
UNIT 2 USES OF FISH MEAL AND OIL, QUALITY AND STORAGE

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2.0 OBJECTIVES

After reading this unit, you will be able to:

- summarize the nutritive components present in fish meal;
- analyze pharmaceutical uses of fish body oil and its components;
- discuss the industrial uses of fish body oil;
- describe the use of fish meal in animal / poultry nutrition;
- justify the principles behind elucidating the quality standards of fish meal;
- explain the precautions to be taken during storage of fish meal; and
- identify changes taking place in fish meal during storage and its effect on quality.

2.1 INTRODUCTION

Even though fish meal is used in small quantities in all types feed, it has a significant nutritional importance because of various nutrients present in it. For the successful production of various animal products such as eggs, poultry, meat, milk and

aquacultured fish, fish meal is an essential ingredient of all synthesized feeds. Fish body oil is the by-product in fish meal production. In fact, fish meal and body oil are manufactured simultaneously using oily pelagic fish by the industry. Fish oil being semi-drying oil, finds number of uses in the industry. Some fish body oil such as sardine body oil is a rich source of omega 3 (ω_3) fatty acids and hence used in treating cardiovascular (heart) diseases and inflammatory diseases. Liver oil of shark is a rich source of vitamin A. Vitamin A is required for treating certain disease conditions of skin and night blindness in human beings. Hence, shark liver oil can be used for curing these disease conditions. Cod liver oil is a good source of vitamin D which is required for growth and bone formation in humans and animals. Liver oil of shark belonging to the genus, *Squalus* contains high proportion of squalene which in turn is used in cosmetics for the preparation of barrier creams or cold creams.

Quality of fish meal varies depending on several factors such as species of fish used as raw material, freshness of fish, method of meal manufacture (whether dry rendering or wet rendering process), process parameters during meal manufacture, packaging, storage conditions and duration of storage. Quality of fish meal is assessed by using standard methods of analyses which employ physical, chemical, biological and sensory methods. Animal or poultry feed manufacturers require fish meal which is a powder having particle size to pass through No. 8 Tyler screen and the colour should be comparatively light. Therefore, the purpose of this unit is also to introduce you to various quality parameters and quality standards of fish meal.

2.2 COMPOSITION AND NUTRITIVE VALUE OF FISH MEAL

In this section, fish meal, its components and nutritive value have been discussed. The nutrients present in fish meal and their importance in livestock nutrition is given below:

- Fish meal is a good source of protein and it is easy to incorporate it with other feed ingredients so that the desired protein level is maintained. Depending on the raw material used in its manufacture, its protein content may vary from 40% to 60%.
- Protein in fish meal is a good source of all essential amino acids. Nutritive value of a given protein is high when it contains all essential amino acids and it will be low when one or two essential amino acids are lacking or occur in deficient quantity; called limiting amino acids. As protein of fish meal contains all essential amino acids, its nutritive value is high.
- Fish meal is a rich source of essential amino acid lysine, which occurs in deficient quantities in most of the cereals and legumes. Bulk of the animal and poultry feeds consist of cereals, legumes and oilseed meals or its by-products such as bran, hull or germ. Hence, if fish meal is mixed with these ingredients, the deficiency of lysine and methionine is made up by fish proteins. Also, the deficiency of tryptophan in fish protein is made up by cereal or pulse proteins.
- Fish meal supplies water soluble B group vitamins such as riboflavin, niacin, pantothenic acid, choline, vitamin B₁₂ in addition to oil soluble vitamins such as vitamin A and D. As fish is a good source of oil, the meal produced from it contains oil to the extent of 6 to 10%. Oil present in meal contributes towards energy and helps in growth and fattening of animals and birds.

Fish Meal and Oil

- Fish meal made from whole fish containing bones is a rich source of essential minerals such as calcium, phosphorus and magnesium. Calcium is required for bone formation in animals and birds. Total mineral content in whole fish meal is about 25 to 30%. If waste parts of fish such as head and viscera (internal organs) waste are used for fish meal manufacture, the mineral content will be more than 35%. Fish meal is also a good source of iron. In addition to major minerals, fish meal also supplies trace elements such as iodine, molybdenum, copper, zinc and manganese, all of which are required for various biochemical processes going on in the body of animals and birds.
- The crude fiber content in fish meal is very low. For proper digestion and absorption of nutrients, the feed should be low in fiber content especially for poultry. Hence, fish meal is particularly suitable for poultry feed.
- Fish meal contains certain growth factors such as protein utilization factor and animal protein factor which makes the feed with fish meal to give maximum nutritive value.



