

Opportunities of Adopting and Significance of Freshwater Fish Powder Based Biscuit: A Review

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Abstract Fish has been widely used as an excellent source of animal protein and other nutrients. It functions to prevent human beings from variety of diseases all over the world. Sturgeon is one of the world's known freshwater fish have a high nutritional value which provide high quality protein, are rich in essential amino acid and good source of vitamins and minerals. Based on the nutritional value, freshwater fish are the best source and replacement of wheat flour based biscuits. Malnutrition is the biggest burden nowadays all over the world particularly in developing countries. Consumers getting complementary biscuits from cereals and crops are especially vulnerable to malnutrition because these biscuits are characterized by poor-protein quality, as well as inadequate micronutrient content like vitamins. Even though consumers are getting biscuits from cereals, however, these types of biscuits have low protein content of essential amino acids like lysine and other micronutrients compared to biscuits enriched with fish protein powder. Biscuit is one type of bakery products, which is widely consumed by young people because of its availability easy to eat convenience. Biscuit supplemented with fish powder could provide biscuit with high nutritional value, solve malnutrition and will increase the usage of freshwater fish at large.

Keywords Role of fish biscuit; Nutritive value; Sensory quality; Consumers

Background

Fish is a high-protein, low calorie sea food and an important source of omega-3, omega-6 fatty acids, vitamins and minerals, such as calcium and phosphorus. Freshwater fish products have attracted considerable attention as an important source of nutritional human diet (Kaya and Kocatepe, 2014). Apart from their delicacy, freshwater fish consist of amino acids, peptides, proteins and other important nutrients (Gunalan et al., 2013). Kaya and Kocatepe (2014) also reported lysine and leucine are major essential amino acids in fresh water fish (such as *S. porcus*).

Freshwater fish, such as Sturgeon, due to its extreme good source of protein, calcium and various extractable compounds and minerals and medium in fat and calories, make it a healthy food choice for consumers (Cataric, 2004). In addition, freshwater fish flesh consists of highly unsaturated fatty acids (FAs), such as eicosapentaenoic (C20: 5n-3, EPA) and docosahexaenoic (C22: 6n-3, DHA) acids, which are essential in the human diet which can help in brain development and eye vision specially in children (Pourshamsian et al., 2012). The inorganic elements available in fish body can support great role in the physiological functions. Since these micronutrients are essential, their absence in the diet may lead to deficiency of several diseases (Kaya and Kocatepe, 2014). The minerals, such as copper, zinc, manganese, iron and chromium, found in fish at acceptable level are very significant for human health and have useful biological function (Palmeira et al., 2014). Having such chemical compositions sturgeon fish were not fully utilized other than the aforementioned advantages. Taken this inconsideration such types of freshwater fish are the best source and replacement of wheat flour based biscuits.

Bakery products are the most consumable type of food particularly by young consumers such as children. The most preferable and highly consumed is biscuit. The availability, convenience to eat and long shelf life are some of the characteristics which makes to consume widely and popular (Mahmoud et al., 2017). Nowadays the big problem in the world is malnutrition. Consumers getting complementary foods from cereals and crops are especially vulnerable to malnutrition because these foods are characterized by poor-protein quality, low energy

density as well as inadequate micronutrient content like vitamins (Wani et al., 2015). Fortification of bakery products with freshwater fish powder can be a way to improve quality of biscuit and a vehicle of nutrients to consumers, particularly young consumers. Therefore, it is highly recommended to eat functional foods (biscuit) which are supplemented with fish and fish products (Neiva et al., 2011). The present work centers on reviewing current scientific literatures on the significant role of fish biscuit towards human health, as well as vital function of sturgeon fish.

1 Description of Sturgeon

The sturgeon fish species are under the family of Acipenseridae and included four genera *Acipenser*, *Huso*, *Scaphirhynchus* and *Pseudoscaphirhynchus*. They have unique physical appearance whisker-like barbels, exterior scutes, and a heterocercal caudal fin (Cateric, 2004).

