QUALITY AND SAFETY ISSUES IN COATED FISH PRODUCTS: INDUSTRY PERSPECTIVE

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Coated food industry particularly based on fish is highly sophisticated so as to produce convenience foods such as ready to eat or ready to use products meeting international quality standards. Coated products viz., fish fingers, squid rings, cuttlefish balls, fish balls and prawn burgers form one of the major fish and shellfish based items of trade by the ASEAN countries (Chang *et al.*,1996). A coated food product, also known as enrobed product, is one, which is coated with another foodstuff. Two types of coatings are in common use, the batter and, the crumb or the breading. A batter may be defined as a liquid mixture composed of water, flour, starch and seasonings in to which food products are dipped prior to breading or frying. The breading is normally a bread-based crumb, but other coatings like crumbled potato chips or puffed and coarsely powdered rice grain are also popular. Several varieties of batters and breading in different colours and mesh size are available and are being used in the industry. The coating will impart the desired characteristics to the product when fried and offered for consumption.

The demand for 'ready to eat' or 'ready to use' products has led to the development of several products diverse in taste, texture and appearance based on fish. A major group among them commanding high consumer appeal is the battered and breaded products commonly known as coated or enrobed products. The first commercially successful coated product is 'fish finger; or 'fish stick'. Later several other products particularly the coated fish fillet, fish portions, fish cakes, fish medallions, fish nuggets, breaded oysters and scallops, crab balls, fish balls, coated shrimp products, coated squid rings etc. became prominent in most of the developed countries with the advent of the fast food trade. The present day production of coated seafood items involve fully automated batter and breading lines which start from portioning and end with appropriate packaging of the product (Suderman & Cunningham, 1983; Dikhoof, 1990; Hutchison *et al.*, 1992 ; Joseph, 2003, Ninan ,2012).

Edible coatings used in fish products

Coating by battering and breading enhances a food product's characteristics such as appearance, flavour and texture. In some cases a predust is applied on the surface before coating. Battering and breading which form an integral part of the formulation of coated fish products make varieties of coated fish products. The several functions of coatings can be summarized as follows(Kester and Fennema, 1986; Gennadios et al., 1997).

- Edible coatings with good moisture barrier properties could help alleviate the problem of moisture loss from the product.
- Could hold in juices, prevent dripping and enhance product' appearance.
- The rate of rancidity-causing lipid oxidation and brown coloration-causing myoglobin oxidation could be reduced by using edible coatings of low oxygen permeability.
- Edible coating solutions, which have been heated just prior to application, could reduce the load of spoilage and pathogenic microorganisms and partially inactivate deteriorative proteolytic enzymes at the surface of coated fish products.
- Volatile flavor loss from, and foreign odor pick-up by seafoods could be restricted with edible coatings.
- Edible coatings carrying antioxidants and/or antimicrobials can be used for direct treatment of meat surfaces, thereby delaying meat rancidity and discoloration, and reducing microbial loads.
- Coatings applied on the surface of fish portions prior to battering, breading, and frying, could improve the products' nutritional value by reducing oil uptake during frying.
- Provides structural reinforcement to the substrate.
- Acts as appetizing medium.
- Increases the bulk of the substrate thereby reducing cost of the finished product.

Pre-dust

Pre-dust is a dry material that is sprinkled on the moist surface of the frozen or fresh food substrate before any other coating is applied. It improves the adhesion of the batter because it absorbs part of the water on the surface of the substrate. If the batter is applied to a surface that is too moist, it can slip, leaving some areas uncovered. Also, the use of predust tends to increase pickup. The predust most commonly used is wheat flour. Starches, gums and proteins, alone or in combination, can also absorb moisture and help to form a structure (Kuntz, 1997; Zhang, 2001). A more sophisticated and expensive pre-dust may contain salt, spices, seasonings and

flavourants for functional and flavouring purposes. Before a fish portion is battered it usually undergoes a pre-dusting step.

Batter

The word 'batter' comes from the old French word 'battre' which means 'to beat" as many batters require vigorous beating or whisking in their preparation. A batter is defined as "a liquid mixture comprised of water, flour, starch and seasonings into which food products are dipped prior to cooking". Egg is also a common component of batter. Often a leavening agent is included in the mixture to aerate and fluff up the batter as it cooks or the mixture may be naturally fermented for this purpose as well as to add flavour.

Types of Batter

Batters are broadly classified as leavened or unleavened. Leavening means adding a substance to make the dough puffed before it is used. Unleavened batters are also termed as traditional batters. The traditional adhesive batter is a fluid, basically consisting of flour and water, into which the product is dipped before it is cooked or fried. A bond between the product and the coating is formed. The proportion of batter and water is generally in the ratio of 1:2. The desired viscosity and pick up decide the ratio of components in the batter mix.

Leavened batters are also known as Tempura batters and they have their origin in Japan. It is the puff-type specialty batter. Corn flour is important in tempura batters. This batter forms a crisp, continuous, uniform layer over the food, constituting its final coating. Tempura batters provide crust coatings of exceptionally high volume, which are also light in texture. The tempuras are used at very high viscosity levels and always contain leavening agents. Leavened batters require special application equipment, mixing and handling procedures.

