Chapter 4

Value added fish products

Binsi P.K, Sreelakshmi K.R and K. Ashok Kumar
Fish Processing Division
ICAR-Central Institute of Fisheries Technology, Cochin
Email:binsipk@yahoo.com

Value addition is the most talked about word in food processing industry, particularly in export oriented fish processing industry because of the increased realization of valuable foreign exchange. Value can be added to fish and fishery products according to the requirements of different markets. These products range from live fish and shellfish to ready to serve convenience products. As far as fish processing industry is concerned value addition is one of the possible approaches to raise profitability since this industry is becoming highly competitive and increasingly expensive.

There is great demand for seafood/seafood based products in ready to eat "convenience" form. A number of such diverse products have already invaded the western markets. One factor responsible for such a situation is more and more women getting educated and taking up employment. Reasonably good expendable income, education, awareness and consciousness towards hygiene and health, increased emphasis on leisure pursuits etc. are some of the other reasons.

Marketing of value added products is completely different from the traditional seafood trade. It is dynamic, sensitive, complex and very expensive. Market surveys, packaging and advertising are a few of the very important areas, which ultimately determine the successful movement of a new product. Most of the market channels currently used is not suitable to trade value added products. A new appropriate channel would be the super market chains which want to procure directly from the source of supply. Appearance, packaging and display are all important factors leading to successful marketing of any new value added product. The retail pack must be clean, crisp and clear and make the contents appear attractive to the consumer. The consumer must be given confidence to experiment with a new product launched in the market. Packaging requirements change with product form, target group, market area, species used and so on. The latest packaging must also keep abreast with the latest technology.

Chilled fish

Chilling is an effective way of reducing spoilage by cooling the fish as quickly as possible without freezing. Immediate chilling of fish ensures high quality products. Chilled fish is another important value added item of international trade. Chilled fish fetches more price than frozen fish. It is generally accepted that some tropical fish species can keep for longer periods in comparison to fish from temperate or colder waters. Up to 35% yield of high value products can be expected from fish processed within 5 days of storage in ice, after which a progressive decrease in the utility was observed with increase in storage days. Modern packaging techniques viz., vacuum packaging, modified atmospheric packaging and active packaging significantly enhances the shelf life of chilled fish products.

Frozen fish fillets

Freezing and storage of whole fish, gutted fish, fillets etc. are methods for long-term preservation of these species. Many varieties of fresh water fishes like rainbow trout, shell fishes, catla, rohu, tilapia fillets can be frozen for domestic market and export to developed countries in block frozen and IQF forms. In the importing countries these fillets are mainly used for conversion into coated products. Fish fillets can also be used for the production of ready to serve value added products such as fish in sauce and fish salads.

Speciality products

Stretched shrimp (Nobashi)

Increasing the length of peeled and deveined shrimp and minimising its curling by making parallel cuttings at the bottom and applying pressure using simple mechanical devices is a new technique adopted by the seafood processing industry in recent years. Increasing the length by about 1-2 cms depending on the size of the shrimp is possible by this method. The stretched shrimp will have better appearance compared to conventional PD shrimp and it also fetches higher unit price. The stretched shrimp because of its increased surface area will have more pickup of coating during battering and breading and also good appearance.

Shrimp is washed in chilled water containing 5-ppm chlorine, beheaded, deveined, using bamboo stick and pealed keeping the last segment and tail intact. The tail is then trimmed and the shrimp is stretched using a metallic stretcher after making 2-3 parallel cuttings at the bottom side. Stretched shrimps are then packed in thermoformed trays under vacuum and frozen at -40°C.

Barbecue

Shrimp is washed in chilled water containing 5-ppm chlorine, beheaded, deveined, peeled and again washed in chilled water. Bamboo stick is then pierced into the meat from head portion to tail. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

Sushi (Cooked butterfly shrimp)

Shrimp is washed in chilled water containing 5ppm chlorine, beheaded, deveined and again washed in chilled water. Bamboo stick is then pierced between the shell and the meat from head portion to tail and then cooked in 1% brine for two minutes at 100°C. The cooked shrimp is then cooled in chilled water, bamboo stick removed and then peeled completely, including the tail fans. The ventral side is then gently cut down lengthwise completely using a sharp scalpel. The cut surface is then gently opened up to form the butterfly shape, packed in thermoformed trays under vacuum and frozen at -40°C.

Skewered shrimp

The process is similar to that of barbecue, but piercing is carried out in such a way that 4-5 shrimps are arranged in a skewer in an inverted " U" shape. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

Shrimp head-on (centre peeled)

Shrimp is washed in chilled water containing 5 ppm chlorine, pealed at the centre keeping the head and the last two segments intact, deveined, and the tail is trimmed. It is

again washed in chilled water packed in thermoformed trays under vacuum and frozen at -40°C.

Shrimp head-on cooked (centre peeled)

Shrimp is washed in chilled water containing 5 ppm chlorine, deveined and then cooked in 1% brine for two minutes at 100°C. It is immediately cooled in chilled water and pealed keeping the head and the last two segments intact. The tail is trimmed and again washed in chilled water. It is then packed in thermoformed trays under vacuum and frozen at -40°C.

