Food Oils and Fats: Chemistry & Technology

Professor H N Mishra

Agricultural and Food Engineering Department

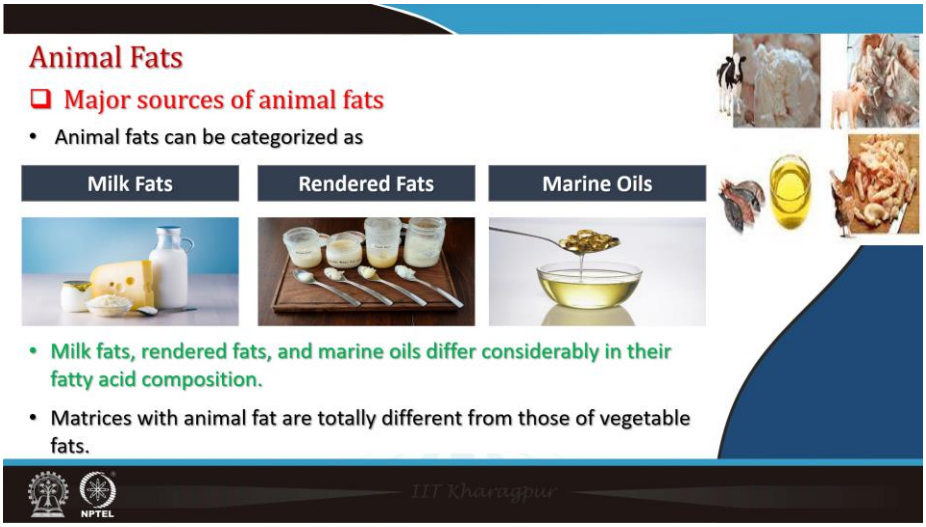
Indian Institute of Technology Kharagpur

Week 1: Course Overview and Introduction

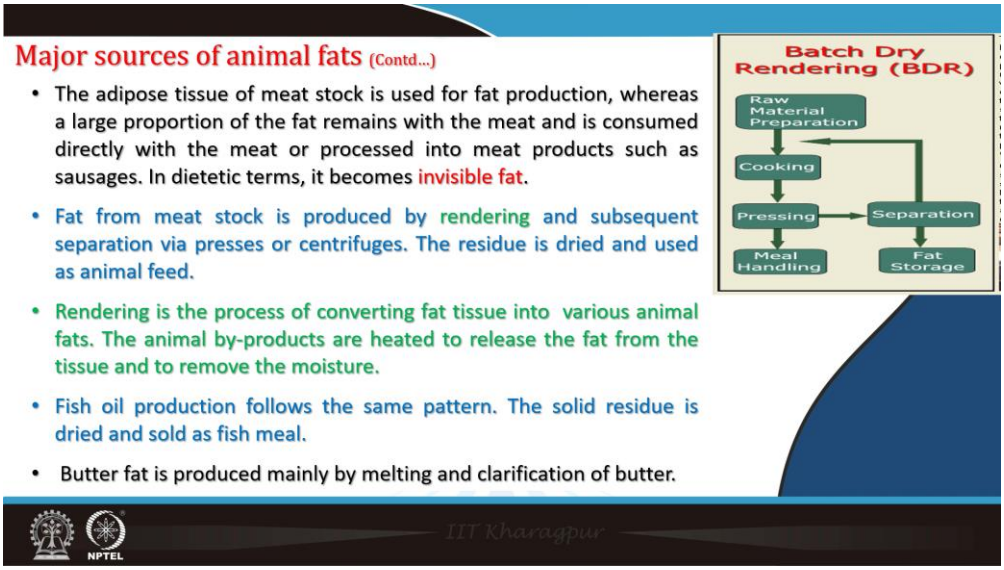
Lecture 4: Animal Sources of Edible Oils and Fats

Hello friends, Namaskar. Welcome you all to this fourth lecture of module 1. In this half an hour lecture, we will discuss about various animal sources of edible oils and fats.

The concept that is covered in today's lecture is that what are the different animal sources. Also, we will take up the dairy fat because they constitute important animal fat materials. So fat globule, its nature and structure we will try to discuss briefly. Then aquatic sources like algae, fish etc. also they are considered good sources of oil. Then the production statistics of all these cattle, animal sources, dairy, aquatic, their market share and finally, we will discuss briefly the utilization pattern of these animal fats and oils.