Ingredients (of batter) and their functions

The commonly used ingredients of batter may be grouped under five categories or classes viz., polysaccharides, proteins, fat/hydrogenated oils, seasonings, leavening agents, gums and water (Table 1). Most of the batters are based on wheat flour, which determines its fundamental characteristics. Gluten in wheat flour with its good elastic properties, can expand during frying, providing a desirable, spongy coating and facilitating the passage of water and oil (Mukprasirt et al., 2001). The moisture content - protein functionality and the quantity of amylase and amylopectin in wheat flour base have found to be well correlated with the texture

characteristics, oil absorption, good appearance and overall acceptability of the coated product. Substitution of wheat flour with rice flour will influence the rheological properties of batter (Mukprasirt et al., 2000). A corn starch-based batter requires continuous mixing during processing because the solids have a tendency to settle out easily, which may result in continuously

changing viscosity and irregular batter pick up (Suderman et al., 1993).

Table 1. Major Ingredients of Batter and their Functions in Coated Products

Class of ingredients	Components	Function in the product
Polysaccharides	Wheat flour, corn flour, starch and gums	Improves viscosity, emulsifying and foaming capacity, texture and shelf life of the product
Proteins	Milk powder, milk protein fraction, egg albumin, seed protein	Improve the water absorption capacity of the flour and thus increase the viscosity of the system
Fat/hydrogenated oils	Triglycerides, fatty acids	Texture, flavour imparting
Seasonings	Sugar, salt , spices	Enhance plasticizing effect, flavour and impart antioxidant and antimicrobial properties
Leavening agents	Sodium bicarbonate, tartaric acid	Release carbon dioxide in tempura batters.
Gums	Xanthan, gum Arabic	Impart viscosity and enhance water binding capacity
Water		Provide gelatinization of starch, hydration of proteins, Improves batter viscosity

*Source - Venugopal, 2006

Modified starches with a high amylose content have good film forming properties which, alone or in combination with other ingredients such as rice flour or flour from other cereals help to reduce oil absorption by creating an effective barrier against oil in fried, battered products. These starches normally have a higher gelatinization temperature (Van Beirendonck, 1998; Higgins et al., 1999; Bertram, 2001).

The gelling ability of hydrocolloids, together with their usual hydrophilic nature makes them suitable for reducing oil uptake during frying in battered products (Annapure et al., 1999). The hydrocolloids most commonly used as a barrier are methylcellulose (MC) and hydroxypropyl methylcellulose (HPMC) (Lee and Han, 1988; Ang, 1989; Stypula, and Buckholz, 1989; Meyers and Conklin, 1990). Guar gum based batter showed superior functional properties

when compared to batters based on other hydrocolloids viz. carboxy methyl cellulose and carboxy methyl chitosan (Abbas et al., 2009).

Egg albumen is useful in binding the batter to the product; the lecithin in the yolk can act as an emulsifier, which contributes to its stability (Loewe, 1993). The use of dextrins in batter formulations is associated with an improvement in the crispness of the fried product (Shinsato et al., 1999).

Batter Preparation

It may be noted that no exact recipes exist for the batter system. Depending on the food substrate and the desired coating appearance, formulae can be extremely flexible to allow for maximum adaptability in the development of coated products. However batter ingredients can be classified as critical and optional ingredients based on the functions (Table 2). The addition ranges cited in the table are relatively wide, which gives a flexible formulation to suit the final product.

Table 2 Ingredients for Batter Formulation

Ingredient	Addition Range (%)
Critical	
Wheat Flour	30-50
Corn flour	30-50
Sodium bicarbonate	Upto 3
Acid phosphate	Adjust, based on neutralizing value
Optional	
Flours from rice, soy, barley	0-5
Oil	0-10
Dairy powders	0-3
Starches	0-5
Gums, emulsifiers, colours	< 1
Salt	Upto 5
Sugars	0-3
Flavourings seasonings	Depends on taste , flavour

*Source – Loewe 1992

Critical Quality Factors of Batter

Viscosity is the most important rheological property in batter formulations since batter is to be coated over the product in a liquid form and is recognized as one of the most important factors in determining its performance during frying (Shih and Daigle, 1999). The viscosity affects the

pick up and quality of the adhering batter, handling properties of the batter, its appearance and the final texture. While reconstituting the batter with water care should be taken to incorporate the correct quantity of water. Too much water can produce thin batter. Thin batter during frying release a large quantity of water and produce a porous coating that absorbs a lot of oil during frying. Insufficient water can result in a thick batter. A thick batter layer can lead to an incompletely cooked final product, lack of crispness, and a generally hard lumpy appearance. It has an adverse influence on oil uptake during flash frying.

The other factors that affect the rheological properties of batters are the composition and proportion of the ingredients, the solids-water relationship and temperature. Also, like the rheological properties of any fluid system, they depend on factors such as shear rate, duration of shearing, and previous thermal and shear histories (Steffe, 1996). As the batters exhibit a shear-thinning behaviour, an increase in shear rate produced a lower viscosity. Also, an increase in temperature resulted in lower consistency index values in several tempura batter formulations (Baixauli et al., 2003; Salvador et al., 2003)

The solids–water relationship is fundamental in order to achieve an optimum water content and distribution. The volume fraction of water is very critical in terms of oil absorption—a linear increase with percentage moisture—during deep-frying (Shukla, 1993). A thin, not very viscous batter capable of releasing a large quantity of water produces a porous coating that absorbs a lot of oil. There is a strong relationship between oil uptake and removal of water (Gamble et al., 1987). Moreover, a layer that is too thin is difficult to handle and has a poor barrier effect before and during frying. A layer that is too thick can lead to an incompletely cooked final product, lack of crispness and a generally hard, lumpy appearance.