Sturgeons are one of the most valuable fish families and important commodities on earth (Burke and Nash, 2014). They occupied diverse habitats in the world mostly in the northern hemisphere. The unfertilized roe, meat, liver and gallbladder are some of the most commercial values which can be obtained from sturgeon species (Cateric, 2004). Sturgeon are also reared and harvested for meat, which can be sell as fresh, frozen and eating pan-fried, and broiled (Moghim et al., 2006; Wei et al., 2011). China is known by rearing sturgeons at large scale for commercial use (Ercan, 2011). Wei et al. (2011) stated in their findings, China have been exported products of sturgeon, caviar and other value added products derived from freshwater and farmed sturgeon. Taken this inconsideration, China stated some strategic management to promote sturgeon product diversification, strengthen and foster deep processing (value added products) and good quality control.

Luxury food products, such as caviar are some of the famous products that can be prepared from sturgeon fish and there is a worldwide demand (Burke and Nash, 2014). In northern hemisphere, they are prized for their meat and unfertilized roe which is processed and marketed as the delicacy, caviar (Cateric, 2004). The dried swim bladder tissue of sturgeon is used to produce isinglass, which in turn is used to clarify wine and beer. Additionally, some Acipenseriformes are made available for sale in the ornamental trade (Cateric, 2004). Wei et al. (2011) reported that, the sturgeon have not only been used as food for human consumption, but also developed to derive at medical products, leather and other use.

Sturgeon meat is rich in proximate composition and well known by its tasty flesh, which can be good source for the human nutrition to prevent from different disease. They are very rich in protein of good biological value, essential ions, vitamins and has a medium fat content (Badiani et al., 1996; Pourshamsian et al., 2012). Earlier reports indicated sturgeon fish has an excellent source of proximate composition. It contains 15-21% protein, 3-4.5% fat, and 1.9-2.8% ash content (Jankowska, 2005).

2 Overview and Importance Chemical Composition of Fish

The main chemical composition of fish includes water, protein, lipid and ash. Other constituents like vitamins, minerals and carbohydrates are present in small amounts. Earlier study done by Meynier et al. (2008) indicates that protein, lipids, ash, minerals and vitamins are the chemicals constituents of fish. Fish has got a recognition by nutritionists at it supplies a good balance of protein, vitamins, and minerals. Venugopal et al. (1996) indicates in the findings that fish is an excellent source of protein and contains nutritionally valuable lipids and fatty acids.

In general a knowledge of chemical composition of fish is important in order to compare its value as food with other protein foods. It is also essential to have detailed information on the composition of fish and fish products in order to make the best use of them as food and in order to develop the technology of processing fish and fish products into varieties of value added or fortified food products, developing new fish product, dietary formulation, nutrient labeling and processing (Gooch et al., 1987). It has been reported that, the chemical composition of fish varies greatly from one species and one individual to another and the variation could be due to sex, age, environment and season (Gooch et al., 1987; Obaroh et al., 2015). Fresh fish usual consist about 70-80% of water, 20-30% of protein and 2-12% of lipid (Tsighe et al., 2017). Meynier et al. (2008) described that fish is a rich source of chemical composition that are easily digestible.

Freshness is essential for the fish quality. Quality assessment of fresh and refrigerated cultured sturgeon meat was researched by Elpida et al. (2007), explained in the research work that sturgeon fish are known and has got appreciation by consumers, due to the quality of nutritional composition. Not only marine fish meat, but also sturgeon freshwater fish is appreciated for its dietary value derived from the content of protein and fatty acids (n-3 and n-6) which go into the composition of cell membranes and play a vital role in the preservation of cardiovascular diseases and build of muscles, increase thinking level of consumers, particularly children. Suvanich et al. (1998) have done a research on prediction of proximate fish composition from ultrasonic properties. Fat, protein, ash and moisture contents of certain fish species were determined (Table 1). They reported that consumption of fish and fish products is crucial for our health as they are rich in protein and other chemical compositions.