Check Your Progress 1

- Note:** a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

1) What is the normal percentage of proteins present in fish meal?

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2) Which essential amino acid is present in fish meal in large quantities?

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3) Name the water soluble vitamins present in fish meal.

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4) Which oil soluble vitamins are present in fish meal?

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5) Name the minerals present in fish meal?

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Activity 1

Visit any animal feed manufacturing unit and find out various feed ingredients incorporated in poultry feed, animal feed for cattle and aquaculture fish feeds. Find out the proximate composition (moisture, protein, fat and minerals) present in each ingredient. Also find out the proportion of fish meal in each of the feeds.

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2.3 IMPORTANCE OF FISH BODY OIL AND LIVER OIL IN HUMAN HEALTH

There is overwhelming evidence that the elevated blood and blood serum cholesterol level is related to incidences of heart attacks and strokes. The risk of these diseases can be minimized by maintaining low cholesterol level in blood. It has been found that by ingestion (taking) of fish body oil such as sardine oil, the level of blood and blood serum cholesterol level can be maintained at a low level. This is because of the presence of polyunsaturated fatty acids present in sardine oil.

Cod liver oil which is rich in eicosapentaenoic acid (EPA) has been shown to be effective in offering protection against diseases such as coronary and cerebral thrombosis.

Patients with active rheumatoid arthritis had significant improvement in the clinical symptoms by ingesting fish oil. Also, there are reports that fish oils rich in omega 3 (ω_3) fatty acid are used in the treatment of asthma, to contain production and growth of tumors and psoriasis. However, fish lipids being highly unsaturated, easily form free radicals both *in vivo* and *in vitro*. Fatty acids of fish oil become oxidized to peroxides which are implicated as the root cause of many ailments. Hence, to avoid harmful effects of dietary fish oil, adequate quantity of vitamin E which is a biological antioxidant should be ingested to guard against *in vivo* peroxidation.

About three centuries ago, fish liver oils were used in the treatment rickets and night blindness when vitamin chemistry was not known. Vitamin A and D can cure night blindness and rickets, respectively. Both vitamin A and D are found in liver oil of certain fishes in varying proportions. Cod liver oil in a good source of polyunsaturated fatty acids (PUFA) especially EPA and DHA. Cod liver oil contains almost 8% EPA and 7% DHA.



Activity 2

Visit a medical shop and buy some fish oil based capsules used in the treatment of high blood cholesterol level and find out the colour, odour and taste of the content inside the capsule. Also find a pharmaceutical product based on fish liver oils used as a source of vitamins.

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2.4 INDUSTRIAL APPLICATIONS OF FISH BODY OILS

Fish oils are being used by the industries in a variety of ways. Some of the industrial uses of fish oils are discussed as follows:

a) Paints and Varnishes

Drying oils such as linseed oil are generally used for the manufacture of paints and varnishes. As fish body oils contain some saturated component in it, it is considered as a semi drying oil and hence it is difficult to replace linseed oil completely for paints and varnishes. However, part of linseed oil can be replaced by heat polymerized fish oils.

b) Leather Manufacture

Fat liquoring is an important step in the production of smooth flexible leather. This is achieved by incorporating sardine body oil into tanned hide for lubrication. Sardine body oil is also used as a tanning agent in the manufacture of chamois leather.

c) Printing ink manufacture

Fish body oil of oily pelagic fishes such as sardine, herring, menhaden and pilchard are used in the manufacture of printing inks. Fish body oil replaces part of linseed oil (a drying oil) used in printing inks. Sulphated and sulphonated fish oils can be used in inks for photogravures printing process.

d) Lubricants and Greases

Fish body oils are blended with other mineral oil in the manufacture of lubricating oils. High titre hydrogenated fish body oil fatty acids are particularly suitable for making heavy duty greases made from aluminum and lithium soaps. Emulsion of fish oil in water is used as cutting or machining oil which serves as lubricant and also as a coolant. Some specialized lubricants of low viscosity for delicate machines are made from whale head oil.