Temperature plays an important role during the reconstitution of batter, since it determines the batter viscosity. Once reconstituted, it should be kept at a temperature low enough to maintain the viscosity and also to control the growth of microorganisms. However very low temperature should be avoided which will result in freezing of the batter on the conveyer line of production (Garthwaite, 1998). The ideal water temperature for batter reconstitution is suggested to be between 10 and 15 ^{0}C. At temperatures below 10 ^{0}C, the viscosity of water could become too high impeding proper handling and at a temperature above 18 ^{0}C, the viscosity could become too low.

Water content can have a direct effect on batter adhesion. Excess water content results in "ice glaze" of the fish portions, which result in poor batter adhesion to fish portions. This will result in a problem called "blow off" which means that batter will blow off or leaving the fish portion's surface when it enters the frying oil. Addition of phosphates in fish blocks will increase the cook time of the product. This will result in darkened and overcooked batters which may give an adverse consumer appeal to the product.

If a prepared batter is not used, it is vital that all dry ingredients should be blended sufficiently so that optimum ingredient distribution occurs. Hydration (mixing with water) of batter before the application should be done slowly by adding a predetermined amount of water to a prescribed quantity of batter mix as the mixing action proceeds. Mixing of batter should continue until no unwetted lumps remain in batter solution. A shortened hydration time of batter results in a partially hydrated batter that may have a chewy texture and contain lumps of dry batter.

Breading

The word breading is a general term that encompasses a large group of flour based , ground coatings. It can be defined as "a flour based bread crumb or cracker meal that is applied to a food in a dry form primarily to create a desired coating texture " .Breadings were used by the sections of the food industry as long as the foods have been fried: however the use of breadings to manufacture prefried convenience foods began only in the middle of 1950's. one of earliest commercial applications of breadings was in the formulation of fish sticks.

Breadings for commercial use are prepared by thermal processing of cereals i.e, by subjecting the cereal particles to heat treatment. Based on this process there are four broad groups of breadings which are outlined below:

Cracker Meal (Traditional Breading):

This type of breading is widely used in coated fish products. The preparation of the cracker meal is as flollows: the flour,with sugars,salt and any other colour are intensively blended and mixed with water in a continuous running mixer to form a dough. The dough is then forced through a series of paired rollers which make the dough into a thin sheet which is then conveyed over a moving steel belt for rapid baking. The baked sheet of dough which contains approximately 30% moisture is then crumbled through a granulating mill and dried to a final moisture content of approximately 8%. This moisture level ensures the shelf life of the breading and also contribute

to its absorptive capacity. The dried coarse particles are then roller milled, sifted and blended to achieve the desired particle size(mesh) specifications.

Home- Style Breadcrumbs

These breadings are prepared in many methods by the traditional bakers. The flour is formed into dough with water, yeast, sugar and salt as required to meet the specifications of the final processor who use the breadings for coating. The dough is then blended and mixed thoroughly using either continuous or batch mixing systems. The dough is then divided, proofed and baked into loaves. These loaves are allowed to cool, and then shredded, dried and sifted to meet mesh specifications.

Japanese Style Crumbs

This crumb is also known as 'Oriental Style' or 'Panko' type. These crumbs are made by standard dough ingredients and mixing methods as described in the previous crumb preparations. However, the dough after mixing is proofed in special baking pans that permit unique heat treatment during baking. This will result in a baked product free of brown crust. The baked loaves are then converted to crumbs as in the previous preparations. The crumbs will be crust free, white in colour and has a very porous nature with a splintered appearance.

Extruded Crumbs

Breadings can also be made on a wide variety of continuous mixers or extruders. In this process, the flour is continuously mixed under highly turbulent and intensive conditions, steam is injected and the resulting slurry of cooked flour is pumped through an orifice. The slurry will be extruded in the form of a cooked 'rope', which then shredded, dried and sifted to achieve the desired mesh size.

Breading characteristics

Breadings may be identified by their functional characteristics when applied to a substrate. The major functional characteristics of breading are mesh size, area to volume relationship, browning rate, moisture absorption, oil absorption, colour and texture.

Mesh: Typical breadings have particle size between No.5 U.S. sieve and No.80 U.S. sieve. The proportion of these various mesh fractions governs the final appearance of the food. Based on

the mesh size industry divides the breading into three broad ranges-courses, medium and fine. The larger particles provide visual interest and textural impact while the finest mesh portion rapidly absorbs the moisture in a very few seconds from any batter.

Area to volume relationship: The area to volume relationship (shape) of food to be breaded is another important factor. A high area to volume ratio permits a good coverage to be applied without any unfavorable effects on appearance and texture. In cube shaped foods coatings are very difficult to apply.

Browning rate: Browning rates of breadings depend largely on the proportion of reducing sugars used in their manufacture. Fast browning rates permit high processing speeds, reduced frying times and lower fry temperatures.

Moisture absorption: The rate at which a particle of breading absorbs moisture is a function of its particle size, porosity and gelation. The production rate can be increased if a breading of a smaller average mesh is used. It is porosity, together with mesh size, that determines the rate of absorption and texture of coating.

Oil absorption: The absorption of oil and the effective rate of heat transfer in porous granules are higher than in dense granules. The absorption of oil and the exchange of the oil for moisture during frying stage have an important advantage in texture development.

Colour: The final fried colour of the product is not solely dependent on the content of reducing sugars in the breading. It also depends on the other colours which are added to the breadings (paprika extracts, tomato pigment, synthesized carotene, annatto etc).

Texture: Mesh, porosity and absorption are the major crumb factors that contribute to texture. Coarse, dense crumbs may be very acceptable when the food is oven heated and non-oil appearances desired. Dense crumbs tend to absorb less oil when pre-fried; however, this same type of crumb when fully fried may have an unacceptably hard texture. The appropriate action is to select a coating with a medium particle size.

