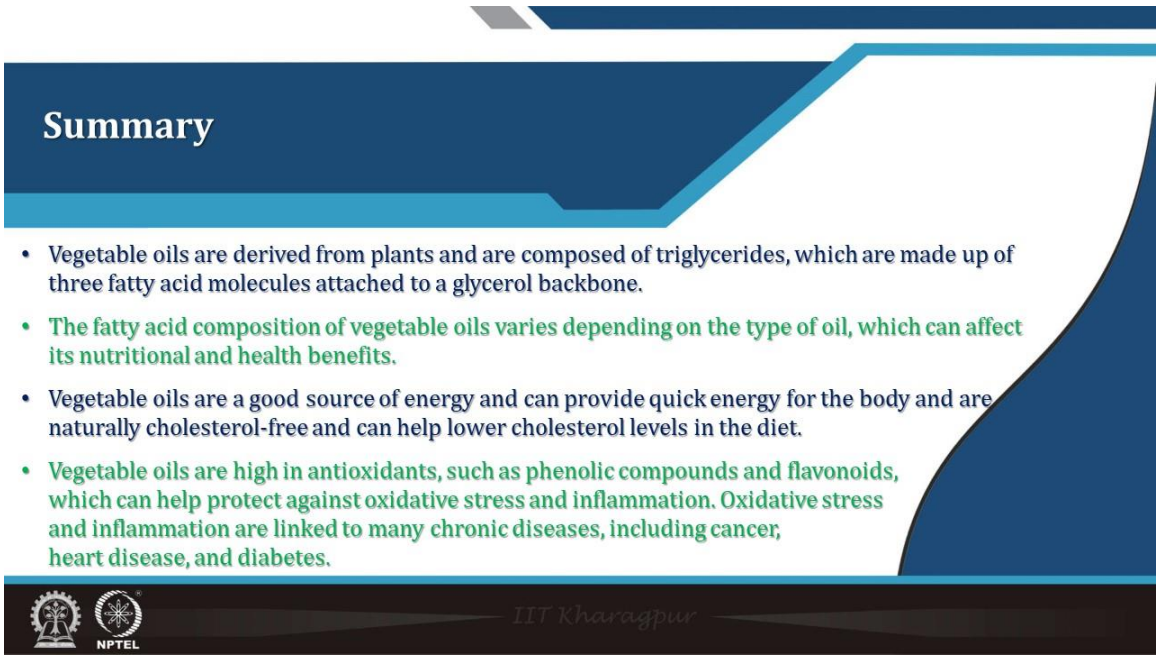
They are low in cholesterol and in fact, vegetable oils are naturally cholesterol-free. They have other sterols, but not the cholesterol. Cholesterol is found only in the oils and fats of animal sources. So, by using vegetable oils instead of animal-based fats individuals can reduce their intake of cholesterol, and they can lower the risk of heart disease or cardiovascular diseases etcetera which are the major problems of the high amount of cholesterol consumption. Also, the consumption of plant oils improves the absorption of fat-soluble vitamins. Consuming that is vitamins A D E and K which are important for overall health. Adding a small amount of vegetable oil to a salad can help improve the absorption of fat-soluble vitamins in the vegetables.



These plant oils as I showed you earlier have good antioxidant properties. Free radical can cause damage to cells and tissues and is associated with several chronic diseases including cancer and heart diseases. So, these antioxidants that are present in vegetable oil help break this free radical chain reaction and therefore, prevent the body from various unhealthy diseases or disorders diseases. For example, olive oil contains polyphenols which are powerful antioxidants that can help reduce the risk of heart diseases. Then they have they are the source of vitamin E. Vitamin E also plays a role in the immune system and it is important for maintaining healthy skin and eyes. So, when we are taking plant oils we are consuming a good amount of vitamin E.



Also, these plant oils are considered a good source of omega-3 fatty acids. These fatty acids are important for brain health and can also help to reduce inflammation in the body Flax seed oil is a rich source of alpha-linolenic acid (ALA) which is an omega-3 fatty acid that can be converted to the more active forms of omega 3 like EHA, EPA or DHA like Ecosapentaenoic acid or Doposahexaenoic acid. So, these plant oils support brain function. Vegetable oils contain fatty acids that are important for brain functions and development.



So, now I would like to summarize today's lecture that vegetable oils are derived from plants and are composed of triglycerides which are composed of glycerol and fatty acids. The fatty acid composition of vegetable oils varies depending upon the type of the oil and their method of extraction. Vegetable oils are a good source of energy and can provide quick energy to the body. Vegetable oils are high in antioxidants like phenolic and flavonoid compounds which help the body from various chronic diseases like cancer, heart disease, and diabetes. Vegetable oils are good sources of essential fatty acids like linoleic acid which play a role in the synthesis of hormones and cell signaling molecules. Consuming vegetable oils with meals can improve the absorption of fat-soluble vitamins. While vegetable oils can be a healthy addition to a balanced diet, it is important to consume them in moderation as they are high in calories. So, they may have a very good effect on health, but at the same time, they will also add a high amount of calories to the body. So, vegetable oils since they are high in calories can contribute to weight gain if consumed in excess. So, this would be used in causes and causes is carefully they should be used.

Summary (Contd...)

- Vegetable oils are a good source of essential fatty acids, such as linoleic acid, which play a role in the synthesis of hormones and cell signaling molecules.
- Consuming vegetable oils with meals can help improve the absorption of fat-soluble vitamins like vitamin A, D, E, and K, which are important for overall health.
- While vegetable oils can be a healthy addition to a balanced diet, it's important to consume them in moderation as they are high in calories.
- Vegetable oils are high in calories and can contribute to weight gain if consumed in excess.

These are the references that have been cited in this lecture. Thank you very much for your patience hearing.

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