Fishery products are made from a wide variety of species found in aquatic environment and usually only the most desirable and easiest to obtain portions of the carcass is salvaged for human food. This leaves a large portion which is high protein and nutritionally desirable as byproduct. In addition, many unconventional known as trash species caught when fishing for food species can also be processed into useful products.

Low value fish are also considered to have high nutritive value as that of high value fish like pomfret, seer fish and cephalopods. The following is a description of some of the products that can be obtained from those unconventional species or trash fish.

**Fish protein hydrolysates**

Protein hydrolysates have attained an important place in the realms of man’s protein fortified foods and beverages. This is mainly due to their high solubility and digestibility. The technology of production of protein hydrolysates has become cheap and all machineries are available commercially. A variety of methods of production technique are available. The most common among them are listed.

**Acid hydrolysis**

The whole fish is cleaned well to free of slime and adhering dirt. They are then comminuted and cooked well with 2 to 6 N acid and maintained at about 90 - 100°C for 12 - 24 minutes to get a completely soluble finished product. Disadvantage of this process is that the final finished product will be acidic and has to be neutralized by alkali to bring the pH to 7.

**Enzyme hydrolysis**

Number of enzymes are used in the industrial production of hydrolysates. The enzymatic production of protein hydrolysates is perhaps the most convenient and cheapest technique. The process is fast and gives hydrolysates without much loss of essential amino acids. However, a suitable enzyme has to be selected for this purpose. The choice of enzyme depends on factors like stability, specificity etc. The important commercially available enzymes are papain, pepsin, bromelain, ficin and trypsin. Most protein hydrolysates are highly bitter in taste because it contains, peptones, peptides and free aminoacids. Hence, flavouring agents like cocoa, and jagery are usually added during their fortification in food preparation to mask their bitter taste.

Among the important proteolytic enzymes listed above the widely used ones are bromelain and papain. The industrial methods of production of protein hydrolysates using bromelain and papain are given below.

Commercially available enzyme is dissolved in citrate buffer of pH 6. It is centrifuged and the supernatant is taken. This is stable for 3 months.
Preparation of water fat emulsion

Ten parts of hydrogenised fat, antioxidant BHA or BHT(0.01%) and 0.15 part of sorbitan monostearate (emulsifier) are mixed together and heated to 65°C for about 10 to 15 min. To this, water containing 0.35 part sorbitan monostearate is added (90 parts) and the whole mixture is homogenized in a waring blender and then kept overnight. Next day the soluble oil water emulsion is separated from the excess fat and taken separately.

Hydrolysis: Take 100 parts mixed fish meat, 20 parts water and 80 parts oil emulsion and homoginate in a blender for 5 min. To the resulting pasty mass the enzyme stock solution is added (six parts by weight) and the whole mass is transferred into a reaction vessel maintained at 57°C. Hydrolysis is allowed to continue for 15 minutes with continuous stirring. After the reaction is over the mixture is heated to 80°C for 12 min. to deactivate the enzyme. The whole mass is again homogenized in a blender and then rapidly cooled to 5°C. It is filtered and the filtrate is dried in a spray drier.

Hydrolysis with papain

Enzyme stock solution. About 25g of the enzyme is taken in 100 ml distilled water and centrituged. The clear filtrate is taken.

Hydrolysis: Comminuted fish meat is cooked with water (1:1 W/V) for 15 minutes and this process results in sterilization of mixture also. The pH of the mixture is adjusted with acid to 6.5. The mixture is transferred to a reaction vessel maintained at 55°C and the enzyme is added to this mixture (1:30, enzyme nitrogen to protein nitrogen). The whole mixture is stirred vigorously and the hydrolysis is continued for half an hour until it is completed. The hydrolysates is filtered and centrifuged, and dried in vacuum to get a fine highly hygroscopic powder.

This can be incorporated in a variety of food preparation like soups, beverages etc as a protein supplement and there by enhance nutritive value.

Protein hydrolysates incorporated beverages

Protein hydrolysates are bitter in taste and as such unpalatable. One of the best ways to make the hydrolysates tasty is to add malt, cocoa, sugar and fat to the hydrolysates and the fortified mass is spray-dried to make it a fine powder which is highly hygroscopic and soluble in water. One such formula is given below:

Recipe

Composition by weight %

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish protein hydrolysate</td>
<td>30</td>
</tr>
<tr>
<td>Malt</td>
<td>20</td>
</tr>
<tr>
<td>Sugar</td>
<td>20</td>
</tr>
<tr>
<td>Milk powder</td>
<td>10</td>
</tr>
<tr>
<td>Fat</td>
<td>10</td>
</tr>
<tr>
<td>Cocoa</td>
<td>10</td>
</tr>
</tbody>
</table>

This product is found highly acceptable to consumers and acceptability with respect to taste, flavour and odour is over 90%. The protein efficiency ratio of the product is 22 compared to casein (37) at 10% level of protein.