Table 1 Composition of fish muscle determined by standard methods (Adapted from Suvanich et al., 1998)

| Fish type | Fat (%) | Ash (%) | Protein (%) | Moisture (%) |
|-----------|---------|---------|-------------|--------------|
| Catfish | 7.7 | 0.9 | 15.4 | 76.3 |
| Cod | 0.1 | 1.1 | 18.2 | 80.8 |
| Flounder | 0.7 | 1.3 | 14.0 | 84.6 |
| Mackerel | 11.7 | 1.1 | 18.8 | 69.0 |
| Salmon | 1.6 | 1.1 | 23.5 | 74.3 |

Badiani et al. (1996) work a research on Nutritional Composition of Cultured Sturgeon (*Acipenser* spp.), reported that, sturgeon fish has valuable source of nutritional composition for human nutrition and appreciated by the Italian people due to its high quality flesh and omega-3 unsaturated fatty acid contents. Sturgeon is a medium fat fish. The range of fat, moisture and protein content were reported as follows: 5-15%, 65-77% and 17-21%, respectively and has ash content within the range covered by most freshwater and marine fish (Badiani et al., 1996).

3 Quality Value of the Sturgeon Fish

3.1 Nutritional quality of fresh sturgeon

The nutritional value sturgeon fish is conditioned by the proximate chemical composition of the meat and by the biological value of the main constituents (proteins, lipids, mineral salts, and vitamins) (Elpida et al., 2007). Elpida et al. (2007) also highlighted that the protein of sturgeon meat encompass all the eight essential amino acids which was considered to be the one with a high biological value or complete protein.

Fish are the main source of omega-3 fatty acids. These types of fatty acids have very crucial role in the human health on reducing arteriosclerosis, prevention and treatment of numerous disorders like cardiovascular disease and others (Pourshamsian et al., 2012). Shaviklo et al. (2011a) suggested that human obtain main parts of fatty acids via consuming fish and fish products and by incorporating into some foods, like bakery products, milk and other type of foods. Several studies have reported that the consumption of fish and fish oils reduces blood lipid levels in humans. Fish oils, in addition to lowering lipid levels, may also play a great role to reduce platelet aggregation, decrease blood viscosity, prevent ischemic damage, and, possibly, lower blood pressure (Gooch et al., 1997). Fish proximate chemical composition can be deteriorate if correct preservation methods (electrical oven drying, solar drying, chilling, smoking, frying, and freezing) is not applied on the right time after the fish captured.

3.2 Drying of fish muscle using electric oven dryer method to make fish powder

Drying of fish is a method of preservation which encompasses the removal of water from fish or fish products by evaporation. Since fish is highly perishable drying can be used to maintain the high nutritious and valued protein contents. It inhibits activities of microorganism, enzymes, fungi and mold, which require aqueous environment, by evaporate water from the food matrix so as to lower the water activity. Hubackova et al. (2014) reported that fish is highly susceptible to spoilage and its meat contain about 80% water by mass in fresh state, which results in an extremely short shelf-life when left unprocessed. The fish protein and other animal protein can be maintained and preserved its quality for long time by drying. Fish and fish products dried in all drying methods can show some noticeable changes in color, taste, odor and texture and minimum loss in production (Ali and Karimi reza abad, 2015).

Electric oven drying is one of the several drying methods which is conventional supplied by electric power. It is the most convenient method to dry a fish as it operates and sets depending the desire and condition of the final product requirement of consumers. Oven drying method is the fastest and safer than the open sun drying method. Fish dried in an oven dryer showed an increase in nutritional value than a fish dried in open sun dryer (Ali and Karimi reza abad, 2015). Hubackova et al. (2014) was compared the drying performance of solar and electric dryers and found that electric oven dryer can reduce the moisture content of a fish to 2.22% and 3.12% after 24 hours respectively. It has been also reported the drying was better in electric oven, due to the uniform drying conditions compared to solar drying (Hubackova et al., 2014). Ali and Karimi reza abad (2015) indicated in their results of research work the oven drying method is a good effective method to decrease moisture level where activities of microorganisms can be inhibited and to achieve high protein content (85.66%). It was also suggested that drying fish with electric oven method is more suitable for feeding health nutrition and good shelf life which can store for long time (Ali and Karimi reza abad, 2015). Drying fish using oven drying, low cost drying technology, for developing dried fish protein has been reported (Chavan, 2008). Huda et al. (2000) recommended that drying fish at 60 °C for 12 h is important to reach less than 10% moisture content of fish protein powder.