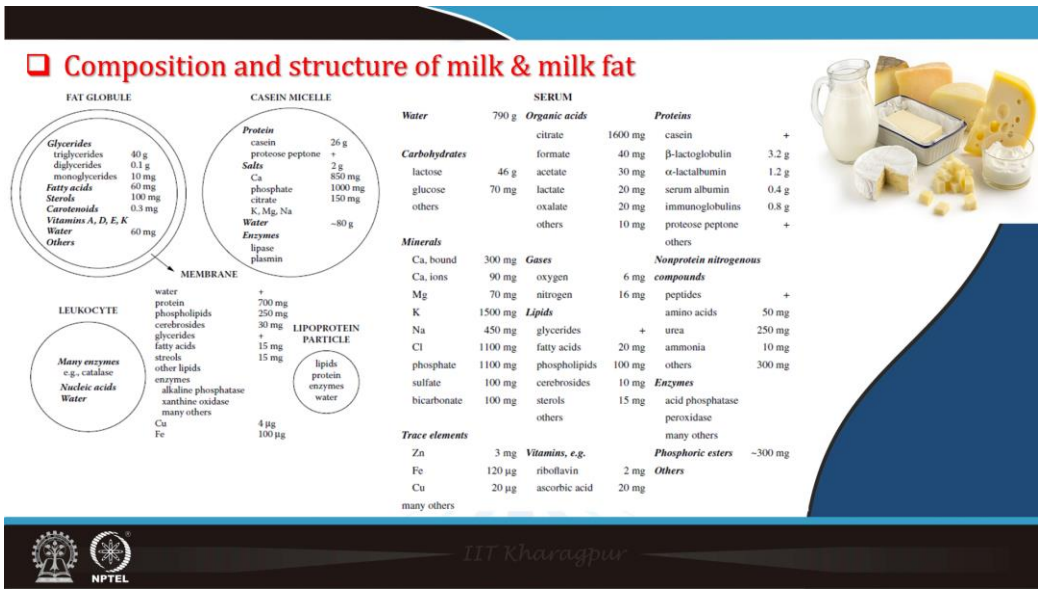
So, these major sources of animal fats you see they can be categorized broadly as milk fat, as I told you, rendered fat and marine oils. There is the particularly from the method, by which they are obtained or from the material, which is used for their recovery. Like milk fat, as I told you, that the fat is present around in the milk I will tell you in the next slide around 4 to 8 % in cow or buffalo milk. So, this milk, they are extracted from the milk as the cream is extracted and then cream is converted into various products. So, they are the one category of major that is animal fat like milk fat, dairy fat. Then the rendered fat, basically these are the fat, which are obtained by pressing after cutting, trimming the fatty tissues after the animals are slaughtered. Then they are from the carcasses fatty tissues, fatty components are trimmed and they are used by a process. That is by pressing and crushing and centrifugation etc., that is normally known as rendering. So, milk fat, rendered fat, and then also the marine oils, they differ considerably in their fatty acid composition and also in the method, by which they are obtained. Matrices with animal fats are totally different from those of the vegetable fat as well-known fat that mostly the animal fats like dairy fat you see they are solid at room temperature. Even rendered fat, lard, tallow etc., they are solid at room temperature, but most of the vegetable oil they are liquid at room temperature. So, this difference is mainly because of the differences in the fatty acid profile of these oils. The saturated fats are mostly present in the animal fats and because of this saturation value they are solids at room temperature. Major sources of animal fat as I told you that you see the rendering means, that is after the animal is slaughtered, then their portions in the meaty tissues are removed. and then by suitable method they are pressed and fat is extracted.