Ambergris

Ambergris is a compound obtained accidentally from the sea and is valued fabulously because of its use in perfumery. Its rarity, uniqueness in chemical composition and high commercial value attributed to some real and certain unimaginative properties, make it one of the most priceless gift
of animal kingdom to man. It is often used in the East as an aphrodisiac although this particular property is not scientifically supported. It has a characteristic musk odour. It is used in blending of a large number of exotic perfumes. Ambergris is collected either from open sea or from seashores. It is often spotted in tropical and subtropical seashore of many countries like Australia, Newzealand, India and Bahamas. Eighty percent of ambergris is cholesterol. A fatty oil called ambreni, benzoic acid, some other steroids and hydrocarbons are also reported as its constituents.

Ambergris is now considered as a morbid concretion from the intestinal tract of sperm whale (Pterodonta, L. physodeidae) and probably only of male whale. It comes from the stomach of dead whale. This is based on the enormous size of ambergris cited in the past. A mass weighing 184 kg and 150 cm in girth and another weighing up to 418 kg were recorded in the past. This would have come from very big animal like whale. When sperm whale feeds on cuttlefish due to some injury or unknown reason the ambergris is formed in the intestines. This is based on the findings that small fragments of cuttlefish are seen in the ambergris when it is freshly collected.

Ambergris is normally jettisoned from the intestines when the whale dies. By constant exposure to sun and seawater ambergris hardens and develops a pleasant scent. A good quality ambergris is soft, waxy and gray in colour. Black ambergris is of poorest quality. Although it is sticky it can be kneaded with the fingers. A good quality and aged ambergris is found to have a concentric layered structure resembling that of onions.

Properties: It is grey to black waxy mass with characteristic odour.

Density – 0.8 to 0.92, Melting point 60 to 65°C, Softening point 45 - 65°C.

It is inflammable and almost volatile by heat. It is insoluble in water or alkali but soluble in hot alcohol, chloroform, ether, fats and volatile oils. It burns with a pale blue flame with characteristic musky odour (resembling the burning smell of rubber) without leaning scum or ash. It also floats on fresh and salt water.

Uses: it is widely used in perfumery on tincture and essence for fixing delicate odours. A good quality ambergris has commercial value ranging from $ 1000 to 2000 depending on its quality. Ambergris is usually found adulterated with whale fat.

Beche-de-mer

Holothurians or sea cucumbers belong to the class Holothuridae. They are entirely marine and distributed in all seas at all depths. They live in large numbers, coral reefs in seas around India, about 200 species of holothurians are known. In these about 13 species are of commercial importance. For processing into beche-de-mer holothurians which are large in size and having thicker body wall are used.

Some important commercially exploited species of holothurians available in Indian waters and are used for processing into Beche-de-mer are:

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holothuria Scabra</td>
<td>Sand fish</td>
</tr>
<tr>
<td>H. Spiquifera/ H. Atra</td>
<td>Lolly fish</td>
</tr>
<tr>
<td>Bobolusia marmorata</td>
<td>Chalky fish</td>
</tr>
<tr>
<td>B. argos</td>
<td>Leopard or Tiger fish</td>
</tr>
<tr>
<td>Actinopyga maritana</td>
<td>Surfred fish</td>
</tr>
</tbody>
</table>

In India the industry is mostly dependent on a single species Holothuria scabra (sand fish) at present. Considering the extensive exploitation and commercial importance it is worthwhile to note the characteristics of Holothuria scabra which is at present almost exclusively used for processing.
Industry

In most of the South East Asian countries and countries where ethnic Chinese population live, beche-de-mer is traditional cooking delicacy. Beche-de-mer in dry form is soaked in water, cleaned and cooked in many delicious ways, it is rich in proteins and has low fat content.

Handling and processing

The value of the product depends upon its shape, size and quality. Being soft-bodied animals, holothurians have to be handled with care after collection. Efficient handling practices through proper maintenance of cleanliness and hygiene on board, reduce losses during processing and keep the high quality of end product which can fetch maximum value for the product. To meet the required standard the following characteristics of the sand fish have to be considered during fishing handling and processing.

1. Like most holothurians, the sand fish eviscerates when disturbed.

2. Its skin ruptures, if keep out of water for long duration.

3. Sticks to each other with dried slime kept under direct sunlight.

4. The body wall shapes into holes or cervices of calcium

As soon as the sand fish is landed up a 2-3 cm slit is made near the cloaca. Pressing the body wall near the oral region facilitates rapid evisceration of gut and entrails. Any water that may remain inside the body is also squeezed out. Plastic fish boxes with smooth interior are ideal for holothurians onboard. Live one can regenerate its lost parts if returned to the sea. The use of ice is not recommended because the body wall raptures with cooling.