Table 3. Characteristics of Processed Breadings

Characteristics	Breading Type			
	Cracker meal	Home-Style	Japanese	Extruded

Granule type	Flat/Spherical	Spherical / Crumb like	Splintered	Shredded/Dense
Presence of crust	Minimal	High	Minimal	Minimal
Granulation range	Wide	Wide	Wide	Medium/Fine
Mesh	4-140	4-140	4-140	20-140
Colour	Variable	Variable	Variable	Variable
Browning Rate	Slow / rapid	Moderate / rapid	Slow except when toasted	Slow
Density	High	Medium	Low	Low
Texture	Firm	Crisp	Tender to crisp	Firm to hard
Water Absorption rate	Variable	Rapid	Rapid	Rapid
Oil Absorption	Low	Medium	Variable	Low
Process suitability	Prefry, full fry	Prefry, sometimes full fry applications	Full fry	Prefry, sometimes full fry applications

*Source - Dyson, 1992

Frying medium

Fat is the frying medium. Some fats may have specific flavour, which may be carried over to the product. Fat, besides being the heat transfer medium, is also a food ingredient and will influence the eating quality. Usually bleached and refined vegetable oils are used for frying.

The fat, because of the high temperature it is exposed to, may become degraded due to oxidation, polymerisation and contamination by food particles. Therefore, the fat used should be tested for evaluation of quality by determination of its free fatty acids, smoke point, peroxide value as well as colour for all of which there are prescribed standard limits.

Steps in the production of coated products

The production of coated fish products involves several process stages and steps and uses a subtle combination of art and technology. In most cases it involves the following steps.

Portioning/forming

Portioning is an important stage in the production of coated fishery products. Cutting loss and surface area of the portions are the two important points, which determine the economics of coated products. Cutting loss is negligible when manually done with a band saw, whereas with automatic block cutting machines it is in the range of 5-10 %. Skinless and boneless fish fillets are nowadays converted into predetermined shape and size using specially designed forming machines. There are forming/moulding machines available for other applications.

Pre-dusting

Before a fish portion is battered it usually undergoes a pre-dusting step. The purpose of pre-dusting is to prepare the surface of the portion so that batter can adhere uniformly. Pre-dusting also improves the adhesion of batters to frozen or greasy food surfaces. Pre-dust normally consists of a very fine raw flour type material. A more sophisticated and expensive pre-dust may contain spices and seasonings for both functional and flavouring purposes.

Application of batter

Conventional batters are of low to medium viscosity and hence can be applied with total submersion or overflow batter applicators. Low viscosity batters are normally applied in an overflow configuration. Medium viscosity batters may require a total submersion system depending on the product requirements.

The pre-dusted product is conveyed to the batter applicator and transferred to the next conveyor, which will draw it through the batter. The fish portion is totally submersed in the batter as it is drawn through it. Other applicators may use a pour-on application in addition to the submersion method. Irregular shaped products should be placed on the line with any concave surface upward to prevent air pockets from inhibiting batter pickup.

Line speed is a very critical factor affecting batter pickup. An excessively fast line speed will reduce the batter pickup. Too low a line speed also can result in excessive batter adherence. Excess batter, if carried over to the breading section, will cause formation of lumps and this can cause blockages in the breading machine. This will also cause formation of shoulders and tails on the edges of the product and contaminate subsequent breading application. Therefore, to overcome the problems the excess batter is removed by blowing air over the product. The position of the air blower should be as close to the product as possible to control the airflow across the product. Carry over from the pre-dusting operation also is critical. Where pre-dust is carried over, the viscosity of subsequent batter will increase leading to an increase in pickup.

Application of breadings

Breadings are applied to the battered food products using breading applicators. The belt speed of the breading machine is so adjusted to closely match the belt speed of the batter applicator. For soft products the crumb depth should be maintained as thin as possible to avoid product

damage in the breading machine; however, frozen or hard products should have a deep bed of crumbs. Pressure rollers are used to apply sufficient force to press crumbs onto the battered product.

Japanese style crumbs with their low bulk density and larger granule sizes make the crumb pickup difficult by the normal batter systems. Special batter formulations, sometimes containing raising agents, may have to be used at medium viscosity for a desired level of pickup of crumbs. Specially designed breading machines are used to apply uniform particle size distribution or granulation to both top and bottom of the product with minimum crumb breakdown. Air blowers are used to remove excess crumb from the product after breading. Excess crumb carried into the fryer can cause unsightly black specks on the product. Filters are used to remove small particles from the oil to prevent this phenomenon.

Pre-frying or flash frying

After coating with batter/bread crumbs many products are often flash fried prior to freezing. The purpose of pre-frying is primarily to set the batter/bread coating on the fish portion. Flash frying develops a characteristics crust and gives the product a characteristic fried (oily) appearance and taste. Therefore, the temperature of frying oil and the time of frying are critical. The normal frying temperature is between 180–200°C and the frying time 20-30 seconds. The term pre-frying is used because the final product frying is completed by the consumer for duration of 4-6 minutes depending on the portion size and thickness. The battered/breaded fish portions enter the frying medium through a conveyor system, the speed of which is adjusted so as to keep the fish portion in the hot vegetable oil for the required time.

Freezing

The fish portion leaves the frying oil with a coating temperature equivalent to that of the oil but still frozen in its center. Although the fish flesh center is frozen the surface flesh may be partially thawed. Hence, a quick and efficient freezing method is very essential to keep the quality of the coated product.

