UNIT 8 SILAGE AND SHARK SKIN

Structure

8.0 OBJECTIVES

After reading this unit, you will be able to:

- identify the suitable raw materials for the preparation of fish silage;
- describe the preparation of different silages;
- differentiate the different types of fish silage;
- justify the principle of preservation of acid fish silage and fermented fish silage; and
- explain the processing and utilization of shark skins.

8.1 INTRODUCTION

Silage production is considered as one of the best ways of preserving agro and animal wastes. Do you know what is silo? The process of storing grains or fodder in a silo (a pit or air tight container) is called ensilaging and the product is called silage. The word "silo" has traditionally been used in conjunction with green forage, preserved either by added acid or by the anaerobic production of lactic acid bacteria. The term "fish silage" has been adopted for analogous products of whole fish or parts of fish. Fish ensilage is a means of utilizing trash fish, by-catch and processing wastes, whilst supplying high quality protein for animals such as poultry, pigs, calves and other species such as mink. It is a stable liquid with a malty odour containing all the water present in the original material. Because of the increasing use of low-value fish for human food, production of fish meal has decreased and interest in production of fish silage has grown. Fish Silage was first developed in Sweden around 1940 and recognized as an alternative to fish meal in animal feeding. The first significant commercial production unit of fish silage was established in Denmark in 1948. In 1956, Freeman and Hoogland prepared fish silage from cod and haddock waste using sulphuric acid.

8.2 WHAT IS SILAGE?

'Fish silage' may be defined as a liquid product made from whole or parts of fish, to which acid is added and the liquefaction of protein is effected by the protein hydrolyzing enzymes already present in the fish. The liquefied silage contains the breakdown products of protein like polypeptides, dipeptides and amino acids. The acid normally added is organic acid like formic acid that is found to be more efficient when compared to mineral acid like hydrochloric acid or sulphuric acid. If we use organic acid, the pH should be brought down to 4.5 and less quantity is required (i.e. 3.5% of acid on w/v basis). Fish residues, trash fish and discards from fishing vessels and wastes from fish processing factories and cutting waste from fish markets can be used for the production of fish silage. The utility of these wastes can be upgraded by this method. Moreover, the problems of waste disposal and associated environmental issues can be successfully overcome by conversion into fish silage. This approach is friendlier toward the environment, safer and more flexible technology and economically more efficient than manufacturing fishmeal.

8.3 RAW MATERIALS

Let us now learn what are the raw materials which can be used in the preparation of silage.

8.3.1 Trash Fish and Fishery Waste

You will be surprised to know that all species of fish and fish wastes can be converted into silage. Silage production is an economical way of using by-catches from shrimp trawlers, fresh fish and fish offal. Annual discard from the world fisheries was estimated to be approximately 20 million tonnes (25%) per year. This includes "waste" or by-products also. Only 36,000 tonnes of the by-products were used for human consumption that amounts to about 15.5 % of the total. The rest is used for the production of fish meal, silage and animal feed. Therefore, silage has a great potential for the fishing industry to utilize more of what is landed. Fish and fishery waste containing more mineral content requires

more acid for proper ensilaging.

8.3.2 Surimi Processing Waste

Surimi is a wet frozen concentrate of myofibrillar proteins of fish muscle. It is deboned, washed and stabilized fish mince. You have already learnt about this in the earlier course. The overall surimi manufacturing process is reported to be quite inefficient resulting in 12-20% yield from round fish to finished product. The bulk of the remaining solid waste (65-70%) ends up as fish meal. The wastage during surimi processing vary with species, size and season as well with the type of processing machinery used so that fluctuations in yield are to be expected.

The material balance during different steps of surimi processing is as follows:

In the filleting machine, 67.1% waste is generated and during deboning 1% waste is generated. If the unused sarcoplasmic protein that comes to 7.5% is included, 75.5% by weight of round fish generated as waste can be used for silage preparation. The surimi production in India is increasing every year and the export of surimi and fish fillet for the year 2004 is 31,509.5 tonnes and 421 tonnes, respectively. During the processing of the above quantity, about 95,000 tonnes of wastes could have been generated, which can be effectively used for the production of fish silage.