e) Fish oils in insecticidal applications

Fish oil fatty acids are found to possess insecticidal properties. Sodium and potassium soaps of fish oil are used as insecticide in horticulture and plantation crops. Fish oil rosin soap is a commercially available product used as an insecticide/repellent.

f) Protective Coating for boats

Sardine body oil is being used in India and abroad as a protective coating for wooden boats. After coating, fish oil undergoes oxidative polymerization and forms a protective coating.

g) Other Uses

Hydrogenated fish body oil is being used in the manufacture of washing soaps.



Check Your Progress 2

Note: a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

- 1) Name two oil soluble vitamins present in fish meal?
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- 2) Name the fatty acids which lower blood cholesterol?
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- 3) Name the diseases (other than vitamin deficiency diseases) which can be treated using fish oils.
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- 4) While ingesting unsaturated fats like fish body oil or the products derived from it, Vitamin should be ingested to prevent *in vivo* peroxidation.
- 5) High titre hydrogenated fish body oil are particularly suitable for making
- 6) Name the preparation made from fish body oil as an insecticide

2.5 FISH MEAL IN POULTRY, ANIMAL AND FISH FEEDS

Fish meal is a well proven source of protein in animal feeds. It is an important ingredient in both compounded feed and homemade feed. The determination of marginal values and cost is an essential and very valuable part in feed formulation exercise. Similarly, it is also important to estimate the nutrient levels in the ingredients. In poultry rations, the essential nutrients which are at limiting levels are energy, crude protein, methionine, lysine, tryptophan, isoleucine and threonine (all essential amino acids present in good quality proteins), phosphorus and calcium (The last two are available at comparatively low cost).

Thus, the value of feed ingredient in a poultry feed is defined as the cost of obtaining these nutrients from it, especially the nutrients which are at limiting levels.

An important factor in poultry rations is that apart from cereals and salt/limestone, a bulk of weight of ingredients which contain all the essential nutrients should be

included. Under these circumstances, fish meal is very important because it is relatively a concentrated source of all the essential nutrients.

The relative values of fish meal and other known sources of nutrients are listed below (Table 2.1):

Table 2.1: Relative Values of Fish Meal and other known Sources of Nutrients

Source	Metabolizable Energy	Crude	Methionine Protein	Lysine	Tryptophan	Available Phosphorus
Fish meal	100	100	100	100	100	100
Soya bean meal	92	68	38	57	78	3
Groundnut meal	104	78	33	37	66	6
Rapeseed meal	83	58	39	43	69	10
Meat Meal (Slaughter house waste meal)	75	78	40	63	54	111

*No allowances have been made for nutrient availability, only their relative values are shown in the table.

In practice, several nutrients are screened. It can be seen in the table that fish meal is remarkably a rich source of all those nutrients which are of importance in practical poultry nutrition.

2.5.1 Fish Meal in Poultry Rations

Taurine is one of the important naturally occurring sulphonic acids responsible for growth promotion in poultry; these are of special interest in poultry.

Fish meal inclusion in poultry feed is beneficial and results in better feed conversion. The level starts from 3% for growers and up to 7.5% for broilers, layers and finishers. A limiting factor in the use of fish meal in poultry feed, is the occurrence of off-flavours, described as fishy taint in poultry meat and eggs; this is due to the presence of poly unsaturated fatty acids. Several precautions are taken to minimize this, which includes selection of low fat fish meal and stabilizing the fat using antioxidants. It is also advisable to reduce the addition of fish meal to about 1.0% of the total feed for finishers and withdraw fish meal in finisher feed about 2-3 weeks before slaughter.

2.5.2 Fish Meal in Animal Nutrition

In pig rations, fish meal is a valuable feed supplement and are said to have protein of the highest quality. In addition, fish meal supplies appreciable amounts of minerals and vitamins. Producers aiming to achieve the most cost effective profitable performance in terms of feed conversion, faster growth and better health, use fish meal for smaller pigs and the level of fish meal additions are upto 12% and for larger ones restricted to 10%. The use of fish meal in pig rations reduces the risk of deficiencies of certain trace minerals and vitamins; nevertheless, vitamin A and D must be added to all diet. The nutritional limitation to the use of fish meal in pig feed is the risk of fish oil taint in the meat but with fish meal containing 6% oil fed up to the day of slaughter has not affected the flavour.