The first step in preparing the fried fish portion for freezing is air-cooling. This is usually accomplished with the use of a fan or a series of fans. This allows the coating temperature to drop, while at the same time allowing the batter coating to recover from the frying shock and

also to stabilize itself. The coated fish portions are then fed to the freezer through conveyor belts. Freezing is usually carried out in air blast freezers at -40°C.

Packing and storage

The coated product may undergo desiccation, discolouration and become rancid during storage. Use of proper packaging can prevent/retard these changes and enhance shelf life. Thermoformed containers are commonly used for packing coated products. The packaged products are usually stored at -20°C in master carton.

Coating systems

The varied and complex systems, which are termed batters and breadings, are merely components of the finished product. Using these components products are custom designed in terms of texture, flavour and visual attributes. The four basic coating systems are single line, Tandem line, Tempura or batter fry line and Tempura Japanese.

The single batter breading system, even one with a pre-dust rarely involves a pickup greater than 30%. Tandem lines consist of two batter breading machines and occasionally a pre-duster. Pickup with in this system is greater than 30%. The single and Tandem lines are commonly used for shrimp and fish sticks. Tempura lines are used for products that are coated with a leavened batter and immediately fried. These batters must be applied and processed evenly because they are the outermost coatings in the finished product. In this method the coated products should not touch each other before the batter is set in frying. Pickup in this system is normally between 30-50%. In Tempura Japanese system a leavened batter in conjunction with Japanese style or porous breadcrumbs are used. Pickup in this case also varies from 30-55%.

Equipment in Battering and Breading process

Prior to the introduction of machines breading lines in food processing plants consisted of a conveyor surrounded by a personnel who battered and breaded by hand. The process was slow, tedious, low production rates and difficult to maintain the hygienic standards. Today a large number of automatic and highly sophisticated processing equipment of varying capacities are available. Commonly used equipment in the production of coated products are grading equipment, peeling and deveining equipment, cooking equipment, meat bone separator, fish meat strainer, automatic band saw, forming machine, kneading machine, pre-duster, battering and breading machine, fryer, freezing equipment such as air blast freezer, cryogenic thermal

freezer, modular spiral belt freezer, fill and seal machine, vacuum packing machine with gas fleshing capability etc.

Processing of some coated fish and fishery products

Fish finger or fish portion

Fish finger is the first commercially successful coated fish product. Fish fingers are regular sized portions cut from rectangular frozen blocks of fish fillet or fish mince. A standard fish block in commercial practice in Europe is 47.9cm long, 25.4 cm wide and 6 cm thick weighing 7.5 Kg. On the production line the blocks are subdivided by a series of band saws and subsequently cut into the desired width and shape. Fish fingers are made into different shapes such as rectangular, square, wedge and French cuts. A typical British fish finger normally weighs about 28 g (1 oz) of which up to 50% of the total weight is contributed by the batter and crumbs. Accordingly, a rectangular piece of 7.5x2.0x1.5 cm weighing about 15 g may give a final weight of 28 g

The frozen fish block is prepared by mixing fish fillet/mince with 0.6% sodium tripolyphosphate and 1% sodium chloride, placing in a frame of convenient size, pressing slightly and frozen to form a solid block of fixed dimension. The frozen block is cut into suitable uniform sizes. These pieces are given a coating of pre-dust, batter and breading. The battered and breaded fish fingers are flash fried in oil at 180-200 ^{0}C for 30 seconds. After cooling, the fingers are frozen preferably in an IQF freezer. The frozen fish fingers are packed in thermoformed trays or pouches and stored at –20^{0}C. Commercial and retail distribution is in frozen state.

The fish fingers when fried in vegetable oil develop a golden brown colour with attractive appearance and odour. It has been observed that the sensory quality of fish finger developed from the frozen block of fish fillets is superior to that developed from the block of mince.

Coated fish fillets

A fish fillet is a skinless, boneless fish loin cut along the central bone frame and trimmed free of loose or hanging meat. Fish fillets can be prepared manually as well as using filleting machines. Manual filleting gives better yield compared to machine filleting.

Big fillets are cut into the desired size and cold blanched in 3% brine containing 0.1% citric acid for 3-5 minutes. The drained fillets are then pre-dusted, battered with an adhesive batter and further coated with bread crumbs. Generally medium size porous crumbs having a relatively large granulation are used. The battered and breaded fillets are then subjected to pre-frying, freezing and packaging as in the case of fish finger.

Coated Shrimp products

Coated shrimp in different forms and styles can be prepared from wild and farmed varieties. The most important among them are butterfly, peeled and deveined, round tail-on, nobashi etc. Generally, shrimp based coated products are expensive. The products from farmed shrimp have indicated longer frozen storage shelf life (16-18 months) compared to those from wild variety (12-14months) at -20^0C.The important steps in the production process are preparation of raw material, cold blanching in 1% brine (optional), pre-dusting, battering, breading, flash frying, packing, freezing and frozen storage .Black tiger shrimp or white shrimp of 26/30 to 31/40 counts /kg are generally used.

Coated Butterfly Shrimp

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising upwards. Peel the shrimp leaving the shell intact on the last segment and the tail fans. De-vein the shrimp and trim the tail fans using a pair of scissors. Cut through the dorsal side length-wise using a sharp scalpel or knife (Butterfly cut) to partially separate the lateral muscle block. Gently open the cut surface to reveal the butterfly shape. Wash in chilled potable water and drain.

Coat the butterfly shrimp with a thin layer of pre-dust followed by coating with a conventional (adhesive) batter or a tempura batter depending upon the market requirement. Coat the battered shrimp with breading (Japanese style light coloured coarse crumbs for Japan markets and darker coloured crumbs (yellow-orange) for European and US markets.