8.3.3 Cephalopod Processing Waste

Cephalopod (squids, cuttlefishes) that amounts to nearly 1.0 lakh tonnes is processed annually in India. The minimum quantity of waste available from the processing of cephalopods is more than 30,000 tonnes. Because of its unpleasant appearance and high moisture content, it is difficult to use it for normal uses. But, this waste can be converted into silage by a simple process.

? Check Your Progress 1

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) What is fish silage?

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2) What are the important raw materials available for the production of fish silage?

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8.4 ACID FISH SILAGE

Ensiling can be achieved either by treating the fish directly with a mineral acid (sulphuric acid) or organic acid (formic or propionic acid). The fish is partially digested and preserved by the action of acid. Among mineral acids, sulphuric acid or a mixture of sulphuric and hydrochloric acids is used to produce silage. The most commonly used organic acids are propionic, acetic and formic acids.

8.4.1 Preparation of Acid Fish Silage

A 3% by weight of 98% formic acid is added to the well ground fish mince and mixed well ensuring a pH of around 4 to prepare acid fish silage using organic acid. The whole fish is comminuted in a mechanical mincer and the required quantity of acid or acid mixture is added and the slurry is mixed well. After this process, the whole material becomes a good paste that can be stored in tanks with daily stirring (Fig.8.1). Within 15-20 days, the silage is ready for use.

For the successful production of acid silage, the following precautions are recommended.

- The material should be reduced in size, preferably to pieces of size 3-4 mm and acid should be thoroughly dispersed throughout the minced fish to avoid air pockets of untreated material where bacterial spoilage can continue.
- Periodic agitation (shaking) is necessary to bring about rapid liquefaction and a temperature of at least 20°C is desirable, since below this temperature, liquefaction is rather slow.

But, for fish with a high mineral content, even 8% (v/w) of a 1:1 v/v mixture of formic and propionic acids may be necessary. Silage preserved with formic acid has a shelf life up to one year in tropical conditions of storage. Since organic acids are more expensive, a combination of organic and inorganic acid is recommended. Cheap mineral acids like sulphuric acid or hydrochloric acid are used to lower the pH and organic acids like propionic or formic acids are added to it for antimicrobial activity. Phosphoric acid also has been used for making silage, but has to be combined with potassium sorbate (0.1%) as preservative to prevent mould and yeast growth.

Acid preserved fish silage liquefies rather quickly and after about a week in tropics, up to 80% of proteins become solubilised. The liquefied silage separates into 3-4 layers; an oily layer at the top, sometimes with an underlying emulsified layer, an aqueous middle layer containing the liquefied proteins and a sediment or sludge containing the undigested protein, scales, bones etc. The liquefaction is due to a wide variety of endogenous proteases (enzymes) present in the fish.