So, the adipose tissues of the meat stock obviously are used for production. Whereas, a large portion of fat remains with the meat because when the animal is slaughtered from the carcass, the fatty adipose tissues are trimmed, but 100 % removal is always not possible. So, some of the fatty tissues are adipose tissues, they remain with the fat and they are consumed directly with the meat or they are further processed into meat products such as sausages etc. and these animal fats, they are consumed along with the meat and in the dietic terms, they are known as invisible fat, that is invisible fat, that is, which we are taking unknowingly. We are taking the meat, we are taking the flesh, but along with the flesh, this fat is also going. So, fat from meat stock is produced as I told you by rendering process and subsequent separation by presses or centrifuges. The residue is dried and used as animal feed. That is the residue means, that is the protein material, that is the fat globule membranes etc. after the extraction. That is the proteins, that is the denatured components etc. It is used as an animal feed. Rendering is the process of converting the fatty tissues into various animal fats. The animal byproducts are heated to release the fat from the tissue and to remove the moisture content present in it. Fish oil production follows the same pattern. The solid residue is dried and then sold as a fish meal, that is again by pressing that just by simple pressing by one or the other sometime, they are crushed and then pressed. Butter fat is produced by mainly by melting and clarification of the butter, that is cream is removed from the milk and then this cream is heated and melted and the butter is removed.

So, the milk fat is the main representative of the milk fat is the fat of cow or buffalo milk. All other milks are almost they have no importance as far as their fat is concerned. Milk fat is a high value milk component, that is processed mainly as butter, cheese, cream and whole milk powder. Approximately 35 million tons of milk fat is projected to be produced globally by 2025. Infant milk formula producers, for instance, they have incorporated enzyme modification, that is they humanized milk fat, the fat composition by enzymatic

modification, they bring it at per with the human milk. So that is, they produce a humanized milk fat and fat globule phospholipid to better mimic human milk fat structures and therefore, to improve their characteristics and utilization in the human body. Minor components like mono- and di-glycerides from milk fat are increasingly utilized as emulsifiers, as I told you in the earlier classes, that is lecithin, which is one of the major emulsifiers presents in the milk, that is then replacing palm esters in premium-priced food products etc.



So here you see, that is I have tried to give you composition and structure of milk and milk fat. So, in the milk, there is you see that, the fat is present, fat globules, there is a milk fat globule, where there are some sort of membranes and inside the membranes, that is various glycerides like triglycerides, diglycerides, monoglycerides, fatty acid, sterol, carotenoids, vitamin A, D, E and K and all these things are present in the fat globule membranes. Also, there are some lipoproteins presents are this phospholipids, cerebrocytes, glycerides, fatty acids, alcohol etc. they are also present in other cells. So, these, the structure I am not going to read all these values, but it gives that a quantity of these various components, which are related to fat and other components, that are present into the milk. The important point here is that all these fat globules, that is they are fats they are enclosed with some sort of membranes and that the fat globule membranes, they are separated by that, in the cream they are obtained as a in the cream, that is in the milk they are normally present in the oil in water emulsion, but when they are taken out in the cream or then cream is subsequently processed into butter oil or other butter etc., other products, then the phase is changed and it becomes, that is the oil in water emulsion phase, which was there in the milk, it is changed to water in oil emulsion that is phase.

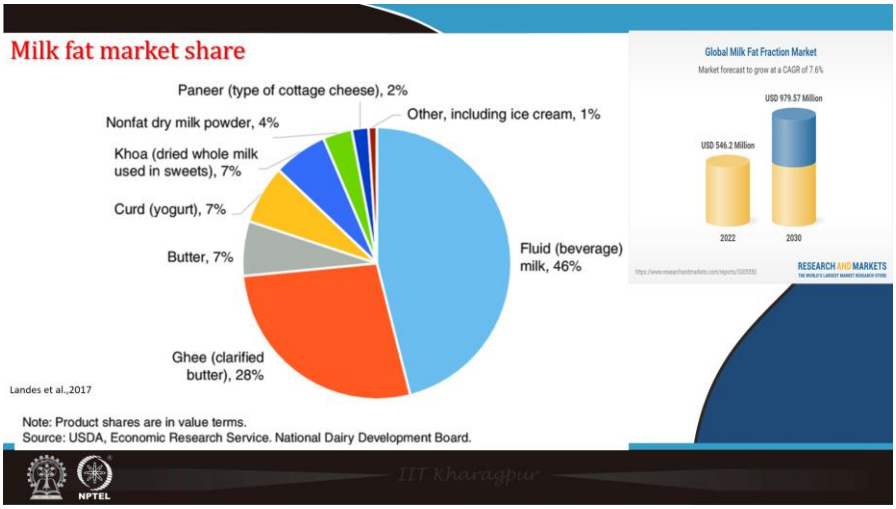
So the milk fat products, that is being the largest entity in milk fat globules can relatively