Battered and breaded fish products

Consumers are looking for better alternative for conventional fresh food that offers time-saving preparation. Hence there exists an increased global demand for ready-to-heat frozen foods, especially breaded and battered products with high standards of quality. Battering and breading enhances the consumer satisfaction by improving the nutritional value, organoleptic characteristics and appearance of the products. The most important advantage of coating is value addition as it increases the bulk of the product. Also this paves way for better utilisation of low cost or underutilised fishes. Coating is referred as the batter and/or breading adhering to a food product. Each ingredient in coating offers unique role in development of functionality and characteristics of the product. Polysaccharides, proteins, fat, seasonings and water are the commonly used ingredients. The method of product development differs with the type of product. Mostly this includes seven major steps.

Portioning / forming

A perfectly portioned product is the right starting point. Mechanically deboned fish meat is formed to different shapes and sizes after mixing with ingredients, if needed. The product should keep its consistency with proper weight and shape. The key factor in this production step is speed and accuracy of processing the frozen fish block at minimum costs without any compromise to the product quality.

Predusting

Predusting is usually done with very fine raw flour type material or dry batter itself, sprinkled on the surface of food substrate before coating. This helps to reduce the moisture on the surface of the product so that the batter can adhere uniformly. Flavourings such as salt and spices can be added in minimum amounts.

Battering

Batter is defined as the liquid mixture composed of water, flour, starch, and seasonings into which the fish products are dipped prior to breading. Two types of batter are there- adhesive batter and tempura batter. The adhesive batter is a fluid, consisting of flour and water. Tempura batter is the puff-type batter containing raising/leavening agents. This forms a crisp, continuous, uniform layer over the food. The predusted portions are applied with wet batter and excess batter can be blown off by a current of air. The batter mix helps in governing the amount of bread to be picked up and it contributes to flavour of the final product. Specific ingredients are used to aid viscosity, texture and adhesion.

Ingredients of batter mix

a) Flour- Wheat flour provides structure to the product through gelatinisation of starch as well as through formation of gluten protein matrix. Higher protein levels in flour increases viscosity of batter and produce darker crispy coatings. Corn flour can be added to produce yellow colour and to enhance browning during frying.

b) Water- The ratio of water to dry batter mix is 1.8:1. Formation of gelatinised starch phase, hydration of flow proteins, batter viscosity etc. depends on the purity of water used.

c) Starch- Corn starch is added mainly to control batter viscosity and thus increasing the batter pickup and breading retention.

d) Flavour and flavour enhancers- salt, sugar, spices etc. can be added to improve the organoleptic characteristics of the products.

e) Sodium tripolyphosphate- This lowers the water activity of the product and has bactericidal property. It increases the hydration of proteins and reduces protein denaturation.

Breading

Breading was defined as the application of a dry mixture of flour starch, seasonings having a coarse composition to battered food products prior to cooking. Normally the battered fish portions are dropped in to dried bread crumbs and are turned over to ensure complete coating with bread crumbs. A fine layer or coarse layer of bread crumps will contribute to structure and tastiness of the product. For soft products the crump depth should be fine so as to avoid the product damage on further processing.

Pre-frying/ flash frying

Pre-frying is the process of giving a shallow fry so as to coagulate batter over the product and lock the flavour and juices to the product. The time of frying and temperature of oil are crucial factors. This could be done at 180-200°C for 40-60 sec, thus restricting the actual heat transfer to the surface of the product. The term pre-frying is used as frying will be completed only when the consumers fry the product for 4-6 minutes depending on the product size.

Freezing

The fish portions are air cooled before freezing. This helps the coating temperature to drop while the batter can stabilise itself and recover from the frying shock. Freezing is done at a temperature of -10°C to -20°C in order to preserve freshness and quality of the product over longer storage periods.

Packaging and storage

Proper packaging and storage is essential to prevent/retard desiccation, discolouration and rancidity in coated products. Packaging in thermoformed containers and storage at -20°C are most commonly used for breaded and battered products. The developments in value added product industry demands the packaging that can withstand the higher temperatures of microwave reheating.

Advantages of coated products

- Enhanced nutritional quality
- Moisture barrier during frozen storage and reheating

- Crispy texture and appealing colour and flavour
- Structural reinforcement of the substrate
- Prevents loss of natural juices
- Increased bulk of the substrate and reduced product cost
- Improved overall acceptability of the product

Battering and breading have contributed significantly to the value addition of fishes, shell fishes and molluscs. The first commercially successful coated fish item was fish fingers. Later several other products like fish cutlets, fish balls, fish nuggets, etc. came into the market. Coated butterfly shrimp, squid rings, stuffed squid rings etc. are among the fancy items that cater to the luxury markets. Sophisticated equipments like meat bone separator, meat strainer, portioning and forming equipment, preduster, battering and breading machine, fryer, freezer and packaging machineries are in the market for preparation of a wide variety of coated products.

Fish finger or Fish portion

Fish fingers, or portions or sticks are regular sized portions cut from rectangular frozen blocks of fish flesh. They are normally coated with batter, and then crumbed before being flash fried and frozen. They may be packed in retail or catering - size packs. The typical British fish finger normally weighs about 1 oz. (28 g) of which up to about 50% of the total weight may be batter and crumbs. Food Advisory Committee of the UK government has recommended a minimum fish content of 55% for battered and 60% for the fingers coated with breadcrumbs.