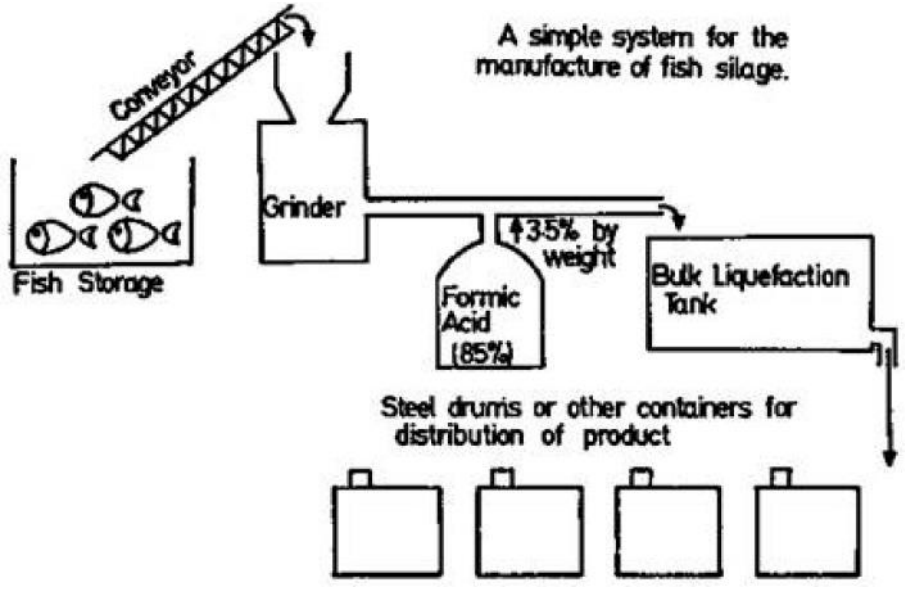

Fig.8.1: A schematic representation of fish silage preparation

8.4.2 Principle of Preservation of Acid Fish Silage

You must realize that the un-ionized acid molecules of the acid are able to cross the cytoplasmic membrane barrier of the microbial cell wall. But, the acid anions cannot cross the bacterial cell wall. But, once inside the cell, the acid molecules get ionized and the membrane traps the ions. Thus, the pH inside the cell gradually comes down killing the bacterial cell. Thus, it is the un-ionized acid molecules that are responsible for the preservative action in fish silage rather than the total acid concentration. At equal concentrations, organic acids are weakly ionized in solution when compared to inorganic acids, thus contain greater amount of un-ionized (free acid) molecule making them more effective preservatives. Thus, in acid fish silage all the bacterial cells are destroyed and the spoilage of the product is prevented.

8.4.3 Quality Problems in Acid Fish Silage

Although a high conversion of proteins to small peptides and free amino acids promotes better liquefaction and separation, it has its own disadvantages because of the following reasons:

(a) the aromatic amino acids separated from the aqueous phase due to their low solubility may even crystallize out;

(b) higher leaching losses can occur when such silages are incorporated into feeds due to their greater solubility; and

(c) intact proteins appear to be utilized better in feeds especially fish.

To curtail the excessive hydrolysis, different methods like heating the mixture to inactivate the proteinases, addition of formalin or addition of ginger and potato extracts have been tried out.

The degree of autolysis and protein solubilisation in silage varies with the nature of raw material ranging from 80% in temperate fishes and 40-45% in tropical fishes like silver bellies. The undigested proteins appear to be peptide aggregates held together by non-covalent forces. Proteolytic breakdown of the silage does not proceed to completion and the presence of residue resistant to proteolysis has been reported.

The exact reason for the incomplete proteolysis is not fully understood so far, but pH, temperature, duration of ensilation and nature of raw materials appear to play an important role for this phenomenon. The autolysis resistant sediment of fish silage consists of a large portion (about 50%) which is soluble in water and a true insoluble portion. Non-polar, ionic and other association forces seem to be responsible for the insolubility of the rest of the sediment. The sludge is highly nutritive, but it is not suitable for animal feeding because of its high lipid content, which may lead to carcass tainting and impaired performance of the animals.

? Check Your Progress 2

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) Which acid is commonly used for the preparation of acid fish silage?

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2) How fish silage is prepared using acid?

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3) What are the precautions to be taken for the successful production of acid silage?

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4) Explain the principle of preservation of acid fish silage.

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5) What are the problems associated with high liquefaction in acid silage and what are the remedial measures.

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8.5 FERMENTED FISH SILAGE

The principle of fermented silage is similar to that of acid silage; preservation is the result of acidity arising from the growth of lactic acid-producing bacteria. The technology relies on the production of lactic acid at a rapid rate in sufficient concentrations by fermentation, which suppresses spoilage organisms and preserves the feed until it is needed. The production of fermented fish silages depends on *in situ* production of lactic acid by lactic acid bacteria (LAB) added to the fish with a fermentable carbohydrate source. Since the natural LAB in fish is limited, an external inoculum of LAB is necessary.