In ruminants, the fish protein is not easily degraded by bacteria in rumen; this is to say that it has a high proportion of un-degradable dietary protein (UDP). Fish meal is rich in both rumen degradable (DP) and un-degradable protein (UDP). Both play vital role in metabolism of ruminants. The DP helps to deal more effectively with grass by supplying amino acids which stimulate rumen bacteria and help them to break down the nutrients in the forage; the UDP passes through the rumen un-degraded and into digestive system where, it is assimilated with minimal wastage. Fish meal has ideal balance of amino acids essential for milk production, the major ones are lysine, methionine, histidine and arginine. Feeding fish meal can also improve conception rates. The compounded meal is fed at the rate of 6 to 8 kg per animal per day.

2.5.3 Fish and Shrimp Nutrition

In aquaculture, formulated feeds are given as supplement to natural foods and in intensive culture, the fish and shrimp depend primarily on commercial feeds which are concentrated diets and nutritionally complete.

As with other animals, the nutritional requirement of fish and shrimp change during each stage, fry and fingerling in case of fish, and pre-larvae, post larval stages in shrimp.

Feeds are expensive and may account for about 50 to 60% of the total variable cost of production. Therefore, it is desirable to maximise feed utilization. Feed quality and cost are directly related and improvement in feed quality which inevitably increases the feed cost. Fish meal and oil form important ingredients in aquaculture feeds due to the presence of good quality proteins and fatty acids. Good quality fish meal contains 60% to 70% protein by weight. From a nutritional point of view, fish meal is the preferred animal protein supplement for the diets of farm animals and often a major source of proteins of cultured fish and shrimp. Typical diets for fish may contain from 32 to 45% total proteins by weight and diets for shrimp may contain 25 to 42% total protein. For the production of table fish, the grow out feeds contain 28 to 30% protein in the diet. The percentage inclusion rate of fish meal in diets for carp and tilapia may be from 5 to 7% and it is 40 to 55% for trout, salmon and some marine fishes. In shrimp feed, fish meal may be incorporated up to 50% of the total feed weight. Generally, sterilized fish meal, an indirectly dried meal is preferred by shrimp feed manufacturers. Fish meal is valuable for shrimp feed and fish feed as it contains unidentified growth factors and protein utilization factor in addition to all other known nutrients.

2.6 STANDARDS OF FISH MEAL

The quality of fish meal is directly related to freshness of the raw material, conditions of manufacture and storage. Temperature control during cooking and drying is very important as the proteins and lipids are very sensitive to temperature. In addition, good hygiene is necessary on board the fishing vessel, fish landing centre and in the fish meal manufacturing plant in order to prevent contamination of harmful bacteria.

Bureau of Indian Standards (BIS) has classified fish meal into three grades based on protein content. Grade I fish meal should contain more than 60%, Grade II not less than 50% and Grade III less than 50% protein. Specifications for grade I and II fish meal are presented below (Table 2.2):

Table 2.2: BIS Specifications of Grade I and Grade II Fish Meal

Grade Parameters	Grade I	Grade II
Moisture (Maximum)	10 %	10 %
Protein (Minimum)	60 %	50 %
Fat (Maximum)	10 %	10 %
Sand (Maximum)	3 %	3 %
Ammonical Nitrogen (Maximum)	0.50 %	0.5 %
<i>Salmonella</i>	Nil	Nil

In the above specification, maximum level is prescribed for moisture because if it exceeds this limit, several deteriorative changes take place specially growth of certain fungus and consequent production of toxins. High moisture content in meal makes it unstable and develop obnoxious odour which is undesirable. Fish meal is incorporated into feeds primarily as a source of high quality protein and hence minimum level is prescribed. Fat or lipids can be considered as a nutrient because of high metabolizable energy, but if it is present in higher proportion, it may cause more harm. Moreover, when fish meal with higher proportion of fat is fed to animals or birds, fishy taint in animal products such as meat, poultry and eggs is observed. Hence, minimum limit is prescribed for fat. High salt content in the feed leads to wet droppings in poultry and it is not desirable. Sand content in the fish meal is high if it is manufactured from fish caught by shore seines and when fish is directly landed on the beach. Ammonical nitrogen is an indication of extent of putrefaction of fish that has taken place prior to meal manufacture.