be easily separated as I told you from the rest of the milk, thereby yielding products of varying fat concentrations, also the processes leading to change in the status of the fat globules with respect to the type of emulsion can result in different products that is in the, originally it is the oil in water emulsion, but when they are taken out from the milk and they are various process so the nature phase is changed. Cream is a yellowish component of milk, which is rich in fat globules, that rises to the surface naturally, if the milk is allowed to stand, because of the differences in the specific gravity of the milk fat and the water etc. then if you allow it comes that is the fat globule membranes it comes in the. So, in fact, we stop that in the milk, now the homogenization process most of the commercial milk are homogenized, where these fat globules are broken down into smaller size to stop their separation and coming on the top. So, in the dairy industry, cream is separated mechanically that using some sort of centrifugal cream separator. When milk fat is concentrated into a fraction of the original milk, that portion is called cream. Then cream may be depending upon the type of the separation and the amount of the fat present into the cream, it may be categorized as low-fat cream, medium fat cream, or high fat cream. Low-fat cream contains milk fat not less than 25% by weight, whereas, the high fat cream contains at least it should contain not less than 60% cream by weight. The medium fat cream contains 40% not less than 40 % cream by weight.

Next important milk fat product is butter. It may be defined as a fat concentrate, which is obtained by churning cream, gathering the fat into a compact mass, and then working it. Butter consists of about 80 to 90% fat with a maximum of 16% water and other dairy ingredients. Then fat spreads are other important milk fat product. Fat spreads are solid plasticized foods of water in fat type emulsion, which by principle contain an aqueous phase as well as fat and oil. These fats and oils are foods on the basis of the fatty acids that have a vegetable, animal marine origin or it may be milk origin. So, these fat spreads even they can be prepared from the vegetable fat as well. So, only thing is that they are worked out, their phase change. Then cream and butter powder are the products, that are obtained by partial removal of water from cream, obtained from milk of cow and or buffalo.

Butter oil and anhydrous milk fat or anhydrous butter oil means the fatty acids or fatty products derived exclusively from milk and are products obtained from milk by means of processes, which result in almost total removal of water and milk solids not fat. So, from the butter oil, it completely it should be theoretical practically it should be complete triglyceride. So, some milk solid not fat or the water and all other components are removed from it. It shall have pleasant taste and flavor free from off order and rancidity. It shall be free from vegetable oil or fat, animal body fat, mineral oil, added flavor and any other substance foreign to milk. So, butter oil means exclusively milk fat and concentrated form of it, but nothing if there in any other thing. It may contain, however permitted food additives like antioxidant, ascorbyl acetate at the rate of 500 milligram per kg maximum, propyl gallate, octyl gallate, ethyl gallate, 1000 milligram per kg maximum for each and

butylated hydroxy anisole may be 175 milligram per kg maximum. Then the other very common product, which has even popular in our Indian homes, houses that is the ghee. Ghee means the pure heat clarified fat derived solely from milk or curd or from desi butter or from cream to which no coloring matter or preservative has been added. So, it is basically that is obtained from the normally the cream, either ripened cream or fresh cream is used for preparation of ghee.



If you look at the global market milk fat market share, that here in the pie chart you see that it has around 46% in the fluid milk is beverage and the clarified ghee clarified butter that is ghee, it has a 28% market share butter 7%. Then non-fat dry milk powder 4% and other products are about 1% and even ice cream 1% right. The global milk fat fraction market, in the view in the term of US dollar in 2022 it was, it is expected to be 546.2 million US dollar and which is expected to reach US dollar 979.57 million by 2030. So, the market forecast is to grow at a CAGR of 7.6% per annum. The milk fat production and consumption statistics, if you see in 2022, the total domestic consumption volume of butter was 6.49 million metric ton in India and this was and there was considered as an increase as compared to the previous year, when the consumption volume was 6.29 million metric tons. So, in one year, there is a little if you compare from the in 21 in 22, there is a more consumption of butter fat. So, the cream if in 2022, 2787.71 tons of total cream was produced in the country. ghee and butter oil to the tune of 2,33,911.7 tons. Butter was produced to the tune of 10,12, 628.22 tons and so on. So, this table gives you the milk fat production and consumption statistics in India in the last 2-3 years.