Shrimp products

Battered and breaded shrimp can be prepared from wild as well as from farmed shrimp in different styles and forms. The most important among them are butterfly, round tail-on, peeled and deveined (PD), nobashi (stretched shrimp) etc. The products from farmed shrimp have indicated longer shelf life, 16-18 months compared to those from wild variety 12-14 months at –20 ºC

Fish fillets

The brined fillets are battered and breaded. Fillets from freshwater fish are also used for the production of coated products. The only problem noticed in this case is the presence of fin bones; its complete removal is still a major hurdle.

Squid products

Squid rings and stuffed squid are the popular coated products processed out of squid. Cleaned squid tubes are cut in the form of rings of uniform size, cooked in boiling brine (3%) for 1-2 minutes followed by cooling, breading and battering. The coated rings are flash-fried, cooled, frozen and packed. Stuffed squid is generally processed out of small size animals. The cleaned tubes are filled with a stuffing mixture prepared using cooked squid tentacles, potato, fried onion, spices etc. It is then battered, breaded and flash-fried.

Clam and other related products

Meat shucked out from depurated live clams after boiling is blanched in boiling brine, cooled, battered, breaded, flash-fried and packed. Other bivalves such as oyster, mussels etc. can also be converted into coated products by the same method.

Fish cutlet

Cooked fish mince is mixed with cooked potato, fried onion, spices and other optional ingredients. This mass is then formed into the desired shape, each weighing approximately 30g. The formed cutlets are battered and breaded.

Fish balls

Fish balls are generally prepared from mince of low cost fish. Balls can be prepared by different ways. The simplest method is by mixing the fish mince with starch, salt and spices. This mix is then made into balls, cooked in boiling 1 % brine. The cooked balls are then battered and breaded.

Crab claw balls

Swimming legs of crab may be used for this purpose. Crab claws are severed from the body, washed in chilled portable water and the shell removed using a cracker. The leg meat is then removed and mixed with 2 % starch based binder. This is then stuffed on the exposed end of the claw. Alternatively the body meat mixed with the binder also can be used for stuffing. The stuffed claw is then frozen, battered and breaded and flash fried. The coated products are packed in thermoformed containers with built in cavities.

Mince based products

Fish mince separated from skin, bone and fins are comminuted and used for preparation of different products. Battered and breaded products like fish fingers, fish balls, cutlet etc. are produced. Fish cultlets fetch good demand in domestic markets while fish fingers are demanded in export market. Fish cutlets with partial replacement of fish meat with soy protein will increase the acceptability and storage stability of fish cutlets. A ready to eat novel battered and breaded snack product, 'Oyster pablano pepper fritter' have a good scope of attraction in value added markets. Fish finger from Bombay duck adds on to the value addition potential of fish in our markets. Fish rolls with good shelf life can be developed from frame meat of fishes, eg: rohu. Fish sausage, cakes and patties are some other mince based products.

Surimi and surimi based products

Surimi, term for the mince that are deboned and washed, also act as an intermediary in development of various products. It is one among the most consumed product fish. Low cost fishes can be conveniently used for the preparation of surimi. Block frozen surimi and surimi based products are popular. Shell fish analogue products from surimi fetches good demand in both domestic and export markets. The history of surimi in India starts in1990's with the first surimi manufacturing plant was set up in 1994. The Indian company 'Gadre Marine' became the third largest manufacturer of surimi, exporting to 24 countries over the world. This shows the potential for production of surimi and surimi based products in India. The demand of these products are less in domestic markets but is expanding nowadays. These healthy and simple products have great scope in indian markets as people are moving towards different alternatives. Shell fish analogue products from surimi fetches good demand in both domestic and export markets.

Ready to serve fish products in retortable pouch

Ready to serve fish products viz. curry products, in retortable pouches are a recent innovation in ready to serve fish products for local market. The most common retortable

pouch consists of a 3 ply laminated material. Generally it is polyester/aluminium/cast polypropylene. These products have a shelf life of more than one year at room temperature. As there is increasing demand in National and International market for ready to serve products the retort pouch technology will have a good future. The technology for retort pouch processing of several varieties of ready to serve fish and fish products has been standardised at CIFT and this technology has been transferred successfully to entrepreneurs.

Extruded products

Fish based extruded products have got very good marketing potential. Formulation of appropriate types of products using fish mince, starches etc., attractive packaging for the products and market studies are needed for the popularization of such products. However, technological studies involving use of indigenously available starches like cassava starch, potato starch, cornstarch and the associated problems need thorough investigation. Such products can command very high market potential particularly among the urban elites. The technology can be employed for profitable utilization of bycatch and low value fish besides providing ample generation of employment opportunities.

Intermediate moisture products (IMF)

The IMF technology is based on the reduction in water-activity of food to a level in which most bacteria in will no longer grow. Intermediate moisture product from fishes can be made from a combination of different techniques like drying, pH modification etc.

Seaweed products/Seaweed incorporated products

Seaweed incorporation in fish products increases the fibre content and retention of PUFA. 'Nutradrink' and fish soup enriched with seaweed bioactive compounds are novel products developed by CIFT. Sulphated polysaccharides with bioactive properties can be extracted from seaweed. Seaweed incorporated semi-sweet biscuits and extruded snack products will also have good nutrirional importance.

Fish caviar substitutes

Polyunsaturated fatty acids and amino acids gives the nutritional importance of fish roe. Besides the commercially available roe from sturgeon, salmon and cod, fish caviar substitute from fresh water carp roe reconstituted with sodium alginate will have a greater potential as value added fish caviar substitute.