Processing of sea cucumber

Beche-de-mer in cylindrical shape is most preferred in the market. The animals are to be introduced in boiling water so that it is quickly killed in seconds. The first reaction of the animal to adverse situations like intense heat is into convex itself with the longitudinal and circular muscles. This facilitates formation of cylindrical shape.

Heating causes both outside and inside water of the animal to boil and hence pressure builds up inside the body wall burns up intest removed from the pan before boiling is reached. If the animals are introduced in the boiling water there is no chance of taking water and building up the pressure and consequent breakage of body wall.

A clean shallow saucer pan made of cast iron is filled to two third height with clean sea water and allow to boil. Eviscerated and water squeezed out animal may be put into the pan one by one till the water rises to nine tenth of the pan. It is stirred up with spatula ended pole for 45 minutes. Bottom layers may be made upside down carefully with the stirrer causing no damage to the animal. The boiling should be adequate enough to proceed to the next stage of processing. With a ring net end pole, the sea cucumbers are removed and allowed to cool on sand.

Removal of outer layer

Pigment and chalk like deposits on the ventral surface of the sea cucumber need to be removed to improve its market value. The traditional method followed involved bacterial decomposition of the outer layer. A shallow pit is made in the clean sandy beach. Cooled sea cucumbers are arranged in layers, packed and covered with jute hessian sack. Water is sprinkled to wet the sack and pit closed with sand. After 15 to 18 h, sea cucumbers have been decomposed and, pasty material is present. These are transferred
in to a plant fibre woven basket to half full and immersed in knee-deep water. Trample upon it until decomposed material is washed away. The sea cucumber at this stage will be cylindrical in shape, rubber like, wrinkled and ash grey in colour. After final wash, the sea cucumbers are spread on sand for removing those with white pigment and muddy skin for another round of boiling. These without any patches are ready for final boiling and drying.

**Final boiling**

To remove the remnants of bacteria, the material is stirred in boiling seawater for another 45 minutes. The product is removed and transferred to drying platforms or wire mesh trays for sun drying. Sea cucumbers are dried until the water content is reduced to 8.10%. The drying process also causes some shrinkage.

**Grading:** The product is graded according to size

a. Size - the larger the better
b. Appearance - smooth surface, uniform shape
c. Odour - pleasing, no decomposition smell
d. Colour - dark generally preferred
e. Moisture content - 10 to 23 % moisture content by weight, hard dry product.

**Chemical composition**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Protein</td>
<td>43 %</td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>2.2 %</td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>27.1 %</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>27.6 %</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>1.2/100g</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>2.5 g/100g</td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>7.5 mg/100g</td>
<td></td>
</tr>
</tbody>
</table>

**Iron**  - 16.5 mg/100g  **Insoluble ash** - 7 g/100g

**Caviar**

Salmon eggs are processed into caviar (smaller eggs). Roe of sturgeon (black caviar) or other fish (eg bream, carp, catfish or paddle fish, coalfish, cod fish, haddock, hake, herring, lumpfish, mullet, pike, salmon (red caviar), spoon bill, tuna or white fish) is prepared by a special process called maturation and salting (mild 3 to 4%, heavy 10%) and should be labeled by the type of fish. The salmon eggs are removed from the body cavity with viscera and separated from it by hand. The salmon eggs are subsequently preserved by freezing, salting or by a chemical treatment. In the salting process the eggs are washed in salt water and placed in a saturated salt brine containing added colour for 20 min. The caviar is then placed in boxes with salt added between the layers and allowed to cure for 1 week and subsequently stored at 5°C. Milt is separated from the viscera and each gallous is treated with 0.13 gallon of caustic soda solution 600g/l which is a preservative and is the first step in processing.

In addition to salting, salted dried roe can be produced by salting for 20 h, washing, draining and pressing and air drying for 20 days, during which the oil is spread on the surface. The roe is blanched by dipping for 3 minutes at 80°C water and packed for storage for up to 9 week. Dried roe has a composition of 16% moisture, 43% protein, 40% fat and 1% ash.

The composition of salmon eggs is 13% fat, 6.2% phospholipids and 0.4 cholesterol. The fat has 3% cholesterol, iodine number of 200 and 6% unsaponifiable. 53% of the unsaponifiable are cholesterol.

The protein of salmon eggs is high in lysine, methionine and isoleucine.
Seaweeds and products

From time immemorial man has utilizing seaweeds as food. Agar, algic acid and carrageenan are the most important phycocollid prepared from seaweeds.

Agar is prepared from the agarophytes Gelidiella acerosa, Gelidiella indica, Gelidiella pusillus, Gracilaria edulis, Gracilaria verrucosa, Gracilaria corticata and Gracilaria crassa.