Lactic acid fermentation represents a low- cost method for the preparation of food and feed products characterized by high hygienic quality and improved shelf life. Good quality fermented silage is found to have the following characteristics:

- Rapid drop in pH from about 6.0 or 6.5 to below pH 5.0. The more successful the fermentation, the more rapid the drop and the lower the final pH value.
- High lactic acid content. The level usually increases sharply during the first few days and remains fairly constant for the rest of the fermentation.
- The ammonical nitrogen content is low.
- Low anaerobic spores former and coliform count.
- No pathogens such as *Salmonella* spp. or *Streptococcus* spp.
- An acceptable fishy smell.
- The volume of gas generated during fermentation is relatively small.
- Remains stable for more than six months in the wet form and more than one year in dehydrated form.

The autolytic activity occurring during the ensilation of fish leads to an increase in the concentration of ammonia, amines, amino acids and peptides. Up to 80% of

the organic nitrogen becomes solubilised in acid preserved fish silages whereas, ensiling by the biological methods yields solubilisation values of around 60%.

8.5.1 Preparation of Fermented Fish Silage

Mixing fish/fish waste with a fermentable sugar source and a starter culture of lactic acid bacteria makes fermented fish silage. The production of fermented fish silages depends on *in situ* production of lactic acid by lactic acid bacteria, which are added to the fish along with a fermentable carbohydrate source. An external inoculation of lactic acid bacteria becomes necessary, as the bacteria are naturally present in few numbers to start a fermentation process. The various species of lactic acid bacteria used in fish silage are *Lactobacillus plantarum*, Yogurt bacteria like *L. bulgaricus* and *Streptococcus thermophilus*, *L. delbruecki* spp. *Bulgaricus* and *S. salivarius* spp. *Thermophilus*, a marine yeast, *Hansenula montevideo* and natural innocula like sauerkraut (fermented cabbage). *Lactobacillus plantarum* appears to be the most effective starter culture.

By-catch or fish wastes, preferably chopped or minced, are placed in non-metallic vats and mixed with a single carbohydrate source, such as cassava, sweet potato or molasses or a mixture of these at 15-20% level and inoculated with LAB at 5% level (v/w). It is stirred well and stored in airtight condition. Periodic agitation and temperatures of at least 20°C tend to induce rapid liquefaction of the raw material. Cooking the minced mass with molasses for 20 minutes and cooling before adding the inoculum will give a better result.

8.5.2 Principle of Preservation of Fermented Fish Silage

Fish silage is preserved against microbial spoilage mainly by the lowered pH, obtained by the added or *in situ* produced acid. In case of fermented silage, preservation occurs by several means. The presence of fermentable sugar is the beginning of the ensilation process which prevents immediate deamination of amino acids by bacteria that would lead to ammonia production and foul smell. Later, as the fermentation by lactic acid bacteria becomes dominant, spoilage bacteria are suppressed or killed by the increasing concentration of lactic acid, lowered pH and the production of several antibiotic substances called bacteriocins by the lactic acid bacteria.

8.5.3 Fermented Fish Silage vs Acid Silage

Fermented Fish Silage	Acid Silage
Fermentable carbohydrate and bacterial culture are added to minced fish waste.	Organic acid is added to the minced fish waste.
The production of fermented silage depends on the *in situ* production of lactic acid by the added bacterial culture.	In acid silage, the acid added exert their preservative action by the passage of the undissociated acid molecule into the bacterial cell where it dissociates and lowers the pH to kill the organism.
The extent of protein breakdown is normally lesser in fermented silage (up to 50 -55%) and it takes 10 days.	Acid preserved fish silages liquefy in a week time and up to 80% gets solubilised in tropical conditions.
Bacterial cells are destroyed due to acid as well as due to bacteriocins produced by the LAB.	Bacterial cells are destroyed due to acid only.
Production of ammonical nitrogen is more.	Production of ammonical nitrogen is less.