Curing

The traditional methods of processing fish by salting, drying, smoking and pickling are collectively known as curing. Cured fish consumption is more in areas where the availability of fresh fish is comparatively limited, namely interior markets and hilly areas. This is also the cheapest method of preservation, since no expensive technology is used. In India roughly 20 % of the fish caught is preserved by curing. Considerable quantities of cured fish are also exported, mainly to Singapore, Sri Lanka and to the Middle East. Simple sun drying was the widely practised traditional method of fish preservation. By this, preservation was achieved by lowering of water content in the fish, thereby retarding the activity of bacteria and fungi. The heat was able to destroy the bacteria to a certain extent. Later on, a combination of salting and drying or salting, smoking and then drying were developed.

Methods of Drying

There are basically two methods of drying fish. The common one is by utilizing the atmospheric conditions like temperature, humidity and airflow. This is traditional sun drying. The other is dehydration or artificial drying, by using artificial means like mechanical driers for removal of moisture from the fish under controlled conditions.

Sun drying depends heavily on the natural weather conditions since the fish is dried by heat from the sun and the air current carries the water away. Here there is no control over the operations and many a time the losses cannot be substantiated. Hence it is necessary that the operations be controlled to get a product, which has an extended shelf life, but at the same time the texture, taste and flavour is maintained. It is here that artificial driers where processing parameters are controlled gain a lot of importance. Such processes are carried out in a controlled chamber or area. Such products have advantages over sun-dried products since they have better keeping quality and longer shelf life.

In mechanical driers, removal of water from the fish is achieved by an external input of thermal energy. This is an expensive method since there is need for fuel for heating and maintenance of the temperature. The drying chamber consists of a long tunnel in which the washed and cleaned fish is placed on trays or racks. A blast of hot air is passed over the material to be dried. After the required degree of drying the product is removed from drier and packed.

Salting

This is one of the oldest methods of preservation of fish. Salting is usually done as such or in combination with drying or as a pretreatment to smoking. During salting osmotic transfer of water out of the fish and salt into the fish takes place, which effect fish preservation. It is based on different factors like diffusion and biochemical changes in various constituents of the fish. Salting amounts to a process of salt penetration into the fish flesh. Penetration ends when the salt concentration of the fish equals that of the surrounding medium. Loss of water during salting limits bacterial growth and enzyme activity, thus preserving the fish. The high salt content prevents the growth of normal spoilage microflora in the fish; but halophiles, which can survive 12-15% of salt, will survive.

Preparation of some popular products

Pickled products

Fish pickle makes use of the non-fatty variety of low cost fish having good meat content. Major ingredients are: fish, garlic, green chilly, ginger, chilly powder, turmeric powder, gingelly oil/ ground nut, salt, vinegar and sugar. The method of preparation of pickle is simple, the preservative being oil, salt and vinegar. The traditional packing is in glass bottles. Modern packing materials suitable for packing fish pickles have also been identified. Pouches and stand packs made of 12 micron polyester laminated with 118 micron LD/HD co-extruded film can be used for packing pickles.

Ingredients	Quantity
Fish (dressed and cut into small pieces)	1 kg
Mustard (shell removed)-Optional	10

	g
Green chilly	50 g
Garlic	200 g
Ginger	150 g
Chilli powder	50 g
Turmeric powder	2 g
Gingelly oil/ ground nut	200 g
Vinegar	400 ml
Salt	60 g
Sugar (optional)	10 g
Cardamom, clove & cinnamon (optional)	1.5 g

Process

Mix the dressed fish with salt at the rate of 3% by weight of fish and dry in the sun /dryer for 2 to 3 hours and then deep fry the fish in oil and keep apart. Then fry mustard, green chilli, ginger and garlic in oil. When frying is adequate add turmeric powder, followed by chilli powder under a low flame and immediately remove from the flame and mixed with fried fish and allowed to cool. Vinegar and salt were added and mixed thoroughly and adjust to a slightly salty taste. Finally sugar was added and mixed thoroughly. Stored the pickle in a clean container for at least 2 overnights for maturing and fill in glass bottles or acid resistant packets (12 µ polyester with 250 gauge LDHD polythene co-extruded film pouches)

Fish Soup Powder

Fish soup powder can be formulated from any type of fish having very low fat content. Soup powder prepared from different food materials like vegetables, meat, egg are in use in different parts of the world. These are dry products rich in dietary constituents like protein and minerals. The soup powder prepared out of miscellaneous fish is also a rich source of animal protein and other nutritional factors.

Ingredients used for the preparation of fish soup powder

Ingredients	**Qty**
Cooked fish meat	750 g
Salt	170 g
Fat	120 g
Onion	750 g
Coriander	12 g
Tapioca starch	250 g
Milk powder	100 g

Sugar/glucose	30 g
Pepper powder	15 g
Ascorbic acid	1.5 g
Carboxy methyl cellulose	3 g
Monosodium glutamate	5 g

Method of preparation

Minced fish can be conveniently used for the preparation of soup powder. If whole fish is using it has to be cooked first and the meat is separated from the bones and skin. Cooked pressed meat is the basic raw material for the preparation. Fry the onion till it becomes light brown. Grind the cooked fish, fried onion and other ingredients in a wet food grinder till it becomes a fine paste. Spread the paste in aluminum trays lined with polyethylene sheet and dried in an electrical drier at 50ºC to reduce the moisture content to 8%. Dried material is then pulverized in a mechanical pulveriser. Milk powder is added and packed in airtight containers or laminated polyethylene bags. It has a shelf life of about 8 months at ambient temperature.