3.3 Preparation, composition and characteristics of fish powder

Shaviklo (2015) commence the idea of processing fish powder via solvent extraction method; however it retains a solvent taint even after prolonged steam stripping under vacuum. Numerous researchers have been worked on production of edible fish powder by solvent extraction method to remove fat thereby making the process costly (Solanki, 1977). In findings of nutritional content and quality attributes, fish with low fat content has been chosen to produce edible fish powder and concluded that, fish with low fat content are recommended for preparation of edible fish powder.

Venugopal et al. (1994) has modified the processing method and stated that preparing fish powder can be by drying fish either whole or muscle without employing solvent extraction. Production of fish powder using drying technique of oven, spray and freeze drying at 50-60 °C can extend the storage life minimum of one year at 10 °C without loss of sensory attributes (Huda et al., 2000). Venugopal et al. (1996) reported that drying methods, types of additives and processing conditions are some of the factors which can affect the functionality, stability and sensory properties of fish powder. Production fish powder from lean fish have longer storage shelf at ambient temperature compared to fatty fish as fat is the main factor to loss sensory attributes. Mohamed et al. (2014) stated that fish powder has high levels of essential amino acids, such as lysine, methionine and cysteine compared to cereal products. In addition to its high digestibility and biological values it is also a good source of vitamins and minerals. Osibona (2011) has done a research on comparative study of proximate composition, amino and fatty acids of some economically important fish species in Lagos, Nigeria and found that mineral content of fish powder was 121.97 mg/100 g calcium, 109.31 mg/100 g potassium, 110.05 mg/100 g zinc and 115.23 mg/100 g sodium.

Vanugopal (2005) highlighted that fish and fish products are very rich in nutritive value due to the essential amino acid favorable patten. Compared with protein from plant source, fish protein is rich in all essential amino acids, particularly lysine and methionine, which lack enough amounts of one or more essential amino acids.

Venugopal et al. (1996) reported that fish powder is an excellent dietary supplement and can be used to fortify diverse range of cereal products to provide a healthy source of easily digested proteins. Enrichment of tilapia fish protein in to bread from wheat flour was done by Adeleke and Odedeji (2010) resulted in an improvement of the nutritional value of bread. It was found that protein content of bread (18.01) was more compared to the control (9.08%). Based on the findings the researchers suggested that acceptable fortified biscuit and bread could be produced from wheat and tilapia fish protein powder.

3.4 Nutritive value of fish powder and its application in food products

Proteins derived from fish are nutritionally superior when compared to those of plant sources. They have a better balance of the dietary essential amino acids compared to all other animal protein sources (Friedman, 1996; Netto et al., 2014).

Fish powder is one type of fish and fishery product with concentrated protein content than in fresh fish (Khoshkhoo et al., 2010). Many scholars have been done a research on it, due to its great applications on different food products and importance towards human being. A lot of agricultural food products, such as biscuit, ice cream can be fortified with fish powder to increase protein content and to improve flavor, taste and nutritive value. Netto et al. (2014) and Shaviklo (2015) reported that fish is a rich animal protein source with high nutritive value, consumption of them can meet many nutritive requirements of body and is useful to improve human health at large. Fish powder contains high levels of essential amino acids such as lysine, high methionine and cysteine content and a high digestibility and biological value compared to grain products which are the typical base for most animal feeds. It is also a good source of minerals, such as phosphorous (P), calcium (Ca), copper (Cu), iron (Fe), and vitamins (Elpida et al., 2007).

Venugopal et al. (1996) observed in the investigation that fish powder is a stable product with low moisture content that can has a maximum storage life of one year at 10 °C without loss of nutritional qualities and to some extent at ambient temperature. Several studies has been done on the nutritional content of fish powder and reported that adding fish powder to diets has significant effect. Akhade et al. (2016) reported that use of this product is especially beneficial for children and pregnant women. Murueta et al. (2007) recommended that fish powder can be used as a supplementary protein to increase nutritive value, as it contains high protein content.