Arrange the coated shrimp in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches. Freeze at -40°C in an air blast freezer and store below -20°C in master carton.

Breaded "Peeled and deveined shrimp"

Process: Wash the whole shrimp in potable water. Peel off the shell and devein. Thoroughly wash in chilled potable water and drain.

Pre-dust the shrimps with a thin layer of flour. Coat the pre-dusted shrimp with the conventional (adhesive) batter followed by breading with Japanese style light coloured coarse crumbs for Japan markets and darker coloured crumbs (yellow-orange) for European and US markets.

Arrange the coated shrimp in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches. Freeze at -40°C in an air blast freezer and store below -20°C in master carton.

Coated fantail round

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising upwards. Peel the shrimp leaving the shell intact on the last segment and the tail fans. De-vein the shrimp and trim the tail fans using a pair of scissors. Wash in chilled potable water and drain.

Pre-dust the shrimps with a thin layer of flour. Coat the pre-dusted shrimp with the conventional (adhesive) batter followed by breading with Japanese style light coloured coarse crumbs for Japan markets and darker coloured crumbs (yellow-orange) for European and US markets.

Arrange the coated shrimp in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches. Freeze at -40°C in an air blast freezer and store below -20°C in master carton.

Breaded "Nobashi" (Stretched shrimp)

Process: Wash the whole shrimp in potable water and remove the head. Remove the telson by gently raising upwards. Peel the shrimp leaving the shell intact on the last segment and the tail fans. Wash the prawns in chilled water and drain. Make three or four parallel cuts, across or diagonally on the ventral side using a sharp razor. Keep the prawn on a cutting board with

bottom side down. Stretch the shrimp to the desired length by gently pressing it using a stainless steel mould.

Pre-dust the stretched shrimp with a thin layer of flour. Coat the pre-dusted shrimp with the conventional (adhesive) batter followed by breading with Japanese style light coloured coarse crumbs for Japan markets and darker coloured crumbs (yellow-orange) for European and US markets.

Arrange the coated shrimp in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches. Freeze at -40°C in an air blast freezer and store below -20°C in master carton.

Coated products from squid

Squid rings and stuffed squid are popular coated products processed out of squid. Stuffed squid is generally processed out of small size animals. Both the products have good demand in the export market.

Squid Rings

Process: Prepare squid tubes from fresh whole squids by carefully removing the ink sac, squid pane, tentacles and viscera. Peel off the skin and wash tubes in potable water. Cut the cleaned tubes in the form of rings of uniform size (1 cm). Cook the rings in 3 % brine containing 0.1% citric acid for 1-2 minutes and cool under a fan. Coat the rings with a suitable pre-dust, batter and bread crumbs. Flash fry the coated rings for 20 seconds at 180°C and freeze in an IQF freezer. Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches. Store the products in master cartons at -20°C.

Stuffed Squid

Process: Prepare cleaned squid tubes as explained earlier. Prepare a stuffing mixture containing cooked squid tentacles, cooked potato, fried onion, spices etc. Fill the cleaned tubes with the stuffing mixture. Give a coating of pre-dust, batter followed by breading with the preferred crumbs. Flash fry the coated stuffed squid tubes at 180°C for 30 seconds and freeze the stuffed squid in IQF freezer. Arrange in PVC/polystyrene trays, preferably in "well" trays and vacuum pack in laminated pouches. Store the products in master cartons at -20°C.

Coated products from bivalves

The most important bivalves which are suitable for the production of delicious coated products are mussels, clams and edible oysters. The glycogens present in their muscle in appreciable amounts gives them a characteristic flavour and taste and make them delicious. Coated products from mussels, clams and oysters have become commercially important in the export as well as domestic market because of their delicacy. Since majority of bivalves are filter feeders, living attached to the bottom of their habitat they accumulate large number of microorganisms in their gut. Hence great care and hygienic handling practices are required for preparing consumer safe ready to eat products out of these animals. The first step in the preparation of products from these animals is a cleansing process called depuration. This is a biological purification process intended for making the bivalve meat fit for human consumption with respect to microbial contamination. The process removes the microbial load from the gut and body of the animals by subjecting them to starvation and facilitating to discharge contaminants.

Coated clams and mussels

The clams and mussels after depuration are washed well by spraying potable water over the animals. Collect the depurated bivalves in a large vat and heat to boil. On heating the animals will start opening their shells. Stop heating when all the animals have opened their shells. Transfer the boiled animals to a table top and allow to cool. After cooling, shuck the meat either by hand or using a sieve that is traditionally used. Blanch the shucked meat in 3% boiling brine containing 0.1% citric acid for 3 - 5 minutes, drain and allow to cool. Pre-dust the meat with fine flour followed by battering and breading with suitable crumbs. Flash fry the coated bivalve meat at 180°C for 20 to 30 seconds depending on the size and freeze in an IQF machine. Arrange in PVC/polystyrene trays and vacuum pack in laminated pouches. Store the products in master cartons at -20°C.

Coated Edible Oyster

Since the shell of edible oyster is covered with mud and dirt, depuration is not always effective in reducing the microbial load from the gut and body of the animals to the desired level. Because of this a slightly different method is followed for the processing of this bivalve unlike clams and mussels.

In this case the meat is shucked out manually using a pair of pliers and then cooked in 3% brine solution containing 0.1% citric acid for 10 minutes and cooled. The gut contents including hepatopancreas are then removed manually. Since it is a post blanching operation utmost care should be taken to avoid any type of contamination. The meat is then pre-dusted with fine flour followed by battering and breading with suitable crumbs. The coated oyster meat is then flash fried at 180°C for 20 to 30 seconds depending on the size and frozen in an IQF machine. The frozen product is then arranged in PVC/polystyrene trays, preferably in "well" trays and vacuum packed in laminated pouches. Trays are packed in master cartons and stored at -20°C.