Preparation of soup

One-teaspoon full (5 g) of powder is made into a paste with 10 ml cold water. This is added to 90 ml boiling water. Continue boiling for 2 minutes. The soup is ready for use.

Fish flakes or wafers

Fish wafers are partially deodourized thin flakes of cooked fish meat homogenized with starch and salt. On frying the wafers swell to two to three times of its initial size and become crisp and delicious. It is an ideal snack. Fish mince and starch are the base material for the preparation of wafers

Ingredients used for the preparation of fish flakes

Ingredients	**Qty**
Cooked fish meat	2 kg
Refined tapioca starch	2 kg
Corn starch	1 kg
Common salt	5%
Water	3.5 l

Process

The cooked fish meat is homogenized in a wet food grinder. Starch, salt and water are added and continued grinding till they become a fine paste. Small portions of the homogenized mass is poured on to flat aluminum trays and spread to a film of 1 to 2 mm thickness. The material is cooked in a steam chamber for 2 to 3 minutes to gelatinise the starch. After this the film become firm and it can be cut into desired shapes. The gelatinized flakes are dried in an electrical drier at 45-50ºC or it can be sun dried. Fry in edible oil and serve hot

Fish paste

Fish paste is a high value convenience food popular in South East Asia prepared by mixing fish and salt and allowing it to ferment. This results in the formation of either a paste or a liquid, which is separated from the residue and is used as a flavoring agent Fish paste can also be prepared with out fermentation. Frozen fish paste is not relished because during storage, texture and spreadability are adversely affected.

Fish paste is prepared by finely grinding texturised cooked fish meat, gelatinized, starch, sugar, milk powder, colouring matter and flavour (Table 5). It was packed in flexible pouches made of co-extruded polypropylene, heat processed in air steam pressure in an autoclave and stored at ambient temperature. The shelf life is 36 weeks. It become unacceptable due to changes in texture and spread ability. The proximate composition of fish paste is given in Table 6.

Recipe of fish paste

Ingredients	**%**
Fish mince	78
Fat	8
Starch	8
Sugar	2.25
Milk powder	2.50
Salt	1.25
Poly phosphate	0.50

Microbiological studies showed that the product is bacteriologically safe for human consumption. Studies showed that the fish paste is acceptable as bread spread or similar types of products. The large quantity of low value fish with low fat and white flesh available in India can be used for making good quality fish paste.

Fish Noodles

This is a product similar to ordinary noodles available in the market, but contains 21% protein. Surimi is used as the base for the production of fish noodles Table 7). Cooked surimi is kneaded with salt and maida. The mix is passed through the extruder. Gelatinised noodles is dried under sun or in an electrical drier at 50ºC to a moisture level of 8%. The dried noodle is packed in airtight containers or polythene bags. The product has very good rehydration property.

Ingredients used for the preparation of fish noodles

Ingredients	**Qty**
Cooked fish mince	800 g
Maida	1200 g
Salt	60 g
Water	1-2%

Just like the noodles available in the market only two minutes cooking is required for the preparation of fish noodles.

Chapter 5

Nutraceuticals from Fish and Fish Wastes: Scopes and Innovations

Suseela Mathew and Tejpal.C.S
Biochemistry and Nutrition Division,
ICAR-Central Institute of Fisheries Technology, Cochin
Email:suseela1962@gmail.com

Bio-active compounds having health beneficial effect on human beingsfrom terrestrial and marine sources are considered as "Nutraceuticals". Nutraceuticals from marine origin are proved to have wide range of therapeutic effects*viz.*,anti-obesity, immune enhancement, natural antioxidant, cardio protective, anti-diabetic, anti-inflammatory effects.These natural products do not have any side effects contradictory to many medicines available today, hence have attracted global market. Microencapsulation technique has been considered as one of the unique methods to encapsulate the bio-active compounds for target delivery. Importance and application of nutraceuticals from marine origin are highlighted.

Introduction

World over in the recent past, research in nutraceuticals has shown continuous growth and the progressive approach is aimed at identifying the potential nutraceutical compounds which are having health benefits in human beings. Awareness among the people is the prime reason for the growing demandfor nutraceuticals.Today people are more aware about the nutrition and related health problems. Recently, researchers across the globe are exploring the possibilities to extract and isolate bio-active compounds from both terrestrial and marine sources.

Nutraceuticalis a combination of two words, "nutrition" and "pharmaceutical," and the word nutraceutical was coined by Stephen L. DeFelice in 1989 (Wildman *et al*., 2006). Nutraceuticals are food products of natural origin from both terrestrial and marine sources having healthcare importance. The word nutraceuticals comprise of variety of products derived from terrestrial and marine sources (isolated nutrients, dietary supplements, and genetically engineereddesigner foods, herbal products, processed foods, andBeverages). Recent report says that nutraceuticals provides a positive healthcare approach with tremendous therapeutic impacts on human body (Das *et al*., 2012; Bagchi*et al*., 2015). A wide range of phytochemicals described as phytoestrogens, terpenoids, limonoids, glucosinolatesphytosterols, polyphenols, carotenoids, flavonoids, isoflavonoids, and anthocyanidins having therapeutic effects on human health as antioxidants, anti-inflammatory, antibacterial, anti-allergic, etc. are identified (Gupta and Prakash, 2014; Karwande and Borade, 2015).