Fish powder, fish protein concentrate and fish protein powder are made by process that concentrate fish protein from whole fish or fillet and other parts into a more stable form. As a form of a low cost animal protein, they can supplement agricultural products, cereals, and vegetable proteins very effectively. Added in low concentrations they can clearly improve the nutritive value of different common food and food products by adding certain essential amino acids deficient in proteins (Jeyasanta et al., 2013).

Rhee et al. (2004) clearly stated that widely consumed food products are cereal products that contain low protein and high carbohydrates. Akhtar et al. (2015) and Veronica et al. (2006) mentioned in that fortification of cereal products with fish products, fish powder, which are rich in protein can increase their nutritional value. Barbut and Mittal (1995) reported that fish can be added into cereal products to increase protein content and improve nutritional value, as an excellent source of protein and key minerals and vitamins.

The level of supplement fish product (fish powder) with cereal products have significant role on the sensory characteristics of enriched product despite increasing the nutritional value of product. Singh et al. (2014) and Shaviklo (2015) stated that the level of enrichment can affect acceptance and sensory properties of the product such as flavor and odor. Therefore, appropriate incorporation level is recommended at any circumstance to meet the desired objective and satisfy consumers need.

Vanugopal (2005) reported that nutritive value of cereal proteins can be increased when fortified with fish protein powder. It was found 12.4% of protein after adding 3% of fish protein powder in to cereal wheat flour with 10.4% protein content. However, several researchers have done enrichment of cereal products with fish protein and successful results were obtained. Fortification of puffed corn snack (Shaviklo et al., 2011a), ice cream (Shaviklo et al., 2011b), bread (Adeleke and Odedeji, 2010), biscuits (Ibrahim, 2009), mayonnaise (Sathivel et al., 2005), crackers (Huda et al., 2001) with fish protein powder have been done.

Shaviklo et al. (2013) studied storage stability and nutritional quality of cutlet fortified with 30% of fish protein powder. Nutritive quality of the product was improved and there were no changes in chemical, biochemical and sensory attributes during storage period of six months. Hussain et al. (2007) reported that incorporation 10% of fish protein powder in to weaning food can result superior quality and concluded that it could be an ideal source of protein for enriching the weaning food.

Bearing in mind the significance of fish powder, it is a valuable supplement to improve the nutritional values of fortified food, particularly biscuit for children and other diets for vulnerable group. Sen (2005) and Shaviklo (2015) have noticed that children who feed a diet fortified with fish protein powder showed significant increase

both in weight and height. Tsighe et al. (2017) reported that fish powder is important to solve problems which can arise from malnutrition. Sen (2005) recommended that fortification cereal food products with fish powder are very beneficial to increase nutritional value of the products.

3.5 Sensory properties of biscuit supplemented with fish powder

Consumer demand is expected to be high for products with good sensory attributes, quality and ready to use convenience products with high nutritional value that require minimal processing before consumption. Sensory attribute like color, flavor, texture and taste have great influence for adopting and consuming biscuit supplemented with fish protein powder. Amount of fortification level can affect sensory attributes of produced biscuit even though it increases nutritional content of prepared biscuit. Researchers recommended that supplementation level should be added the right to the amount with accurate amount of wheat flour while producing fish based biscuit without affecting finished product. Several researchers find out that, 6-10% of fish protein powder is the recommended level to incorporate with wheat flour for producing biscuits. According to Abou-Zaid and Elbandy (2014), 6% of crayfish tail powder and protein concentrate should be used in biscuit supplementation of wheat flour blends. The concentration level of fish powder to be added during fortification of products play great role for the acceptability of the fortified product. Shaviklo et al. (2012) studied the characteristics of freeze-dried fish protein isolated from saithe (*Pollachius virens*). It was found that snack containing 9% fish protein powder had lower score for odour, texture, flavor, and overall acceptability, whereas snack fortified with 7% had higher score and was acceptable.