8.5.4 Natural Sources of Starter Culture

You must remember that the use of bacterial cultures would obviously be a deterrent for low technology processing by smallholders. It is therefore interesting to note that although raw materials low in lactic acid bacteria content generally benefit from the use of suitable innoculants, it is not always essential that they be included. The smallholders could well be able to produce fermented silages without the need to produce or purchase starter cultures provided that appropriate mixtures of fermentable and non-fermentable materials are selected.

a) Papaya latex

The papaya latex fermentation technique was developed for fish silage preparation, in which 5% level of papaya skin peel was added with molasses to the cooked and cooled fish and the pH changed to 4.0 in 72 hours. It is likely that the micro-organisms present in the skin of papaya initiated the production of acid by microbial fermentation

b) Fermented cabbage

One day old fermented cabbage at 5% level as bacterial inoculum can be used for the production of fermented silage. It is added to the cooked fish and minced well which attains the required pH of 4.4 in 48 hours when kept in airtight plastic containers.

c) Buttermilk

Buttermilk at 5% level as inoculum instead of LAB starter was tried and it was observed that the pH dropped to 4.5 in 24 hours and the silage so obtained had similar odour, flavour and composition as that of LAB fermented silage.

8.6 NUTRITIONAL CHARACTERISTICS OF FISH SILAGE

Fish and marine invertebrates are important sources for nutrients for the world population, and many species have exceptionally high market value. The utilization of fish in different forms depends upon the quality and availability. Fish silage is a nutritionally balanced diet extensively used in feeds in combination with other ingredients. It is found to be superior to other protein diet of plant or animal origin. Simple method of preparation and long shelf life make it a preferred choice of preservation of trash fish and fish waste. The nutritional qualities of fish are preserved in silage and in case of fermented silage, it is enhanced. The nutritional composition of fish silage is almost similar to fish except a slight increase in moisture content. In many countries, seafood constitutes the main source of animal protein in human diet. The protein content of the silage is in the range of 16-19%; the protein content of different types of fermented silages are more or less same as that of fresh fish. The fat content of fish silage varies according to the fat content of the species used. With the same fish a higher level of fat (3.6% - 5.1%) in acid silage and nearly 1% fat in fermented silage was noted. The presence of oil with high levels of polyunsaturated fatty acids (PUFA) makes it prone to oxidation. The ash content of silage also depends on the nature of the raw material used; a higher level of ash can be expected if fish waste is used for ensilation. Generally acid silage contains less ash compared to fermented silage when the same raw material is used probably due to the minerals present in the added molasses.

8.7 ADVANTAGES AND USES OF SILAGE

Silage production could have many advantages for the maritime countries as it can make use of trash fish, by-catch fish and fish waste from processing industries which are currently wasted. The scale of operation can be easily varied depending on the supply of fish. The conversion of fish waste to silage has the advantage of being an inexpensive supplement for animal feeds while at the same time reducing waste and environmental contamination.

The degree of hydrolysis of the protein in fish silage is likely to affect the nutritive value for ruminant livestock. The small peptides and amino acids formed during ensilage are more readily available to the ruminal microflora. When metabolized by the microflora in the rumen, the efficiency of nitrogen utilization by the animals can decrease and toxicity problems can occur, particularly when the animals are on a low energy diet. The lower degree of hydrolysis in biological fish silage can thus, for these animals, be regarded as advantageous from the nutritional point of view.

Storage and feeding study of co-dried fermented silage from *tilapia* for catfish (*Clarias gariepinus*) was conducted and it was observed that the protein quality of wet *tilapia* silage was reduced during storage; there were no differences ($P > 0.05$) in the apparent protein digestibility coefficients. It is suggested that autolysis in the stored *tilapia* silages had little effect on protein digestibility in the catfish. However no decrease in weight gains was observed when chicken were fed diets in which autolysed fish silages contributed up to 400g/kg of the total dietary protein.

The nutritional assays for broiler showed a net increase in the weight relatively to the control diet when fed with silage. All the formulae made with the combinations of different proportions of silage and ingredients resulted in similar growth of broilers compared with the commercial control feed formula. Broiler chicks fed with a ration containing 5% and 10% fish silage reported better ($P < 0{\cdot}05$) feed efficiency than did birds fed a ration with no silage. Results indicate that up to 10% fish silage could be included in broiler rations without adversely affecting feed efficiency or body weight.