Classification of Nutraceuticals

Based on the bio-functional properties of bioactive compounds from terrestrial and marine sources are classified into following –

1. Dietary Supplements
2. Functional foods
3. Medicinal food

Dietary Supplements

According to the Dietary Supplement Health and Education Act (DSHEA), 1994 in USA, dietary supplements are defined as products comprised of "dietary constituents" and orally administered to supplement the nutritional requirement of diet. The "Dietary constituents" refers to bioactive components comprising of amino acids, vitamins, minerals, fibres, important metabolites, and certain enzymes. The dietary supplements also include extracts available in tablets, capsules, powders, liquids, and in any other dosage form (Radhika *et al*., 2011).

Functional Food

Functional foods are foods derived from natural origin enriched in nutrients and are being fortified with essential nutrients (Jones, 2002). As per the Health Canada, functional food defines a regular food with an ingredient having specific therapeutic effect along with nutritional value (Wildman *et al*., 2006). Whereas in Japan, functional foods are assessed on the basis of three important standards: (1) functional foods must be derived from natural sources and consumed in their native state instead of processed in different dosage forms like tablet, capsule, or powder; (2) consumed regularly as a part of daily diet; and (3) exert a dual role in prevention and management of disease and contribute in biological processes (Arai, 1996).

Medicinal food

Medical foods are foods that are specially formulated to be consumed internally under the supervision of a physician, which is intended for the dietary management of particular disease that has distinctive nutritional needs that cannot be met by normal diet alone. Dietary supplements and functional foods do not meet these criteria and are not classified as medical food (Radhika *et al*., 2011).

Nutraceuticals from marine sources

Chitin and chitosan

Chitin,a cationic amino polysaccharide,is a natural biopolymer composed of *N*-acetyl-d-glucosamine with β (1 → 4) glycosidic linkages. The term chitosan is used when nitrogen content of chitin is more than 7% by weight or the degree of deacetylation is more than 60% (Peter *et al*., 1986; Gagne and Simpson 1993). Chitosan is a biopolymer and it consists of d-glucosamine units obtained during the deacetylation of chitin by adopting hot alkali treatment. Chitin and chitosan can be obtained from the bio-waste generated from both terrestrial and marine sources. Chitin is abundant in the marine organisms like lobster, crab, krill, cuttlefish, shrimp, and prawn. The extraction of chitin form marine source comprises of thee-steps: deproteinization (DP), demineralization (DM), and decolorization (DC). Further, chitin has to undergo a de-acetylation process to obtain chitosan. Chitin is known for its unique properties like, biodegradability, nontoxicity, physiological inertness, antibacterial properties, hydrophilicity, gel-forming properties (Se-Kwon, 2010). In India, a few entrepreneurs are producing chitin and chitosan on a commercial scale under the technical guidance of the ICAR-Central Institute of Fisheries Technology, Cochin. In-line with chitin, chitosan also finds extensive application in multidimensional sectors, such as in food and nutrition, biotechnology, material science, drugs and pharmaceuticals, agriculture and

environmental protection, dental and surgical appliances,removal of toxic heavy metals, wine clarification, industrial effluent treatment, etc. (Se-Kwon, 2010).

Glucosamine Hydrochloride

Generally, glucosamine is obtained from the crustacean waste (Xu and Wang, 2004; Tahami, 1994). Glucosamine is part of the structural polysaccharides such as chitosan and chitin, which is present in the exoskeletons of crustacean and other arthropods. Though, glucosamine was discovered long back, market for glucosamine has gained popular interest due toits health benefits. Dietary supplementation of glucosamine (glucosamine sulphate, glucosamine hydrochloride, or N-acetyl-glucosamine) is proven to promising biomolecule for the treatment of osteoarthritis, knee pain, and back pain (Houpt*et al*., 1999; Luo *et al*., 2005). It is also known for its unique properties like anti-cancer, anti-inflammatory and antibacterial effects (Nagaoka *et al*., 2011).

Chondroitin sulphate

Chondroitin sulphate (CS) consists of repeated disaccharide units of glucuronic acid (GlcA) and *N*-acetylgalactosamine (GalNAc) linked by β-(1→3) glycosidic bonds and sulfated in different carbon positions (CS no-sulfated is CS-O). Shark cartilage is found to be a good source of chondroitin sulpahte. Chondroitin sulfate plays various roles in biological processes such as the function and elasticity of the articular cartilage, hemostasis, inflammation, cell development, cell adhesion, proliferation and differentiation by being an essential element of extracellular matrix of connective tissues (Schiraldi*et al*., 2010).

Hyaluronic acid (HA)

HA can be obtained from the bio-waste like fish eyeball and it is also present in the cartilage matrix of fishes. HA finds several biomedical applications *viz.*viscosupplementation in osteoarthritis treatment, as aid in eye surgery and wound regeneration. Further, hyaluronic acid finds its applications in drug delivery, tissue engineering applications, gene delivery applications, targeted drug delivery, tumor treatment, environmental applications and sensors (Mathew *et al*., 2017).