Then we come to the other segment of the rendered fat, that is the as I told you earlier also when animals are slaughtered to produce meat for human consumption approximately 50% of it is turned into animal by product. There is an only about 50% of the total body weight may come in the form of flesh or meat remaining 50% goes to the by product and here that these adipose tissues, another meat fat containing tissues etc. also included in those 50%. So, these by products are processed and used for variety of applications and thus adding

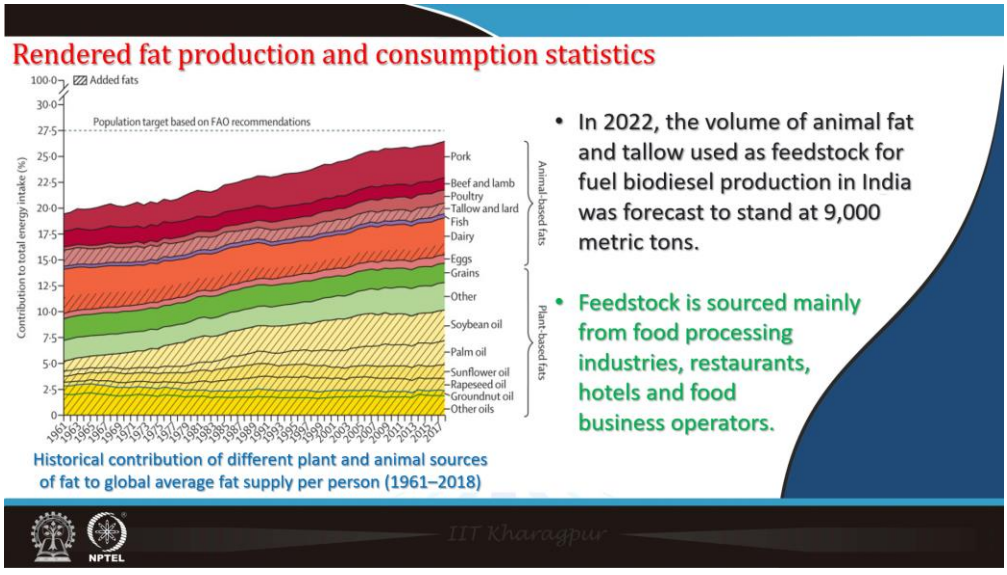
value to the animals. So, what are the different types of animal fats which are derived from these by products, they may be tallow, it is the hard fat rendered from the fatty tissues of cattle that is removed during processing of beef. There are two types of tallows, one is the edible tallow other is the oleostock. According to the Codex Alimentarius Commission the standard for the edible tallow is that a rendered from certain organs of healthy bovine animals only it is also known as dripping. So, edible tallow means according to the regulations, that is it is the fat, which is rendered from certain specific organs of bovine animals, whereas, the oleo stock is the high-grade tallow, that is obtained by low temperature wet rendering of the fresh animal fat from beef carcass. It has light yellow color and mild pleasant flavor. Its free fatty acid content is less than 0.2%.

Lard is defined as the fat rendered from clean, sound, edible tissues of hogs in good health at the time of slaughter, that is very important. Its production is limited to certain killing and cutting fats from the hog. Deport fat, such as those surrounding the kidney portion are example of killing fats since they are removed during the slaughtering operations. Cutting fats are those fats which are obtained when the hog is cut into various wholesale or retail cuts. Caul fat is the fatty membrane which surrounds internal organs of some animals such as cow, sheep, and pig. It is often used as a natural casing. It is also known as lace fat. Then leaf fat is the fat lining of the abdomen and kidneys of hog that is used to make the lard.

Rendered pork fat is the fat other than the lard. It is rendered from clean, sound carcasses of edible organs from hogs in good health at the time of slaughter with certain parts of the animal especially excluded. It includes bacon skins, then fleshed skins, checked meat trimmings, sweet pickle fats and fat obtained from skimming and rendered tanks. Inedible tallows and greases are the main inedible animal fats which are produced in many grades. Inedible tallows and greases produced by meat packing industry may contain either hog or beef fat. Fat with titer of 40 or greater than 40 are called as inedible tallow and those with titer less than 40 are called as greases. Titer is a measure of the temperature developed as a result of the heat of crystallization during cooling of the melted fatty acids from the fat.