Fig. 8.2: Feeding trials of duck with fish silage

Feeding trials (Fig. 8.2, 8.3 & 8.4) performed on several species of birds and monogastric (single stomach) animals showed that it might be advantageous to have some pre-digested protein in the diet, but there is a limit over which the animals would have difficulties in using the absorbed protein for synthetic purposes. The nutritional evaluation conducted in chicken showed that feed containing up to 8% silage showed similar results as control, but a high level (29%) had shown a

depression in growth. Feeding trials carried out with mice and chicken showed that the fish silage was suitable for use either as a complete or partial replacement in the diet of young animals. Acceptability by the trial animals was good and no ill effects were observed.

Fig. 8.3: Feeding trials of pigs with fish silage

Fig. 8.4: Feeding trials of calf using acid fish silage

Fish silage has several advantages over fish meal. It is generally a better preferred option of waste utilization in small operations and works well on large or small fishing vessels or even in small isolated places with little fish production, which is economically not feasible for a fish meal plant.

With a few exceptions, acid or fermented fish silage showed better performance compared to control (fish meal or soy meal) in fish and shell fish. A variety of fresh water and marine fish have been raised with fish silage with no apparent ill effects. The use of fish ensilage has been proved to be effective in the feeds of salmon and in Indian major carps. It has been observed that the simpler peptides present in ensilage are easily assimilable (absorbable) by fish. Equal to or better growth than control for African catfish was reported when fed with 38% of fermented sardine silage. Better growth performance of common carp when fed with 30.8% protein as fish silage has also been reported. When Atlantic salmon were fed with fermented silage, it showed no difference in fillet flavours between silage and control diets. Fish silage diets seem to be advantageous in the crucial early stages of aquaculture as better larval growth and survival rate have been reported with hybrid striped bass and sea bass respectively.

8.7.1 Problems Associated with Silage and its Remedies

The disadvantage of fish silage is that it is more bulky and difficult to transport than fishmeal. Oil retained in fish silage can become oxidized, rendering the feed unpalatable or unsafe to livestock. To overcome these problems, the liquid silage

can be co dried after mixing with rice bran in the ratio of 1:2 (rice bran: silage) before transportation to the feed manufacturing plant.

Check Your Progress 3

Note: a) Use the space given below for your answers.

b) Check your answers with those given at the end of the unit.

1) For successful fermentation, an external inoculum of LAB is necessary. Why?

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2) Write down three points on good quality fermented silage.

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3) Write down the method of preparation of fermented silage?

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4) Write down two examples of feeding of silage in animals and what were the results?

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5) What is the disadvantage of fish silage? How can we overcome this?

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8.8 PROCESSING AND UTILIZATION OF SHARK SKINS

Sharks are cartilaginous fishes having uses in many different fields. The products available from shark include shark meat which is used as food; shark liver oil which finds applications in medical and pharmaceutical fields and shark fin rays used in the preparation of Chinese soups. The value of shark can be further enhanced if the skin also can be used for industrial purpose. Historically, shark skin has been used as an abrasive and, in Asia, to decorate sword hilts and sheaths. Dried but untanned skin, called shagreen, was once used like fine sandpaper for polishing wood. Shagreen was also used for the membranes on drums in the South Pacific. The most characteristic feature of shark skin is its roughness, resulting from the placoid scales, or denticles, embedded in the skin.

The skin of shark (Fig.8.5) is very tough and can yield good quality leather which compares very well with any other good quality animal leather. It is very important that the skin should be available in fresh condition with minimum damage. The skin is firmly attached to the flesh and it requires a special skill to peel off. This is a very important preliminary step in getting good quality leather after tanning.

8.8.1 Method of Separation of Shark Skin

Remove the head by cutting just below the gill slits.

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Remove the fins by cutting along the margin of the base by which the fin is attached to the body.

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Make a deep longitudinal cut on the body extending the whole length of the belly portion which will help in the removal of the muscle in convenient slices.