Many-a-times, fish meal may contain specified levels of protein, fat, moisture, salt and sand but fail to produce satisfactory growth in animals and birds, or even worse causing mortality. This is because of certain deteriorative changes taking place prior to processing, during processing and storage. If the fish or meal is exposed to high temperature, a toxic compound namely, gizzarosin is formed which in turn causes erosion of gizzard lining of poultry. In addition, such exposure leads to oxidation and oxidative polymerization of fat which in turn reduces the digestibility of proteins and reduction in biological availability of lysine present in fish meal. The significance and principles of estimation of important quality parameters have been presented as follows.

1) Protein content

For the estimation of protein content, nitrogen present in the fish meal is first estimated by Kjeldahl method. As fish proteins contain 16 % nitrogen, estimated nitrogen percentage multiplied by 6.25 (factor of conversion of nitrogen to protein) gives percentage of protein present in the meal.

2) Fat content

Fat is generally estimated by extracting a known weight of fish meal using solvent such as n-hexane or petroleum spirit (petroleum ether) using a Soxhlet extraction unit. Finally, traces of solvent present in the flask is driven off and the flask is weighed to calculate fat percentage in the meal.

3) Moisture

Moisture content in the fish meal is determined by taking 2 to 5 grams of sample and keeping in a moisture bottle at 100° C in a hot air oven till it reaches a constant weight. The loss in weight of the sample at the end of drying of the sample represents the moisture present in the sample and calculated as percentage.

4) Salt

The salt content determination is based on the assumption that all the water soluble chlorides are in the form of sodium chloride (salt). The chlorides are estimated by argentometric titration using standardized silver nitrate solution.

5) Sand

Sand content in fish meal is estimated by burning off all organic matter present in a known weight of fish meal sample using muffle furnace at about 550° C. The ash that is obtained is dissolved in hot dilute hydrochloric acid solution. The part of the ash which is insoluble in the acid solution is considered as sand.

6) Pepsin digestibility

High quantity of protein in a material alone does not make it a high quality material as a feed ingredient. The digestibility of protein in a biological system can be a measure of its quality. This concept led to measuring digestibility of a protein using the enzyme Pepsin in the laboratory. The ability to digest proteins by pepsin or pepsin digestibility is a reliable means of differentiating the quality of proteins in various fish meal samples.



Check Your Progress 3

- Note:** a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

- 1) Name any one factor present in fish meal which is responsible for growth promotion in Poultry?
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- 2) In poultry feed for growers, fish meal is incorporated at _____% and for broilers up to _____% .
- 3) Fishy taint in poultry meat and eggs can be minimized if meal containing _____ is incorporated.
- 4) Good quality fish meal contains _____ to _____ % protein in it.
- 5) The Grade I fish meal should contain a minimum of _____ % of protein as per B.I. Standards
- 6) More ammonical nitrogen in a given sample of fish meal is an indication of _____ of fish prior to manufacture of meal.

2.7 PRECAUTIONS TO BE TAKEN DURING STORAGE

Fish meal generally contains less than 10 % moisture and it is hygroscopic in nature. When exposed, it absorbs moisture from atmospheric air and forms lumps. Such lumps of fish meal are difficult to incorporate into other feed ingredients and distribution of fish meal in feed will not be uniform and representative. Such absorption of moisture by fish meal should be prevented during storage not only for the reason mentioned earlier, but also it leads to microbial activity, growth of undesirable fungus and formation of aflatoxins. Therefore, fish meal is usually packed in jute or paper bags, high density polyethylene (HDPE) or polypropylene (PP) woven sacks which are lined with polyethylene lining to act as a barrier to moisture.