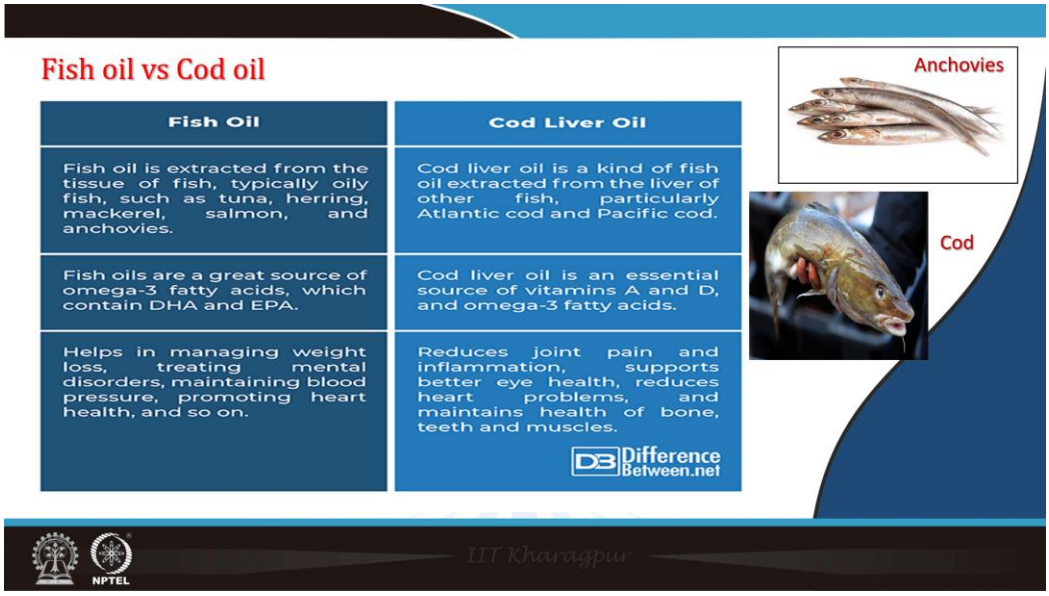
Then we come to the chicken fat, another important source of the fat both hidden fat and it is the fat obtained usually as a byproduct from the chicken rendering and processing. It is high in linoleic acid, which is the beneficial omega-6 fatty acids, that linoleic acid levels in the chicken fat ranges from 17.8 to 22.9%. It is used in the production of pet foods and biodiesel. Chicken fat is one of the two types of animal fat referred and schmaltz and the other being goose fat.

Rendered fat market share if you look here in 2022, it was US dollar 2501.97 million by 2030 it is expected to grow at US dollar 9893.62 million. The market forecast is to grow at a CAGR of 18.8% rendered fat. So, in that year 2021, animal fat where the world's 947th most traded product with a total trade of dollar 911 million between 2020 and 2021, the export of animal fat grew by 4.02% from dollar 875 million to 911 million. Trade in the animal fat represents about 0.000043% of the total world trade. So, very insignificant. In 1921, the top exporters of the animal fats were Spain, Germany, Canada, Netherlands, and Italy. In 2021 top importers of the animal fats were China, Philippines, Japan, Mexico, and Belgium. In 2018 the average tariff of animal fat was 18.4%, making it the 128th lowest tariff using the HS4 product classification. Animal fat ranks 419th in the product commodity index that is called PCI. So, in this figure, I have shown you just you can see the statistics for the rendered fat production and its consumption.



So, in the year 2022, the volume of animal fat and tallow used as a feedstock for fuel biodiesel production in India was to stand at 9000 metric tons. Feedstock is sourced mainly from food processing industries, restaurants, hotels, and food business operators.