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Peel off the skin from head downwards by applying a slight pressure, releasing the ligaments, wherever it is firmly attached, by a sharp knife, taking care to see that the skin is not punctured anywhere.

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Scrape off the muscle, if any adhering to the skin.

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Rub the skin with fine salt crystals.

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Stack in stretched condition with the dorsal side down.

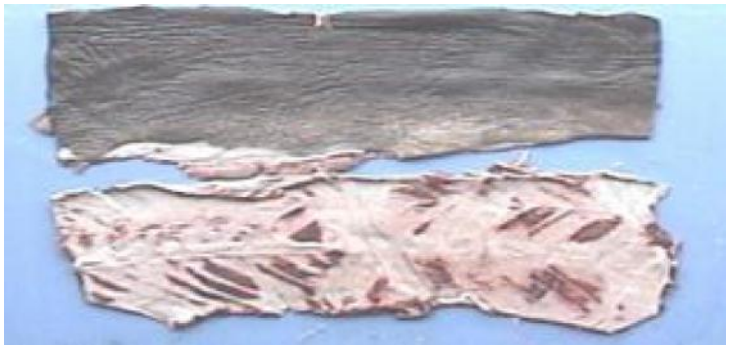

Fig. 8.5: Shark skin

The peeling of the skin of sharks measuring more than 4 feet in length is bit difficult as the attachment of the skin to the muscle is very firm. In such cases, suspend the shark in a strong hook after removing the head and fins and then peel off the skin. The shark skin can be converted to good quality leather after tanning, from which a number of fancy articles like shoes, handbags (Fig.8.6), straps etc can be made.

Fig. 8.6: Bags made of shark skin

Check Your Progress 4

Note: a) Use the space given below for your answers.
b) Check your answers with those given at the end of the unit.

1) What is shagreen and what is its use?

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2) What are the uses of shark skin?

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Activity 1

Visit a landing centre. Buy a gunny bag full of by catches. Use this to prepare fish silage using the methods described in the unit. Try to add the required percentage of silage in the feed of poultry or cattle.

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8.9 LET US SUM UP

Silage production is a very easy method for preserving the trash fish and fishery waste. Any type of fishery waste can be used for the preparation of fish silage and it does not require any sophisticated equipment except a homogenizer for mincing the raw material. The production of silage can be carried out in small quantities at any place even on board the fishing vessel. There are two types of silages. In the first case, *viz.*, acid silage, formic acid is added @ 3.5% and in the second case *viz.,* fermented silage or microbial silage, an external inoculum of lactic acid bacteria along with a fermentable carbohydrate is added and the acid produced *in situ* acts as preservative. Fish silage is highly nutritious and in case of fermented silage, the nutritive quality is enhanced. It is used in feeds of cattle, poultry, pigs and mink. It has been proved that fish silage is as good as fish meal in the feeds of domesticated and farmed animals and fish. Conversion of fishery waste into fish silage can yield a highly valued nutritional product with reduced environmental problems and investment. The value of shark can be further enhanced if the skin also can be used for industrial purpose after proper tanning.

8.10 GLOSSARY

Amino Acids : Amino acids are the building blocks of proteins. There are 20 standard amino acids with which almost all proteins are made out of.

Cephalopod : The cephalopods (Greek plural (kephalópoda); "head-feet") are the mollusks, class Cephalopoda characterized by bilateral body symmetry, a prominent head, and a modification of the mollusk foot, a muscular hydrostat, into the form of arms or tentacles.eg. squids and cuttle fishes.

Deamination : Deamination is the removal of an amine group from a molecule.

Ensilaging : Ensilage or silaging is the process of preserving green food or fishery waste for livestock in an undried condition in airtight conditions, either in a storage silo (an airtight pit), or in plastic wrapping after adding acid. The fodder which is the result of the process is called silage.

Fermentation : Fermentation is the process of deriving energy from the oxidation of organic compounds, such as carbohydrates, using an endogenous electron acceptor, which is usually an organic compound with the help of microorganisms.