Fish meal is highly reactive due to its content of highly unsaturated fats. These fats easily get oxidized. Moreover, fat oxidation reaction is exothermic and hence temperature of fish meal in stacks continuously increases and sometimes spontaneous fire can occur and burn the whole stack of fish meal. This problem is minimized by incorporating antioxidants into fish meal during manufacture and by properly packing the fish meal as explained above and excluding air during packing. In addition, the bags of fish meal are stored in small stacks with air gaps between the stacks in well ventilated warehouses.

Salmonella is a major problem in fish meal. Even if *Salmonella* is present in the raw material for fish meal, it is destroyed during processing. Therefore, should *Salmonella* occur in fish meal, it is due to contamination during packing and storage. In order to minimize the risk of *Salmonella* contamination, the following precautions should be taken.

The premises around the factory and storage should be well maintained to keep away rodents, insects, flies and birds by installing insect screens and rat wires.

The dry storage should be separate from wet processing area. The storage shed should have concrete floor, leak proof walls and roof. Walkways to storage area should be kept clean and at the entry of storage, foot-bath mat charged with disinfectant should be provided for personnel working in the storage.

2.8 QUALITY CHANGES IN FISH MEAL

Properly manufactured, packed and stored fish meal should exhibit minimum changes in quality due to its low moisture content. However, because of its hygroscopic nature and the presence of highly reactive unsaturated lipids in it, some quality changes may be expected depending on the storage conditions.

Improperly packed fish meal, stored under humid condition, is likely to absorb moisture and the moisture content in the meal will increase. As a consequence, relative reduction in protein content of the meal occurs and even changes the quality grade of the fish meal; that is Grade I meal may become Grade II. Other changes such as microbial attack and subsequent formation of toxic substances due to increase in moisture content has already been discussed. When microbial growth occurs in fish meal, the free fatty acid content in the oil of fish meal also increases. Improperly packed fish meal exposes itself to insect and pest attack. Hence, it is not only important to pack the meal but also to maintain dry conditions to minimize pest attack.

Other important changes in quality are brought about by fat. Fish body oil especially sardine oil is highly unsaturated and easily gets oxidized to produce fatty peroxides and hydroperoxides which subsequently form carbonyl compounds such as aldehydes and ketones and the meal becomes rancid. These compounds react with free amino groups of proteins and free amino acids resulting in the formation of brown compounds. The reaction is termed as non-enzymatic browning reaction or Maillard reaction. Because of these reactions fish meal becomes dark during storage and such a meal is less acceptable to animals. Also, biological availability of lysine decreases when the meal is fed to the animals, in other words, biological value of proteins of the fish meal decreases. During oxidation of fat, heat is generated and due to rise in temperature of the meal, oxidative polymerization of fat takes place which in turn reduces the digestibility of proteins. Thus, improper and prolonged storage leads to darkening of the meal, changes in other quality parameters and reduction in overall nutritive value of fish meal.

? Check Your Progress 4

Note: a) Write your answers within the space provided.
b) Check your answers with those given at the end of the unit.

- 1) The moisture content in fish meal should be kept below 10 % for the following reasons?
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- 2) Which of the packages are used for packing fish meal?
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- 3) You can minimize insect and pest attack in stored fish meal by providing and
- 4) In order to minimize the risk of contamination in fish meal, the premises around the factory should be maintained in such a way that the birds, rodents, insects and flies are kept out.
- 5) Fish meal is in nature and absorbs when exposed to humid atmospheric air.
- 6) Name two carbonyl compounds formed from oil present in fish meal.
..... and

2.9 LET US SUM UP



There are several factors which bring about changes in fish meal quality especially during manufacture and storage. These factors not only bring about changes in sensory quality, but also affect the nutritive value of fish meal. Proximate

composition, namely content of protein, fat, moisture and ash are important in determining nutritive value. In addition, putrefaction that has taken place in fish prior to processing, presence of non-nutritive substances such as sand and salt, also affect the quality of fish meal. Hence, these factors are also taken into consideration in the BIS Standards for fish meal. Because of the hygroscopic nature of fish meal and the presence of highly reactive fat, certain quality changes such as increase in moisture content and consequent microbial attack, fat oxidation and browning reaction take place which bring down the nutritive value. By packaging, proper storage and by taking certain precautions during storage, not only these deleterious changes can be minimized, but also the contamination of *Salmonella*. The changes taking place in fish meal during storage results in both quality loss and physical loss due to spontaneous fire.