Fish Mince based coated products

Fish mince from marine as well as freshwater fish can be used for processing a variety of coated products such as fish cutlets, fish balls, burgers, loaves, patties etc.(Regenstein, 2004; Grantham, 1981; Venugopal and Shahidi, 1995; Venugopal et al.,1992; Joseph et al.,1984) .The mince from different species could be combined to prepare composite fillets (Venugopal, 2006).The method of preparation of these products is briefly outlined below:

Fish cutlets: Fish cutlets are prepared using cooked fish mince, which is mixed with cooked potato, fried onion, spices and herbs. It is then formed into the desired shape, each weighing approx. 40 g. The formed cutlets are pre-dusted with a fine flour (optional) battered with a medium thick batter and then coated with medium bread crumbs and flash fried for 30 seconds at 180°C(optional). The pre-fried cutlets are then frozen in an IQF machine and then arranged in PVC/polystyrene trays, preferably in "well" trays and vacuum packed in laminated pouches. Trays are packed in master cartons and stored at -20°C.

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.

Fish burgers (Fish patties): Fish burgers are more or less similar to fish cutlets. Fish mince from lean white meat fish is used. Cooked mince is mixed with cooked potato, fried onion, flour, mild spices and formed into round shapes. Generally, the starch content is to be kept below 15% and the meat content must not be less than 30% for ensuring a meaty flavour. Burgers are battered, breaded and flash fried before packing and freezing.

Crab Claw Balls

Crab claw ball is a highly delicious high value moulded and coated product. Crabs of Portunus / Charybdis species are generally used.

Process: Crab claws are severed from the body and washed well in chilled potable water. The last (distal) segment carrying the pincers is cut open using a pair of scissors or cracked open using a cracker and shell removed leaving the cartilaginous septa and muscle intact. The meat from the legs and claws is separated by using a cracker and washed in chilled potable water. The shell on the claw is removed keeping the claws unbroken and the meat removed exposing the claw ligament. The meat is mixed with 2% starch based commercial batter mix to the required consistency. This is then stuffed in ball shape on the exposed claw ligament. Alternatively the body meat mixed with the batter mix also can be used for stuffing. The stuffed claw balls are then frozen in an air blast freezer. The frozen stuffed claw balls are then pre-dusted with fine flour, battered with medium viscous batter and breaded with medium coarse bread crumbs. The coated claw balls are then flash fried for 30 seconds at 180 0C, arranged in PVC/polystyrene trays, preferably in "well" trays and vacuum packed in laminated pouches, frozen at -40°C in an air blast freezer and stored at -20°C in master carton.

Common quality problems encountered during the coating of Seafood

Voids

Presence of voids is a common quality problem that occurs during the application of batter to fish portion. Voids are bare areas on a fish portion that do not accept the batter. This is caused by many factors such as excessive line speed, shape of the fish portion, absence of predusting material, a non-adhesive surface, ice glaze, and air pockets formed during the application (Suderman, 1992). Once the void is formed, it is difficult to remove it from the fish portion due to the thick consistency of the batter. Hence the portion has to be removed from the line.

Blow off

Blow off can be observed when some or all of the batter is blown off or removed during frying. This problem is accelerated if the portions contained voids. The lingering portions of batter will be fried excessively and give the product a dark unacceptable appearance.

Pillowing

Pillowing will appear as an elevated dome of batter on the product with a large air pocket beneath it. It is caused by the formation of steam pocket due to water vapourization which is trapped under the batter during the frying process. Once the product is cooled, the puffed dome collapses and create an undesirable wrinkled appearance. Pillowing is mainly caused due to the improper blending of the batter mix and also in some cases, due to the very high leavening levels of batter mix (Suderman, 1992).

Tailings

Batter extends beyond the product like a tail or stringer. This is caused due to the excessive thick batter which results in inadequate blow off during the production (Johnson and Hutchison, 1983). The batter will accumulate behind the product as the name suggests.

Standards for Quick Frozen Fish Sticks (Fish Fingers), Fish Portions and Fish Fillets - Breaded or in Batter (Codex Standards 166-1989)

This standard applies to quick frozen fish sticks (fish fingers) and fish portions cut from quick frozen fish flesh blocks, or formed from fish flesh, and to natural fish fillets, breaded or batter coatings, singly or in combination, raw or partially cooked and offered for direct human consumption without further industrial processing.

Product Definition A fish stick (fish finger) is the product including the coating weighing not less than 20 g and not more than 50 g shaped so that the length is not less than three times the greatest width. Each stick shall be not less than 10 mm thick. A fish portion including the coating, may be of any shape, weight or size. Fish sticks or portions may be prepared from a single species of fish or from a mixture of species with similar sensory properties. Fillets are slices of fish of irregular size and shape which are removed from the carcass by cuts made parallel to the back bone and pieces of such fillets, with or without the skin.

Process Definition The product after any suitable preparation shall be subjected to a freezing process and shall comply with the conditions laid down hereafter. The freezing process shall be carried out in appropriate equipment in such a way that the range of temperature of maximum crystallization is passed quickly. The quick freezing process shall not be regarded as complete unless and until the product temperature has reached -18°C or colder at the thermal centre after thermal stabilization. The product shall be kept deep frozen so as to maintain the quality during transportation, storage and distribution. Industrial repacking or further industrial

processing of intermediate quick frozen material under controlled conditions which maintains the quality of the product, followed by the re-application of the quick freezing process, is permitted.

