Course Name: Canning Technology and Value Addition in Seafood
Professors name: Dr. Maya Raman, Dr. Abhilash Sasidharan
Department: Food Science and Technology
Institute: Kerala University of Fisheries and Ocean Studies
Week:7
Lecture:24
Nutritional quality of seafood

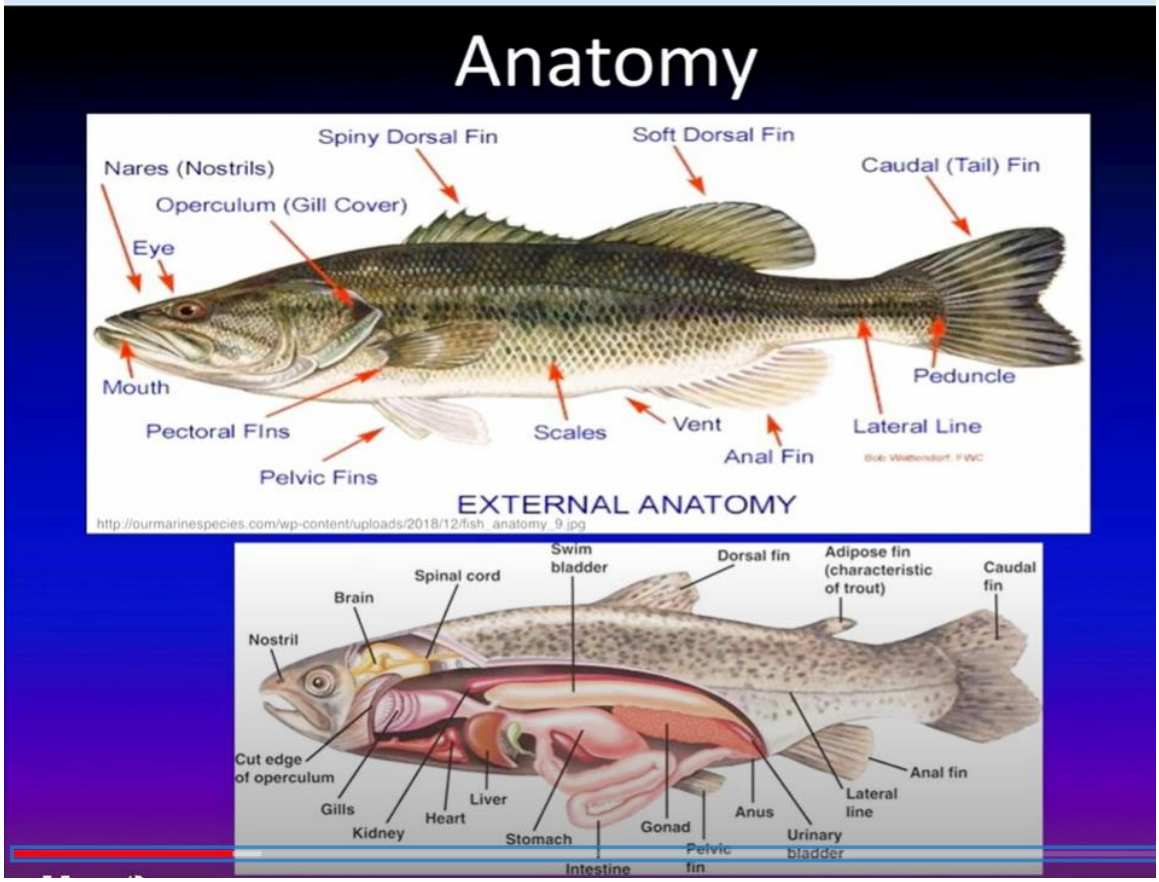
Hello everyone, welcome to the NPTEL course, Canning Technology and Value Addition of Seafood. In the previous classes, we were discussing about the concept of canning technology, history of canning technology, containers being used in canning and their properties. We have also discussed about different canning processes, heat penetration calculations and their importance in canning process. We also saw the spoilages that are involved in canning and in the last class, we discussed about the canning of different seafoods and what are the different considerations or parameters that need to be considered while doing the canning of these different products.