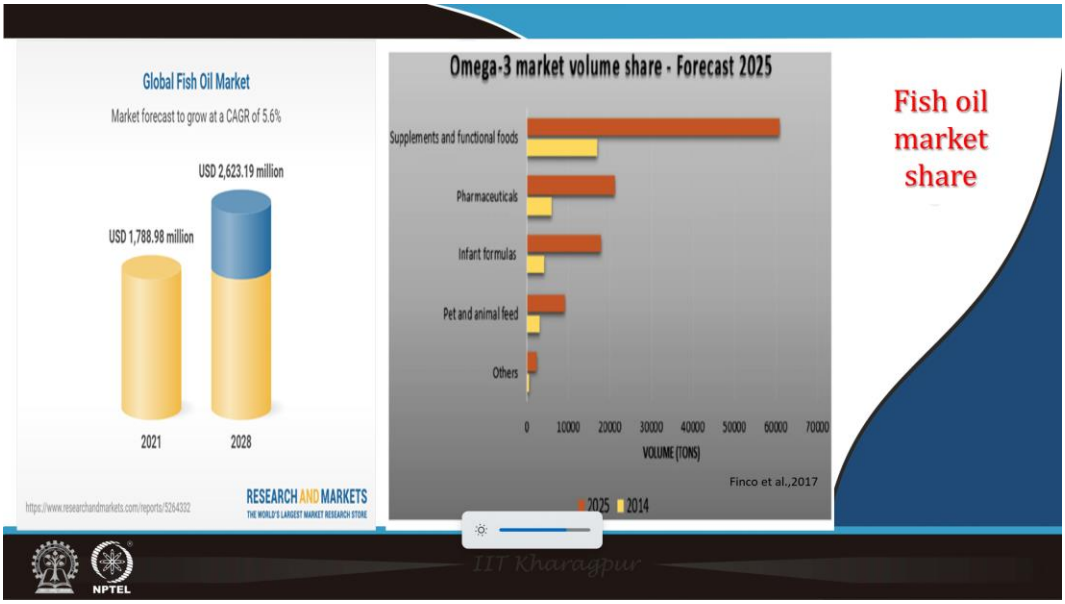
Marine oil, another very important component, that is the fish oil, cold water fish such as menhaden, salmon, sole, herring, anchovies, mackerel, and sardines, contain large amounts of the long-chain omega-3 fatty acids with a profile of around seven times as much omega-3 as omega-6. They have a good proportion of both omega-3 as well omega-6. Conventional purification process like refining, bleaching and deodorization will remove the undesirable heavy metals and pesticides residue that might be present in these fish oils and other pollutant that may be present in the crude fish oils. Flavour reversion of fish oil is more severe problem with less oil than any of the vegetable oil. This is mainly due to the presence of high levels of long chain polyunsaturated fatty acid. So, more the unsaturated fatty acid present in the oil more it will be prone to reversion or flavour reversion problem. So, fish oils are a mixture of unsaturates with many different bioactives which may have detrimental effect on some of the application.



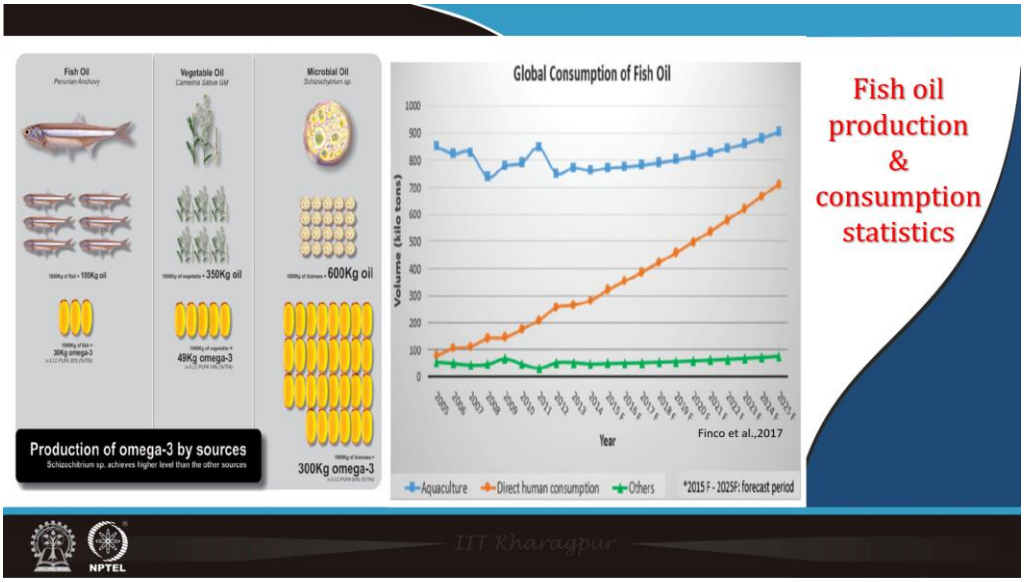
So, here in this slide there is a comparison between fish oil and cod liver oil. Fish oil is extracted from the tissue of fish typically oily fish such as tuna, herring, mackerel, salmon, and anchovies, whereas, cod liver oil is a kind of fish oil extracted from the liver of the other fish particularly Atlantic cod and Pacific cod. The fish oils are a great source of omega-3 fatty acids which contain DHA and EPA, whereas, the cod liver oil is an essential source of vitamin A and D and also it contains some amount of omega-3 fatty acids. Fish oil helps in managing weight loss, treating mental disorders, maintaining blood pressure, promoting heart health and so on whereas, the cod liver oil reduces joint pain and inflammation, it supports better eye health, reduces heart problems and maintains