Collagen, gelatin and collagen peptides

Fish skin and scales which constitutes about 30% and 5% of the total seafood processing discards respectively are considered as the richest source for collagen and gelatin. Collagen derived from marine sources is finding wide applications in various sectors due to its biocompatibility, biodegradability, high cell adhesion properties and weak antigenicity (Yamada *et al*., 2014). Another major application of collagen is to act as a source for extraction of collagen hydrolysates, peptides, gelatin and gelatin peptides. Collagen peptides are reported to have bioactive properties like antioxidant, antimicrobial, antihypertensive, metal chelating, tyrosinase inhibitory, immunomodulatory, neuroprotective, antifreeze, wound healing, cell-proliferation, activities (Zhuang *et al*., 2009; Chi *et al*., 2014).

Gelatin, the denatured form of collagen, by virtue of its surface active properties finds extensive applications in food, pharmaceutical and biomedical industries. Gelatin peptides are reported to have antihypertensive, antioxidant properties. The major

difference between fish and mammalian gelatin lies in the iminoacid composition, viz, proline and hydroxyprolinecontents. (Mathew *et al*., 2017).

Fish lipids

Across the globe the researchers have well documented the health beneficial effects of long chain omega-3 polyunsaturated fatty acids (PUFA) (Connor, 2000). The major omega-3 PUFA, such as eicosapentaenoic acid (EPA C20:5) and docosahexaenoic acid (DHA C22:6) are very much essential for human beings, and hence are considered as essential fatty acids. The intake of long chain omega-3 PUFA is promoted by many health organizations owing to the health benefits associated with it. An average intake of 0.2 g and 0.65g of EPA and DHA a day is recommended by the European Academy of Nutritional Sciences (EANS) and International Society for the Study of Fatty Acids and Lipids (ISSFAL) respectively (Dedeckere, *et al*., 1998). Fish oil remains as an excellent and economical source of omega-3 PUFA. Having high contents of fat soluble vitamins and lipids, especially EPA, cod liver has been exploited as an omega-3 PUFA source for development of nutraceuticals (Mondello*et al*., 2006). Dietary consumption of fish oil (omega-3 PUFA) in adequate quantities is reported to have health benefits in the treatment of cardiovascular diseases, cancer, hypertension, Alzheimer's disease, diabetes, arthritis, autoimmune disorders and to improve overall functioning of brain and retina (Cole *et al*., 2009).

Squalene

Squalene, a naturally occurring triterpenoid compound, is an intermediate in cholesterol synthesis. It is widely present in nature, such as wheat germ, rice bran, shark liver and olive oils and among all the sources identified, shark liver oil is considered to be the richest source accounting for about 40% of its weight. Recently, the squalene has gained attention due to its diverse bioactivities such as antioxidant, anti-lipidemic, membrane stabilizing, cardioprotective, chemopreventive, anti-cancerous, antiaging properties etc (Passi*et al*., 2002; Ko*et al*., 2002). Further, it is also reported to protect human skin surface from oxidation (Kabuto *et al*., 2013). Based on its diverse bio-active properties, squalene finds applications in field of biomedical, cosmetic, drug delivery systems and even in food industries.

Minerals

Marine organisms especially fish are considered as important source of minerals such as sodium, potassium, calcium, phosphorous and magnesium. Fish bone which is often discarded after the removal of protein is an excellent source of calcium and hydroxy apatite. Being rich in minerals, fish bone powder can be fortified into several food products. However, for fortification, the fish bone should be converted into an edible form by softening its structure by pre-treatment with hot water or hot acetic acid or superheated steam. Calcium powder processed from the backbone of tuna is a potential nutraceutical. It can be used to combat calcium deficiency in children. Fortification of calcium in foods helps consumers in meeting the calcium requirements and may reduce the risk of osteoporosis. Other than fish bone calcium, certain other minerals such as selenium, potassium, iodine, zinc, magnesium are more abundant in seafood than in meat. The higher intake of seafood diet will also ensure that adequate amount of iodine is obtained.

Nutraceutical industry in India: Current scenario and future trends

During the year 2015, global nutraceutical industry, valued at US$ 182.6 billion and is one of the fastest growing industries today and expected to grow at a Compound Annual Growth Rate (CAGR) of 7.3% from 2015 to 2021. As on today, the United States, Europe and Japan account for about 93% of the total global nutraceutical market and seems to have attained maturity in all three major regions. Hence, nutraceutical industries across the world are now showing their interest to emerging markets like India and China. Nutraceuticals industry in India is one of the rapid growing markets in the Asia-Pacific region. As per the record, the nutraceuticals industry in India is worth about US$ 2.2 billion and is expected to grow at 20% to US$ 6.1 billion by 2019-2020.

Innovative work done at Central Institute of Fisheries Technology, Cochin

By adopting grafting and micro-encapsulation technology, ICAR-Central Institute of Fisheries Technology, Cochin has developed some of the nutraceuticals products, such as thiamine and pyridoxine-loaded vanillic acid-grafted chitosan microspheres; sardine oil loaded vanillic acid grafted chitosan microparticles; microencapsulated squalene powder; vanillic acid and coumaric acid grafted chitosan derivatives; thiamine and pyridoxine loaded ferulic acid-grafted chitosan. These nutraceuticals products were shown to have health beneficial and immunomodulatory response in animal models.

Further reading

Arai, S., 1996. Studies on functional foods in Japan—state of the art. Biosci. Biotechnol. Biochem. 60, 9–15.

Bagchi, D., Preuss, H.G., Swaroop, A., 2015. Nutraceuticals and Functional Foods in Human Health and Disease Prevention. Taylor & Francis, USA.