In today's class, we will be discussing about value addition in thermally processed seafoods. We will also discuss about the quality standards of seafood and other value-added products. The outline of the class is, it consists of five different topics, composition and nutritional quality of seafood, muscle structure of seafood, the spoilages that are very common in the seafood and importance of preservation methods and what are the different value additions that can be done in thermally processed seafoods and in other seafoods or the byproducts derived from the seafood industry.

Now, coming to the first topic, composition and nutritional quality of seafood, you are all familiar with the fish. It's a skeletal and cartilaginous fish or the cartilaginous body. The structure consists of either exoskeleton or the endoskeleton and it might be a cartilaginous in some cases. The edible part of the fish is generally muscle and which compromise or which accounts to about most of the weight of the fish. It is protected on the outer side by the skin and by a slimy mucus and it also contains scales in some cases. Gills are generally the breathing mechanism and the body cavity, it contains all the major organs and it is protected by the cavity and again just like any other living organism, the gut harbours the microbes. The major number of microbes are limited to the gut region and hence during preservation, de-gutting is a very important step and these microbes or the gut has to be removed to prevent the spoilage of the fishery product.

If you look at the anatomy of the fish, you can see here that on the surface you can find the gills which are the breathing mechanism. We can also see on the surface the scales are there which protects the body from external invasions or from other objects in the water and we also have a slimy mucus on the skin which prevents its decomposition in the aquatic environment and on the inner side or the inner body cavity, all the other major

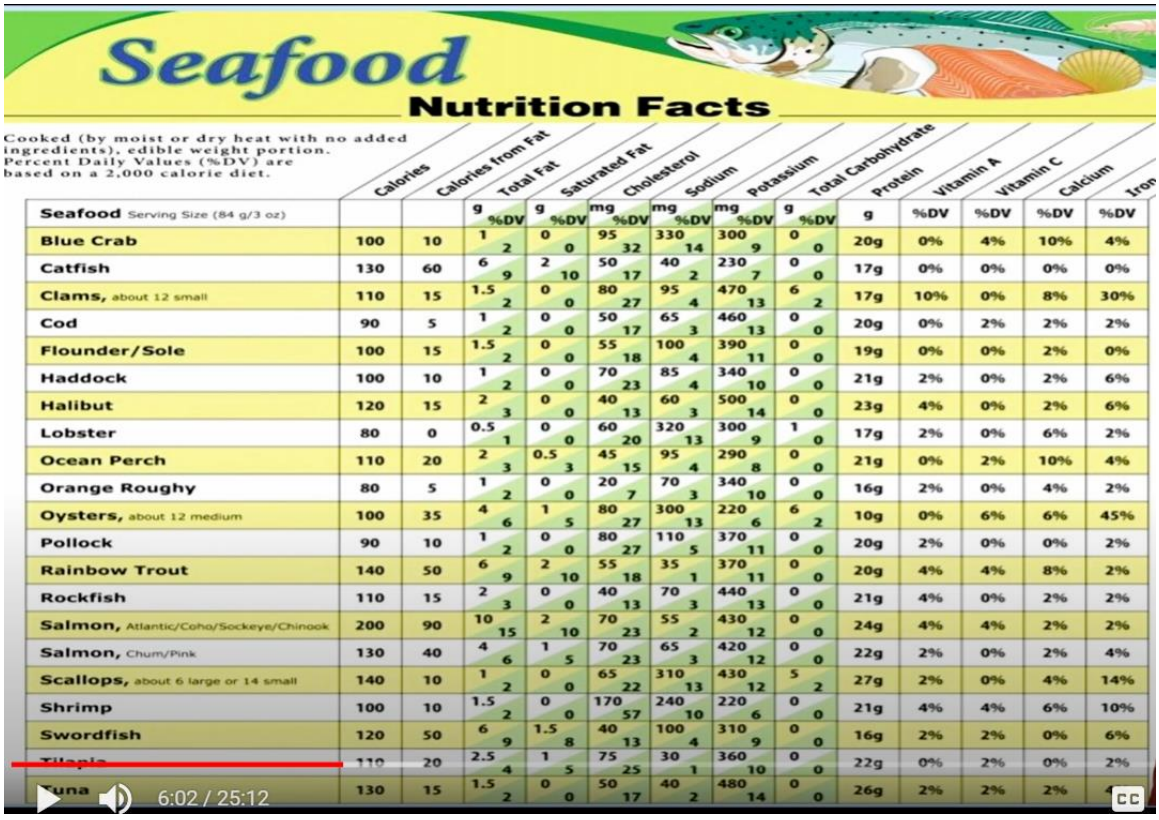
organs are protected and intestine- it contains most of the microorganisms. Gills and the slime also contain microorganisms but comparative to gills and slime, most of the microorganisms they are concentrated in the gut region. The fish can be utilized, mainly it is used as a food and the usually the muscle part is used for the consumption but the other parts like bones or the head region or the viscera and trimmings blood, they can also be used to develop other value-added products. They are rich in other components like lipids or pigments. They can go into the animal feed or in the poultry's industry.