health of bone, teeth and muscle. Then microalgae oils, the primary food source of these oils are sea life marine microalgae contributes most of the long chain polyunsaturated fatty acids in fish. Fermentation technology has been developed for the production of omega-3 fatty acid from microalgae.

Microalgae oils contain an abundance of single bioactive compounds such as DHA fatty acids rather than a mixture of unsaturated. This technology includes isolating series of algae that meet the fatty acid objective, cultivating, harvesting, and processing of the DHA fatty acid rich oil. The DHA fraction is purified to obtain a clear semi solid orderless oil that is typically blended with a high-oleic oil to a 40% minimum DHA content for the oxidative stability. Additionally, microalgae oil has a better oxidative stability than fish oil due to the lower unsaturated levels. Then blubber oil, it is a thick layer of the vascularized fat found under the skins of pimples, cactations and siren oils these are all marine animals.



Here this slide shows that fish oil market share that in the year 2025 and its comparison with the 2014 you see the in the it is using the supplement and functional foods that is in the maximum that is the volume they turn around 6000 tons in the pharmaceuticals, the second one after the supplements and functional foods then in fact into formulations then pet and animal feeds and other. So, global fish oil market that is the forecast is to grow at a CAGR of 5.6 %. In 2021 it was to the tune of US dollar 1788.98 million. In 2028 it is expected to reach 2623.19 million US dollar.



So, the fish oil production and consumption statistics, if you see here that this for making that is about 100 kg of fish oil, we may have required about 1000 kg of fishes and it gives about 30 kg of omega-3 and if comparison is made between vegetable oil and micro algal oil. So, the in the micro algal oil from 1000 kg of the vegetable oil from 1000 kg of the oil is bearing materials, vegetable material 350 kg of oil we can get and which will give you 49 kg of omega 3. In the micro algal oil from 1000 kg, we can get 600 kg oil and 300 kg of omega 3. So, you can see here from this data itself indicates that micro algal oil or marine oil etc. they are cheap source and good source of this omega 3 and other oils etc. and this table shows that was the aquaculture direct human consumption and other there is the how this year wise from 2005 to up to 2025. How this volume is increasing the global consumption of fish oil and in the direct human consumption the value is increasing there is a significant steep increase in the consumption pattern.

So, now I will summarize this lecture by saying finally, that animal fats can be categorized as milk fat, rendered fat and marine oils. Milk fat include the fat fractions of milk such as cream, butter, ghee etc. Rendered fats are the fat collected during the rendering process of animal byproduct such as lard, tallow etc. Marine oils include the cod liver oil, fish oil, algal oils, and blubber. The global edible oil and fat market is projected to grow from dollar 45.65 billion in 2021 to 63.98 billion dollars in 2028 and its growth is projected to be at a rate of CAGR of 4.9% in the forecast period of 2021 to 2028.

So, these are some of the references that are used in preparing this lecture. This I thank you very much for your patience hearing. Thank you.