Presentation Any presentation of the product shall be permitted provided that it:

- Meets all the requirements of the standard, and
- Is adequately described on the label to avoid confusing or misleading the consumer

Essential Composition and Quality Factors

Raw Material: Fish Quick frozen breaded or battered fish sticks (fish fingers) breaded or battered fish portions and breaded or battered fillets shall be prepared from fish fillets or minced fish flesh, or mixtures thereof, of edible species which are of a quality such as to be sold fresh for human consumption.

Coating: The coating and all ingredients used therein shall be of food grade quality and conform to all applicable Codex standards.

Frying fat (oil): A fat (oil) used in the cooking operation shall be suitable for human consumption and for the desired final product characteristic.

Final Product: Products shall meet the requirements of this standard when lots examined in accordance with provisions outlined in Codex standards for lot acceptance and comply with the provisions set out in the definitions for defectives. Products shall be examined by the standard methods of sampling, examination and analysis.

Decomposition: The products shall not contain more than 10 mg/100 g of histamine based on the average of the sample unit tested. This shall apply only to species of Clupeidae, Scombridae, Scombresocidae, Pomatomidae and Coryphaenedae families.

Hygiene

It is recommended that the products covered by the provisions of this Standard be prepared and handled in accordance with the appropriate sections of the General Principles of Food Hygiene (CAC/RCP 1-1969), the Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003), the Code of Practice for the Processing and Handling of Quick Frozen Foods (CAC/RCP 8-1976) and other relevant Codex Codes of Hygienic Practice and Codes of Practice: The products should comply with any microbiological criteria established in accordance with the Principles and Guidelines for the Establishment and Application of Microbiological Criteria

Related to Foods (CAC/GL 21-1997). The final product shall be free from any foreign material that poses a threat to human health.

When tested by appropriate methods of sampling and examination prescribed by the Codex Alimentarius Commission, the product:

(i) shall be free from microorganisms or substances originating from microorganisms in amounts which may present a hazard to health in accordance with standards established by the Codex Alimentarius Commission;

(ii) shall not contain histamine that exceeds 20 mg/100 g. This applies only to species of Clupeidae, Scombridae, Scombresocidae, Pomatomidae and Coryphaenedae families;

(iii) shall not contain any other substance in amounts which may present a hazard to health in accordance with standards established by the Codex Alimentarius Commission.

Labelling

In addition to provisions outlined in Codex General Standard for the Labelling of Pre-packaged foods, the following specific provisions apply:

- The Name of the Food The name of the food to be declared on the label shall be "breaded" and/or "battered", "fish sticks" (fish fingers), "fish portions", or "fillets" as appropriate or other specific names used in accordance with the law and custom of the country in which the food is sold and in a manner so as not to confuse or mislead the consumer.
- The label shall include reference to the species or mixture of species
- The proportion of fish content should be declared on the label.
- In addition, there shall appear on the label either the term "quick frozen" or the term "frozen" whichever is customarily used in the country in which the food is sold, to describe a product subjected to the freezing processes.
- The label shall show whether the products are prepared from minced fish flesh, fish fillets or a mixture of both in accordance with the law and custom of the country in which the food is sold and in a manner so as not to confuse or mislead the consumer.
- The label shall state that the product should be maintained under conditions that will maintain the quality during transportation, storage and distribution.

Definition of Defectives

The sample unit shall be considered defective when it exhibits any of the properties defined below:

Foreign Matter (Cooked State) The presence in the sample unit of any matter which has not been derived from fish (excluding packing material), does not pose a threat to human health, and is readily recognized without magnification or is present at a level determined by any method including magnification that indicates non-compliance with good manufacturing and sanitation practices.

Bones (Cooked State) (In packs designated boneless) More than one bone per kg greater or equal to 10 mm in length, or greater or equal to 1 mm in diameter; a bone less than or equal to 5 mm in length, is not considered a defect if its diameter is not more than 2 mm. The foot of a bone (where it has been attached to the vertebra) shall be disregarded if its width is less than or equal to 2 mm, or if it can easily be stripped off with a fingernail.

Odour and Flavour (Cooked State) A sample unit affected by persistent and distinct objectionable odour and flavours indicative of decomposition, or rancidity or of feed.

Flesh abnormalities Objectionable textural characteristics such as gelatinous conditions of the fish core together with greater than 86% moisture found in any individual fillet or sample unit with pasty texture resulting from parasites affecting more than 5% of the sample unit by weight.

Lot Acceptance

A lot shall be considered as meeting the requirements of this standard when:

(i) the total number of defectives as classified according to Section 8 does not exceed the acceptance number (c) of an appropriate sampling plan with an AQL of 6.5;

(ii) the average percent fish flesh of all sample units is not less than 50% of the frozen weight;

(iii) the average net weight of all sample units is not less than the declared weight, provided there is no unreasonable shortage in any container; and

(iv) the Food Additives, Hygiene and Labelling requirements of Sections 4, 5 and 6 are met.

Conclusion

Coated fishery products are an important category of ready–to-cook products which command a high consumer appeal and replaces the conventionally processed fish products in many

market segments, particularly the urban and semi urban sectors. The production and marketing of these products offer greater scope for the utilization of low value fishes. Besides, many of the cultured freshwater species can be potential raw material sources for the production of coated items which can significantly improve the prospects for value addition and income generation in the fast growing freshwater aquaculture sector. The coating process can also modify the flavour and enhance the acceptability of freshwater species. Coating is the best option for value addition in fisheries which can ensure the total utilization of resources.

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