Now, coming to the components of fish muscle, the major components just like any other organism you will find here water, fat and protein. The carbohydrate part is less in fish and it is mainly glycogen. Water it being the major component. It comprises of 70 to 80 percent or it contributes to 70 to 80 percent of the body and protein ranges between 15 to 20 percent whereas lipids varies from species to species also it is seasonal, it depends upon the season. So, in some season it will be more and some season it will be less and also it has been found that there is an inverse relationship between fat and water. So in spawning season when the fat content increases in the body obviously the water content will come down.

In lean fish we find the deposits of fat in liver whereas in case of fatty fish the fats are deposited in the muscles. Apart from the major components like water, protein and lipid we also find glycogen, minerals, vitamins, water, extractable components. In case of

plant based or animal based or terrestrial based foods the carbohydrate content also forms a major component but in case of aquatic products or the fish it is a minor component and is generally in the form of glycogen. Now, this table (Table 1) it shows the nutritional facts about different fishes and if you look at the table here the protein content is generally high in the fish and most of the fish they are considered as the cheap source of protein. Now coming to the components let's see each component and water is the first or the major component.



Seafood Serving Size (84 g/3 oz)	Calories	Calories from Fat	Total Fat g	Total Fat %DV	Saturated Fat g	Saturated Fat %DV	Cholesterol mg	Cholesterol %DV	Sodium mg	Sodium %DV	Potassium mg	Potassium %DV	Total Carbohydrate g	Total Carbohydrate %DV	Protein g	Protein %DV	Vitamin A %DV	Vitamin C %DV	Calcium %DV	Iron %DV
Blue Crab	100	10	1	2	0	0	95	32	330	14	300	9	0	0	20g	0%	4%	10%	4%	
Catfish	130	60	6	9	2	10	50	17	40	2	230	7	0	0	17g	0%	0%	0%	0%	
Clams, about 12 small	110	15	1.5	2	0	0	80	27	95	4	470	13	6	2	17g	10%	0%	8%	30%	
Cod	90	5	1	2	0	0	50	17	65	3	460	13	0	0	20g	0%	2%	2%	2%	
Flounder/Sole	100	15	1.5	2	0	0	55	18	100	4	390	11	0	0	19g	0%	0%	2%	0%	
Haddock	100	10	1	2	0	0	70	23	85	4	340	10	0	0	21g	2%	0%	2%	6%	
Halibut	120	15	2	3	0	0	40	13	60	3	500	14	0	0	23g	4%	0%	2%	6%	
Lobster	80	0	0.5	1	0	0	60	20	320	13	300	9	1	0	17g	2%	0%	6%	2%	
Ocean Perch	110	20	2	3	0.5	3	45	15	95	4	290	8	0	0	21g	0%	2%	10%	4%	
Orange Roughy	80	5	1	2	0	0	20	7	70	3	340	10	0	0	16g	2%	0%	4%	2%	
Oysters, about 12 medium	100	35	4	6	1	5	80	27	300	13	220	6	6	2	10g	0%	6%	6%	45%	
Pollock	90	10	1	2	0	0	80	27	110	5	370	11	0	0	20g	2%	0%	0%	2%	
Rainbow Trout	140	50	6	9	2	10	55	18	35	1	370	11	0	0	20g	4%	4%	8%	2%	
Rockfish	110	15	2	3	0	0	40	13	70	3	440	13	0	0	21g	4%	0%	2%	2%	
Salmon, Atlantic/Coho/Sockeye/Chinook	200	90	10	15	2	10	70	23	55	2	430	12	0	0	24g	4%	4%	2%	2%	
Salmon, Chum/Pink	130	40	4	6	1	5	70	23	65	3	420	12	0	0	22g	2%	0%	2%	4%	
Scallops, about 6 large or 14 small	140	10	1	2	0	0	65	22	310	13	430	12	5	2	27g	2%	0%	4%	14%	
Shrimp	100	10	1.5	2	0	0	170	57	240	10	220	6	0	0	21g	4%	4%	6%	10%	
Swordfish	120	50	6	9	1.5	8	40	13	100	4	310	9	0	0	16g	2%	2%	0%	6%	
Tilapia	110	20	2.5	4	1	5	75	25	30	1	360	10	0	0	22g	0%	2%	0%	2%	
Tuna	130	15	1.5	2	0	0	50	17	40	2	480	14	0	0	26g	2%	2%	2%		