From the sensory attributes, color of a product play great role for adopting and increasing level of consumers, Mohammed et al. (2016) highlighted that increase levels of fish powder resulted in decreased scores of color which could be due to maillard reaction and protein content has inverse relationship with color and texture. Khan and Nowsad (2012) reported that flour with protein content of fish and fishery product, 7-10%, tends to yield biscuit with a better and longer-lasting crustiness, more-over has good acceptance by young consumer.

3.6 Role of biscuit supplemented with freshwater fish powder versus biscuit from wheat flour

Fortification level play enormous role for the protein content of produced biscuit from fish flesh (Table 2). Protein content of the formulated biscuit has direct relationship with amount of fortification level fish flesh. The increase in protein content is due to fish contains higher protein content compared to cereals (Netto et al., 2014). The more fish flesh used in fish based biscuit, the higher the protein content of fish biscuit. Thus, the low content of protein indicates low fish flesh content in the supplementation (Mohamed et al., 2014; Yi et al., 2016). Biscuit made from wheat flour has higher carbohydrate and lower protein content compared with biscuit fortified with fish powder (Table 2). As many scholars report that fish protein is the building block of human health. Increasing fish consumption can prevent from various types of disease such as, obesity, chronic non communicable, blood pressure and heart disease.

Table 2 Protein content of biscuit supplemented with fish powder at different levels

| S/N | Fortification levels | Protein content of biscuit (control) | Protein content of fish based biscuit | References |
|-----|----------------------|--------------------------------------|---------------------------------------|-------------------------------|
| | 40% | ND | 18.23 | (Nurul et al., 2009) |
| | 45% | ND | 23.81 | (Nurul et al., 2009) |
| | 5%+40% soybean | ND | 20.40 | (Bristone et al., 2017) |
| | 5% | 10.05 | 12.50 | (Ibrahim, 2009) |
| | 1% | 9.51 | 10.22 | (Mohamed et al., 2014) |
| | 2% | 9.51 | 11.10 | (Mohamed et al., 2014) |
| | 3% | 9.51 | 12.00 | (Mohamed et al., 2014) |
| | 40% | ND | 4.37 | (Netto et al., 2014) |
| | 3 | 9.15 | 11.73 | (Abou-Zaid and Elbandy, 2014) |
| | 6 | 9.15 | 14.41 | (Abou-Zaid and Elbandy, 2014) |
| | 9 | 9.15 | 16.29 | (Abou-Zaid and Elbandy, 2014) |

*ND: Not done

Fish based biscuit could play a significant role in humans' life. Young people particularly are advisable to take such products in their daily life. Ultimately, they can be the beneficiaries from the advantages which can be obtained from fish and fish products as fish is well known by its nutritional aspects. Nurul et al. (2009) recommended that, the higher and lower content of carbohydrates and protein are one of the reasons for the important substitution of starch flour with fish to provide more nutritional biscuit products.

4 Conclusion

Freshwater, Sturgeon meat, are rich in proximate composition and well known by their tasty flesh, which are good source for the human nutrition to prevent from different disease. Industries and consumers should have detailed information on the chemical composition of fish and fish products in order to make the best use of them as food and in order to develop the technology of processing fish and fish products into varieties of value added or fortified food products, developing new fish product, such as fish biscuits. Fish powder is an excellent dietary supplement and can be used to fortify diverse range of cereal products like biscuits to provide a healthy source of easily digested proteins, ultimately alleviate malnutrition, since consumers could not get from cereal based biscuit products. Proteins derived from fish are nutritionally superior when compared to plant sources. The level of enhancement fish product with cereal products have significant role on the sensory characteristics of enriched product despite increasing the nutritional value of product. However, appropriate supplementation level is recommended at any situation to meet the desired objectives and to meet and satisfy consumers demand.

Authors' contributions

Bereket Abraha, and Whenshui Xia designed the review manuscript; Bereket Abraha collected all the scientific literatures and wrote the review article, with input from all other authors, Whenshui Xia and Yang Fang provided advice, critical review and edited of the article. All authors read and approved the final manuscript.

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