Chi, C.F., Cao, Z.H., Wang, B., Hu, F.Y., Li, Z.R. and Zhang, B., 2014. Antioxidant and functional properties of collagen hydrolysates from Spanish mackerel skin as influenced by average molecular weight. *Molecules*, *19*(8), pp.11211-11230.

Cole, G.M., Ma, Q.L. and Frautschy, S.A., 2009. Omega-3 fatty acids and dementia. *Prostaglandins, Leukotrienes and Essential fatty acids*, *81*(2), pp.213-221.

Connor, W.E., 2000. Importance of n− 3 fatty acids in health and disease. *The American journal of clinical nutrition*, *71*(1), pp.171S-175S.

Das, L., Bhaumik, E., Raychaudhuri, U., Chakraborty, R., 2012. Role of nutraceuticals in human health. J. Food Sci. Technol. 49, 173–183.

De Deckere, E.A.M., Korver, O., Verschuren, P.M. and Katan, M.B., 1998. Health Aspects of Fish and N-3 Pufa from Plant and Marine Origin: Summary of a Workshop.

Gagne, N. and Simpson, B.K., 1993. Use of proteolytic enzymes to facilitate the recovery of chitin from shrimp wastes. *Food Biotechnology*, *7*(3), pp.253-263.

Gupta, C., Prakash, D., 2014. Phytonutrients as therapeutic agents. J. Complement. Integr. Med. 11, 151–169.

Houpt, J.B., McMillan, R., Wein, C. and Paget-Dellio, S.D., 1999. Effect of glucosamine hydrochloride in the treatment of pain of osteoarthritis of the knee. *The Journal of rheumatology*, *26*(11), pp.2423-2430.

Jones, P.J., 2002. Clinical nutrition: 7. Functional foods—more than just nutrition. *Canadian Medical Association Journal*, *166*(12), pp.1555-1563.

Kabuto, H., Yamanushi, T.T., Janjua, N., Takayama, F. and Mankura, M., 2013. Effects of squalene/squalane on dopamine levels, antioxidant enzyme activity, and fatty acid composition in the striatum of Parkinson's disease mouse model. *Journal of oleo science*, *62*(1), pp.21-28.

Karwande, V., Borade, R., 2015. Phytochemicals of Nutraceutical Importance. Scitus Academics LLC, New York, NY.

Ko, T.F., Weng, Y.M. and Chiou, R.Y.Y., 2002. Squalene content and antioxidant activity of Terminalia catappa leaves and seeds. *Journal of agricultural and food chemistry*, *50*(19), pp.5343-5348.

Mathew, S., Tejpal, C.S., Kumar, L.R., Zynudheen, A.A. and Ravishankar, C.N., 2017. Aquaceuticals for Developing High Value Noble Foods and Dietary Supplements. *Indian Journal of Agricultural Biochemistry*, *30*(1), pp.1-9.

Mondello, L., Tranchida, P.Q., Dugo, P. and Dugo, G., 2006. Rapid, micro-scale preparation and very fast gas chromatographic separation of cod liver oil fatty acid methyl esters. *Journal of pharmaceutical and biomedical analysis*, *41*(5), pp.1566-1570.

Nagaoka, I., Igarashi, M., Hua, J., Ju, Y., Yomogida, S. and Sakamoto, K., 2011. Recent aspects of the anti-inflammatory actions of glucosamine. *Carbohydrate polymers*, *84*(2), pp.825-830.

Passi, S., De Pità, O., Puddu, P. and Littarru, G.P., 2002. Lipophilic antioxidants in human sebum and aging. *Free radical research*, *36*(4), pp.471-477.

Peter MG, Kegel G & Keller R (1986) In*: Chitin in Nature and Technology, (RAA Muzzarelli, C Jeuniaux& GW Gooday, Editors) New York: Plenum Press*, pp. 21–28.

Radhika, P.R., Singh, R.B.M. and Sivakumar, T., 2011. Nutraceuticals: an area of tremendous scope. *Int. J. Res. Ayurveda Pharmacy*, *2*, pp.410-415.

Schiraldi, C., Cimini, D. and De Rosa, M., 2010. Production of chondroitin sulfate and chondroitin. *Applied microbiology and biotechnology*, *87*(4), pp.1209-1220.

Se-Kwon K (2010) *Chitin, chitosan, oligosaccharides and their derivatives: Biological activities and applications; CRC Press-Taylor & Francis Group*: *Boca Raton.*

Tahami, M., 1994. "Synthesis of chitosan and Glucosamine from crustaceans wastes (Shrimp, Crab, Lobster)", Iranian Fisheries Journal, 3: 5-15.

Wildman, R.E.C., Wildman, R., Wallace, T.C., 2006. Handbook of Nutraceuticals and Functional Foods, second ed. CRC Press, Boca Raton, FL.

Xu, Y.S. and Y.M. Wang, 2004. "Preparation of D (+) glucosamine hydrochloride from crab shell", Chemistry Adhesion, pp: 4.

Yamada, S., Yamamoto, K., Ikeda, T., Yanagiguchi, K. and Hayashi, Y., 2014. Potency of fish collagen as a scaffold for regenerative medicine. *BioMed research international*, *2014*.

Zhuang, Y.L., Zhao, X. and Li, B.F., 2009. Optimization of antioxidant activity by response surface methodology in hydrolysates of jellyfish (Rhopilemaesculentum) umbrella collagen. *Journal of Zhejiang University-Science B*, *10*(8), pp.572-579.