Table 1

As discussed earlier, 72 to 80 percent of the fresh weight it comprises of water and if you look at the Bombay duck (*Harpadon nehereus*), it is seen in the Indian coast and mainly in the Bombay region it has very high amounts of moisture that is 90 percent and usually it is dried immediately to reduce the moisture content.

Moisture is very important for all the physiological functions in the body and generally this moisture or the water in the body it can be classified into two types that is bound water and free water. If you look at the figure (Fig. 1) you can see that there are free waters and bound water these bound water they are tightly bound to the protein molecules or the macro components due to the charges present in the protein and these are not freely available for any activity and since they are bound closely or bound tightly to the proteins

they have reduced mobility. Whereas free water they can just be squeezed out or just by applying a mere pressure you can remove the water from the tissue so that is the free water and it is generally held inside the cells.

Now why water is important? Because all the microorganisms they need moisture or they need water to grow through to multiply and in food or in fish when you where you have high amounts of moisture this moisture content has to be brought down by some means so that you can regulate you can control the growth of microorganisms and in case of food, we generally go by two terms that is moisture content and water activity. Moisture content it gives an idea about the free water content that can be operated out when you are subjecting the food to the drying. Usually, we follow the AOAC method where you dry the food at 105 degrees centigrade and the difference between the samples it indicates the moisture content whereas water activity it is the measure of the availability of water molecules to participate in chemical and biological reactions.

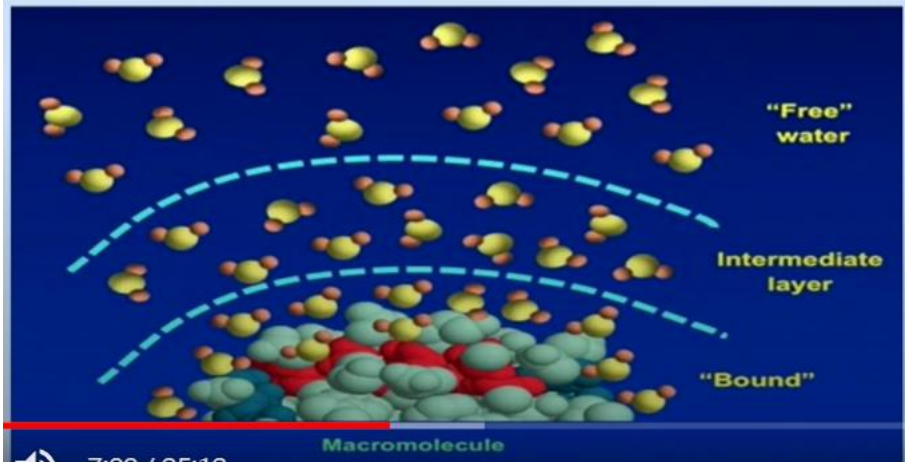


Fig.1

These include both microbial and enzymatic reactions.