2.10 GLOSSARY

Aflatoxin	: Toxic compounds produced by some specific fungi.
Antioxidants	: Substances which retard the oxidation process.
Aquaculture	: It is practice of cultivating fish and shellfish.
Biogenic Amines	: Amines formed by bacterial decarboxylation of amino acids.
By-product	: Subsidiary product obtained while producing a main product.
Cardiovascular	: Related to heart and blood vessels.
Crude Fiber	: Indigestible polysaccharides present in foodstuffs which do not contribute towards energy metabolism.
Dry rendering	: Drying without cooking and pressing to prepare fish meal.
Eicosanoids	: Biochemicals synthesized from fatty acids which have specific physiological role in the body.
Exothermic Reaction	: Heat is given out during the reaction and the temperature of the reactants increases.
Foot-bath Mat	: Near the entrance, a shallow depression in which a wire mesh mat and water containing disinfectant are kept.
Histamine	: A toxic organic base formed in fish by decarboxylation of histidine.
Hygroscopic	: Materials capable of absorbing moisture from the atmospheric air.
<i>In vitro</i>	: In an artificial environment outside the living organism.
<i>In vivo</i>	: Inside a living organism.
Limiting Amino Acids	: Amino acids which are not present in required quantities.
Livestock Feeds	: Feed for poultry, cattle, pigs etc.

Lysine	: An essential amino acid occurring in large quantities in fish proteins.
Metabolizable Energy	: Components undergoing biochemical changes in the body, ultimately to produce heat energy.
Miscella	: Solvent containing extracted fat.
Mutual Supplementation	: When two proteins are mixed and ingested, the deficiency of an amino acid of a protein is supplemented by the other protein and <i>vice versa</i> .
No. 8 Tyler Screen	: A standard sieve with a specified mesh size.
Oxidative Polymerization	: Formation of large molecular weight compounds by absorption of oxygen and by chemical reaction.
Pepsin Digestibility	: The amount of soluble components formed by hydrolyzing the proteins using the enzyme, pepsin.
Polyunsaturated Fatty Acids	: Long chain fatty acids containing three or more double bonds.
Purse Seine	: Net used for catching shoaling pelagic fish.
Putrefaction	: Decomposition of fish tissues by bacteria.
Shore Seine	: A net operated from the shore for catching shoaling fish.
Squalene	: Highly unsaturated hydrocarbon present in liver of certain species of shark.
Thrombosis	: Clot formation in blood vessel which obstruct the flow of blood.
Tryptophan	: An essential amino acid present in proteins of cereals and pulses but occurring in deficient quantities in fish proteins.
Wet Droppings	: Faeces with watery (liquid) consistency.
Wet Rendering	: By cooking, pressing and drying for fish meal preparation.

2.11 SUGGESTED FURTHER READING



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Malcom Windsor & Stuart Barlow.1981. *Introduction to Fishery By-products*. Fishing News Books Ltd., Surrey, London.

2.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

- 1) 40% to 60%
- 2) Lysine
- 3) Riboflavin, niacin pantothenic acid, choline, Vitamin B₁₂
- 4) Vitamin A and D
- 5) Calcium, phosphorus and magnesium

Check Your Progress 2

- 1) Vitamin A and Vitamin D
- 2) Polyunsaturated fatty acids
- 3) Rheumatoid arthritis, asthma, tumors and psoriasis
- 4) Vitamin E
- 5) Heavy duty greases made from aluminum and lithium soaps
- 6) Sodium and potassium soaps

Check Your Progress 3

- 1) Taurine
- 2) 3% for growers and up to 7.5% for broilers
- 3) Low fat fish
- 4) 60% to 70% protein
- 5) 60%
- 6) Putrefaction

Check Your Progress 4

- 1) Lump formation; fungal growth and formation of aflatoxin.
- 2) Polyethylene lined jute bags or HDPE or PP woven sacks with polyethylene lining.
- 3) Insect screens and rat wires
- 4) *Salmonella*
- 5) hygroscopic, moisture
- 6) aldehyde, ketone