The harvested or collected seaweeds should be thoroughly washed in seawater to remove the sand and other foreign materials. For keeping it for long period, seaweeds are to be dipped in 2% formalin. A cottage industrial method for the extraction of agar is as follows:

Sun bleached sea wees are washed in fresh water and wet grinded in a stone mortar to remove impurities and other foreign materials. Sea weeds are boiled with dilute mineral acids for few minutes. Agar gel obtained is filtered using a cloth filter. Gel is allowed to cool at temperature 0°C to 5°C. When it is thawed at room temperature water is removed. Freezing and thawing are repeated several times. By this method impurities and water are separated. The gel obtained is bleached and dried. After drying it is powdered and packed. The quality of the agar obtained is not very high in this method. By adopting alkali treatment method (treating seaweeds with 0.5N sodium carbonate or sodium hydroxide, prior to extraction very good quality agar can be prepared.

Uses of agar

Agar was the first phycocollid used in food industry. In human food industry, agar is used mainly as a gelling agent and in a secondary way as a stabilizing agent for controlling viscosity. It is also used as an additive. Usually 1 to 1.5 % solution is used for all purposes.

In confectionary to prepare jellies, marmalades, marshmall and fillers and candies or candy fillers. In marmalade production, agar is used as a thickening and gelling agent. In bakery it is used to cover cakes and icing. It is also used for dehydration of the confectionary. It is also used in gelly preparation and yogurt. Meat industry it is useful for sausage preparation. It is prepared for tissue culturing of plants, and as a bacterial medium and is also used for pharmaceutical purpose as a thickening agent.

Alginites

Most of the brown seaweeds are potential sources of alginites. The properties of alginites vary from one species to another. The main commercial sources are Ascophyllum, Drvillaea, Eckmer, Laminaria, Lessonia, Macrocystis, Sargassm and Turbinaria, Of these the most important are Laminaria macroystes and Ascothrus. In India, sargassm and turbinaria are the two species of seaweed used for the production of alginic acid.

Indian alginate industry depends on the sargassum grown in Tamil Nadu coast, Kerala and Gujarat Coast. The species growing in Gujarat coast gives low viscosity alginites which are unsuitable for the main Indian market of textile printing. Sargassum found in Philippines is exported to Japan for use in animal feeds and fertilizers.

Extraction of alginic acid

The processes used to make sodium alginate from brown seeds are relatively simple. The difficulties of the process arise from the physical separation of residue, from viscous solutions to separate gelatinous precipitate which hold large amount of liquid. The method of preparation of alginic acid and alginites are given in the flow diagram (Fig 1).
Fig. 1. Preparation of alginic acid/sodium alginate from seaweed

**Uses of alginates**

It is used for film formation, filament formation, food additive, some salts, alginic acid are considered as safe as food. It is used as a thickening gelling and general colloidal properties. It is used as a immobilized bio-catalyst.

Surface sizing of the paper is the main use of alginates in paper industry. It is also used in welding industry to coat welding rods.

It is also used in pharmaceutical industry. It is added to increase the viscosity of the medicine, other uses are in medical dressing. It can be used in fish feed as a binder. Alginate gel find small use in confectionary.

**Carrageenans**

Carrageenans contribute the third most important hydrocolloid after starch and gelatin. They are extracted from the main plants, carrageenophytes.
They serve a structure of function analogue to that of cellulose in land plants.

Philippines is the world’s largest producer of carrageen. Irishmoss is also known as carrageenan. Important species of seaweeds used for the production of carrageenan are Chondrus crispus, and other Chondrus species Eucheuma cottoni, Furcellaria lumbricalis and Hypnea species of all these species only few species are commercially exploited and used for the manufacture of carrageenans.

When carrageenans are fractionated with potassium chloride two fractions, kappa and lamda carrageenans are obtained. Kappa was the fraction which was precipitated by potassium chloride and lamda was the fraction which remained in the solution. It was also reported that small quantities of iota and theta and Xi carrageenan are obtained from some species of carrageenophytes.

**Extraction of carrageenan**

In the Philippines carrageenan is processed into three grades: 1. PNG 2. Semi refined carrageenan and 3. Refined carrageenan.

**Process:** The carrageenophytes are washed, cleaned and digested with 5 M KOH. The alkali is drained off and residue is washed free of alkali, dried, powdered and packed. The product is called semi-refined carrageenan. It is used directly as food additive. The flow diagram is given below.

**Uses of carrageenans**

Food – clarification of liquors/beverages, chocolate/milk drinks or shakes, icecreams, desserts, and processed food.

Meat industry: Beef patty, poultry and ham, Non food – pet food, toothpaste and freshness materials.