Water activity is very critical for the shelf life or the safety of the food also for the quality of the food and generally correlate water activity and bound water it shows an inverse relationship that means if the product is completely dried then even the bound water will be utilized or it will be removed from the body and thereby the water activity will come down. So, if you look at the figure (Fig.2) , here the water activity of 1 or above 0.5 you can see that most of the microorganisms they can survive even you can find moles and yeast and by microorganisms ie., bacteria but at water activity below 0.5 the organisms these organisms they then cannot thrive and most of such foods like biscuits or dried powders or milk powders or dried vegetables they have lower water activity and because of this reason they can be stored for a longer period and without any spoilage.

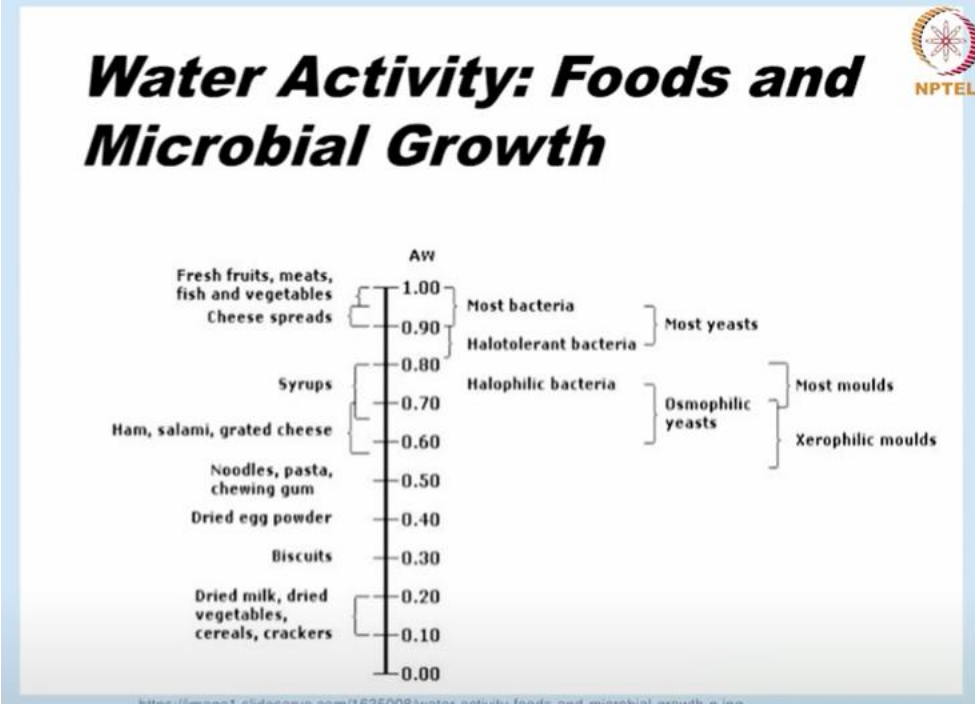


Fig.2

Fish has higher water activity and that is the main reason why it shows spoilage and our intention should be to reduce the water activity by employing some processing means you can go for conventional method or you can go for some novel method and reduce the water activity so that it will not be available the moisture will not be available for the growth of microorganisms.

Now let's see the second major component that is protein. As you all know protein the base molecule for protein is amino acids. There are 20 main amino acids now 2 more has been added to this list and proteins they range between 15 to 20 percent and just like lipids they also show variations with season feeding and spawning etc. For example, if there are a lot of food available or the feeding grounds are plenty then those algae or the organisms that are available in the feeding grounds they will be consumed by the fish and this will increase the protein content. Similarly, during season whenever if a particular season is rich in particular organism, then fish will feed on those organisms and their protein content will be increased. So, generally it ranges between 15 and 20.