Hydrolysis : Hydrolysis is a chemical reaction during which one or more water molecules are split into hydrogen and hydroxide ions which may go on to participate in further reactions.

Proteinases : A protease is any enzyme that conducts proteolysis, that is, begins protein catabolism by hydrolysis of the peptide bonds that link amino acids together in the polypeptide chain.

Polypeptides : Amide combining the amino group of one amino acid with the carboxyl group of another; usually obtained by partial hydrolysis of protein.

Poly Unsaturated Fatty Acids (PUFA) : Polyunsaturated fatty acids (PUFA) are those fatty acids which contain more than one double bond.

8.11 SUGGESTED FURTHER READING

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8.13 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Fish silage may be defined as a liquid product made from whole or parts of fish, to which acid is added and the liquefaction of protein is by the protein hydrolyzing enzymes already present in the fish.

2) Trash fish and fishery waste, Surimi processing waste and Cephalopod processing waste are the commonly available raw materials for fish silage.

Check Your Progress 2

1) Formic acid is the commonly used acid for the preparation of acid fish silage

2) A 3% by weight of 98% formic acid is added to the well ground fish mince and mixed well ensuring a pH around 4 to prepare acid fish silage. The whole fish is comminuted in a mechanical mincer and the required quantity of acid or acid mixture is added and the slurry is mixed well.

3) The material should be reduced in size, preferably to pieces of size 3-4 mm and acid should be thoroughly dispersed throughout the minced fish to avoid air pockets of untreated material where bacterial spoilage can continue. Periodic agitation is necessary to bring about rapid liquefaction and a temperature of at least 20°C is desirable.

4) Only the acid molecules can enter the cell but acid anions cannot cross the bacterial cell wall. Once inside the cell, the acid molecules get ionized and the membrane traps the ions. Thus, the pH inside the cell gradually comes down killing the bacterial cell.

5) (a) High liquefaction results in the separation of aromatic amino acids from the aqueous phase due to their low solubility may even crystallize out, (b) higher leaching losses can occur when such silages are incorporated into feeds due to their greater solubility and (c) intact proteins appear to be utilized better in feeds especially fish. To reduce excessive hydrolysis, different methods like heating the mixture to inactivate the proteinases, addition of formalin or addition of ginger and potato extracts etc. have been recommended.

Check Your Progress 3

1) Because fish does not contain sufficient number of lactic acid bacteria; to efficiently ferment the carbohydrate an external inoculum of LAB is necessary

2) Three points on good quality fermented silage are as follows:
   - Rapid drop in pH from about 6.0 or 6.5 to below pH 5.0. The more successful the fermentation, the more rapid the drop and the lower the final pH value.
   - Sufficient lactic acid content. The level usually increases sharply during the first few days, and remains fairly constant for the rest of the fermentation.
   - Low anaerobic spores former and coliform count and no pathogens.

3) By-catch or fish wastes, preferably chopped or minced, are placed in non-metallic vats and mixed with a single carbohydrate source, such as cassava, sweet potato or molasses or a mixture of these at 15-20% level and inoculated with LAB at 5% level (V/W). It is stirred well and stored airtight condition. Cooking the minced mass with molasses for 20 minutes and cooling before adding the inoculum will give a better result.

4) Feeding studies with fish silage for catfish (*Clarias gariepinus*) was conducted and it was observed that the protein quality of wet tilapia silage was reduced during storage; there were no differences ($P > 0.05$) in the apparent protein digestibility coefficients. The nutritional assays for broiler showed a net increase in the weight relatively to the control diet when fed with silage.

5) The disadvantage of fish silage is that it is more bulky and difficult to transport. Oil retained in fish silage can become oxidized, rendering the feed unpalatable or unsafe to livestock. To overcome these problems, the liquid silage can be co-dried after mixing with rice bran in the ratio of 1:2 (rice bran: silage).

Check Your Progress 4

1) Dried but untanned skin, called shagreen, was once used like fine sand paper for polishing wood.

2) The shark skin can be converted to good quality leather after tanning, from which a number of fancy articles like shoes, handbags, straps etc. can be made.