Fish has generally it has two types of muscle that is light muscle or white muscle and red muscle. Red muscle it contains generally it contains low protein but it is rich in fat it also contains high amounts of myoglobin whereas white muscle they are they contain low protein content compared to the red muscle. Now, based on the solubility of proteins the fish protein can be classified into three types that is sarcoplasmic protein, myofibrillar protein and stroma protein. Myofibrillar protein and stroma protein together they are also called structural proteins. Sarcoplasmic proteins they are otherwise called enzymatic

proteins. They are soluble in water and they are in low ionic strength solutions. Any solution below 0.15 molar you can use for the extraction of sarcoplasmic proteins. They generally contain myogens, globulins, enzymes, myoalbumins and like I said the total protein content is 15 to 20 percent. Off this total protein the 25 to 30 percent will be sarcoplasmic protein and it is generally high in pelagic fishes like sardine and mackerel and low in demersal fishes. By demersal fish I mean the deep-sea fishes which are not floating on the surface. Pelagic fish they float on the surface or they live on the surface and demersal fishes they are deep sea they live in the deep-sea oceans. And usually sarcoplasmic proteins are also used to characterize or to identify the species so you just have to extract it with water and run the PAGE and just looking at the bands you can say that it belongs to a particular species. So, each species they have their own identity with respect to sarcoplasmic proteins.

Now coming to myofibrillar proteins, they are not soluble in water but they are soluble in little higher strength solutions like 0.3 and 0.7 M. So, any solution ranging between 0.3 and 0.7 M you can use it for the extraction of myofibrillar proteins and these generally consist of actin, myosin, actomyosin and troposin. Actomyosin is the complex form of actin and myosin and myofibrillar proteins. They are generally involved in contraction and relaxation. Now, again off the total protein, myofibrillar protein contributes to around 65 to 75%. Myofibrillar proteins are also used for the preparation of surimi because they exhibit gelling property and coagulation properties. Surimi is another fishery product which is developed using myofibrillar proteins of low value products or the bycatch which is usually thrown to the sea when the catch is very high and only the economically feasible ones are brought to the shore. So, the bycatch is it is generally thrown to the ocean and these bycatches they are used for the development of surimi. Surimi is the value-added product.

Now, coming to the individual components of myofibrillar proteins. The major one is myosin and as you all know the myosin is a heavy molecular protein. So, it is 500 kD and it is a thick filament and it contributes to around 40 to 60% of the total myofibrillar proteins. It consists of six chains that is four light chains and two heavy chains and these four light chains they contribute or they form the myosin head whereas the heavy chains they form the tail portion and the entire myosin is used or it participates in the contraction and relaxation of the muscles. Also, they participate in the conversion of adenosine triphosphate (ATP).

The next component of myofibrillar protein is actin. Actin is a thin filament and it comprises about 22% of the myofibrillar proteins. Actin can be in two forms. Globular form then it is called G-actin and if it is polymerized it forms fibrous or filament structure it is called F-actin and both has important functions in contraction and mobility. Now, the actin and myosin; they for complex together to form actomyosin and actomyosin also plays an important role in the contraction and relaxation.

The next components of myofibrillar proteins are troponin and tropomyosin. Troponin contributes to 8 to 10% of total myofibrillar proteins whereas tropomyosin it contributes to 5 to 10% of total myofibrillar proteins. Troponin can be classified into troponin-C, the calcium binding protein, it is denoted as TnC and we have TnT that is troponin T binds to the troponin tropomyosin and then we have troponin I (TnI) that is inhibitory protein. Tropomyosin is a polypeptide chain it consists of two polypeptides alpha and beta chain to which you will find the troponins are attached and together they all play an important role in the muscle contraction.

Now, coming to the third component of fish protein is stroma protein. Stroma protein is also called connective tissue protein and it mainly consists of collagen in the fish and whereas in higher animals you will find the presence of elastin. Collagen it is soluble in neutral salt solutions it can also be extracted using dilute acids like acetic acid and you can also use alkalis and it contributes to 3 to 10% of total proteins. Generally, in tea leaves you will find the lower amounts of collagen whereas in elasmobranchs that is in fishes like sharks you will find high amounts of collagen that is it accounts to about 10% and collagen along with the myofibrillar proteins it contributes to the texture. Therefore, these are also called as structural proteins. Now, the basic unit of collagen is a tropocollagen it is a helical structure and this triple helical structure it contains or it encloses GAGs that is glycosaminoglycans or glycosproteins and these are very important for bone health for the osteoarthritic people collagen is very important. It helps in restructuring of the body and collagen it contains the major amino acid is glycine it also contains proline, alanine and hydroxylated forms of proline and hydroxyl lysine.

Proline is an distinguished amino acid in collagen to decide or to understand whether it is a collagenous protein or myofibrillar protein or any other protein if you look at the percentage of protein you can make out whether it is collagen or not and the hydroxylation of proline it forms hydroxyproline at which causes bending in the collagen. Now, denaturation of protein is another important concept and you all know that in native protein the proteins the secondary or the tertiary or the quaternary structures of the proteins they are intact. The moment it starts undergoing denaturation, it starts uncoiling so it can happen when the proteins are subjected to external stresses like acids, bases, salts, solution, heat or radiation. So, as soon as these changes happen that is chemical or physical changes happen the protein structure is lost and it gets denatured. So, the native structure of the protein will be lost. The fish proteins they are rich in most of the amino acids and therefore they are also considered as important source of protein and they are particularly rich in lysine but the tryptophan amounts are less in fish protein.

Now, coming to the third major component macro component that is lipids. Lipids are complexes of fatty acids it contains three fatty acids and glycerol molecule we are all familiar with the structure of lipid. Lipids can generally be extracted using solvents like

chloroform, methanol, water mixture or you can also use diethyl ether or petroleum ether. So, these solvents they help in extracting crude lipid and generally it contains fatty acids, glycerides, phosphoglycerides, sphingo lipids, aliphatic alcohols, waxes all this depends upon the functional groups that is attached to the backbone of glycerol. Then triacylglycerols they are the major constituents of lipid and generally the lipid content it ranges between 0.5 to 18% and this variation it is mainly dependent upon the season or the maturity stages of the animal and in lean fishes generally the liver is the organ where the fats are stored whereas in case of fatty fish the fats are stored in the muscle tissue.

The lipid distribution is not uniform throughout the body. In the head region it is more and when you move towards the caudal region or the tail region the lipid concentration decreases. Again, based on the muscle distribution the lipid composition is also different. The dark muscle they have high amounts of lipid concentration whereas in white muscle lipid concentration is much lesser. Now lipids the fish they are rich in polyunsaturated fatty acids and these polyunsaturated fatty acids are classified as omega-3 and omega-6. These are the major ones which we find in fish oil or the fish lipid and omega-3 and omega-6 fatty acids have lot of benefits they help in regulating cholesterol, maintaining blood pressure, they prevent Alzheimer's and dementia in elderly people. Even in infants they help in the healthy growth of brain and eyesight. So, generally PUFA is recommended for any age group and it consists of omega-3 fatty acids like Docosa hexainoic acid and Icosa pentainoic acid and it also contains linolenic acid and linoleic acid and arachidonic acid they are omega-6 fatty acids and this numbering omega-3 and omega-6 fatty acids the numberings because of the double bond from the methyl end.

Now, lipids undergo oxidation they undergo rancidity and rancidity is the process which indicates that the lipid has undergone some spoilage. Lipid can undergo a hydraulic rancidity or oxidative rancidity. Generally, in case of hydraulic rancidity enzymes are involved lipids is involved and this happens in the presence of water molecules whereas oxidative rancidity happens in the presence of oxygen and there will be a catalyst either copper or iron will be present as a catalyst which will speed up the reaction of rancidity. The primary products like hydroperoxides and secondary products like aldehydes, ketones, alcohols are produced. Rancidity can be or auto oxidation process can be divided into three that is initiation, propagation and termination (Fig.3). Initiation starts with the formation of radical and this radical it causes propagation or cycling. So, more and more radicals are produced and these radicals it causes rancidity or participate in rancidity. So, it has to be terminated immediately.

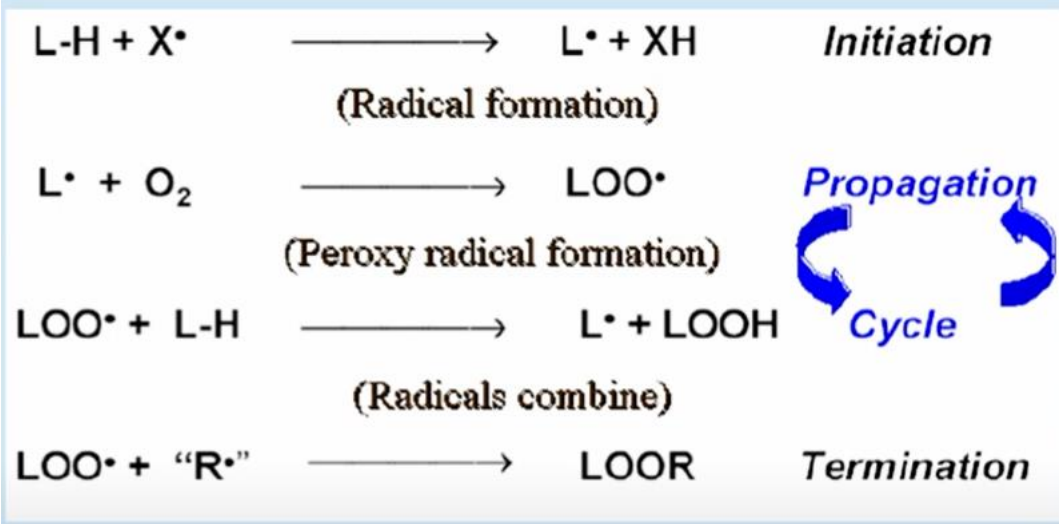


Fig.3

This can be done either by using some antioxidants or by reducing the oxygen contact or cutting off the water contact. So, reduce the moisture content or cut off the oxygen contact the rancidity in oils can be prevented.

Now, coming to the next components vitamins. Vitamins are the micro components then vitamins as we all know it can be classified into water soluble and fat-soluble vitamins. Then fat soluble vitamins include vitamin A, vitamin D, vitamin E and vitamin K and water-soluble vitamins include big complex vitamins and vitamin C. Usually, liver oil contains or it's a good source of vitamins. Since, fat soluble vitamins since they are soluble in fat, they will be deposit in the organs where fat deposits are there and since in lean fish the liver is organ where the fats are deposited vitamins are also richly found there. In cod liver oil we find abundant amount of vitamin D and in shark liver oil vitamin A is abundantly found. So, along with the benefits of fatty acids; omega 3 fatty acids of polyunsaturated fatty acids, we will also find the benefits of vitamins when they are consumed.

Now, minerals they are next micro components and you can see that the fish body it is rich in calcium that is the main micro component. Then we also find sodium, potassium phosphorus, magnesium, iodine and fluoride are also found in fish.

Then apart from these major minerals you also find traces of selenium and zinc. Selenium is again it's a very important mineral because it exhibits anti cancer properties. Zinc for example it also contributes anti inflammation or it reduces or it modulates the immune power of the person.

Now coming to the last part of the slide the take home message is that fish is a nutritionally rich product. It contains high amounts of protein but that is not the only

component it also contains high amounts of polyunsaturated fatty acids, minerals and vitamins. Since they contain high amounts of proteins and minerals and moisture it is necessary that we adopt some processing methods or preservation methods to reduce the enzymatic changes or biochemical changes in the fish. So that its nutritional quality can be retained as such in the product. So, with this let's end the session.