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Utilization of Trash Fishes as Edible Fish Powder and its Quality Characteristics and Consumer Acceptance

K. Immaculate Jeyasanta, Velammal Aiyamperumal and Jamila Patterson

Suganthi Devadason Marine Research Institute, 44-Beach Road,Tuticorin- 628001 Tamil Nadu, India

Abstract: Large quantities of commercially important juvenile fishes are fished as bycatches and were discarded as waste. For food control this was utilized for the development of edible fish powder and their quality, shelf life and it was incorporated with normal food items and their consumer acceptance were assessed to eradicate malnutrition.

Key words: Edible Fish Powder · Quality · Storage · Utilization

INTRODUCTION

Conventional shrimp trawlers are poor selective fishing gear and it retains large quantities of non-targeted species, this is termed as bycatch [1]. Bycatches from shrimp trawls was estimated around 11.2 million tons worldwide [2]. The by catches from shrimp trawls has attracted worldwide attention [1, 3]. Tamil Nadu marine Fishing Regulation Act, 1983 requires that all shrimp trawl net cod end should not exceed 35-40 mm mesh size [4]. The law also recommends that the ratio of fish and prawns should be maintained at 75:25%. In practice, this is never maintained and more fish as high as 90% fish relative to prawns are caught. Fishermen using illegal trawler with a net size of 10 -15 mm mesh size for fishing results in increasing by catch. World fish production has peaked at around 128.8 million tons and among that over 60% is used for human consumption and almost 40% is left unused [5]. The fish that are not utilized for human consumption include 30 millions tons of small pelagic fish used for the production of fishmeal and 20 million tons of by catch is discarded [6]. The discarded fish has little economic value because of their small size, poor quality or limited appeal to consumers and are called “trash fish” and trash fishes are only caught by ‘by catch’. This by catches comprises of small sized juveniles of many commercial fish and shellfish [7]. Marine fish species like Silver bellies, Flat fish, Ribbon fish, Sciaenids, Carangids and Catfish constitute low value [8]. In addition significant amount of fish quality is lost during improper distribution, handling and processing [9]. Estimated marine fish landing of *Leiognathus* in Tuticorin, India during 2010 - 2011 were 995,245 t which is 43.68% of total by catch landings [10]. Utilization of low valued by catches for human consumption is mainly done in the form of mince based products like fish sausage, cakes, cutlets, patties, balls, pastes, wafers, fingers, surimi, texturised products etc, or fish protein concentrate with or without bone was already studied [11-18]. All these are made from commercially high value market sized fishes. However in the above products fish bones are discarded for the convenience of eating, there by wasting important minerals like calcium, potassium, sodium and zinc [15].

Value addition and diversification to satisfy the ever changing demand from the importing countries as well as urban consumers at home are some of the major challenges faced by the Indian fish processing industry. Value addition means “any additional activity that changes the nature and presentation of the product thus adding value to it for sale”. Present market trends are indicative of extensive growth in the demand for ready-to-cook or ready-to - serve convenience products processed out of a variety of fin and shell fishes.

Among the trash fishes juveniles of *Leiognathidae* family was found to be dominant in Tuticorin fish landing center. Here the total length of *Leiognathidae* varied from 2.0 to 10.0 cm and the average total length was 8.5 cm. Consumer prefer usually above the size of 7 cm of this species However small sized *Leiognathus* sp. (<4 cm) also enter the landing center due to the use of small mesh

Corresponding Author: Jamila Patterson.Suganthi Devadason Marine Research Institute, 44-Beach Road, Tuticorin- 628001 Tamil Nadu, India.
Tel. +91-461-2336488.

sized cod end trawlers. These small sized fishes are segregated and marketed separately. These small sized fishes are having less market demand and hence attract low price.

Consumer demand is expected to be high for ready to use convenience products with high nutritional value that require minimal processing before consumption. A major problem in preparing convenience products from *Leiognathus* sp. is the presence of bones. Removal of these bones is difficult, more over the removal of bones results in loss of important essential minerals like calcium and potassium, sodium, zinc. Low value marine by catch utilized as fish protein concentrate and edible fish powder with de boned fish was already studied [11, 12]. Edible fish powder was prepared from red meat of tuna [19]. Edible fish powder was prepared from small marine fishes without deboning the fishes [15]. The acceptability of bread fortified tilapia fish flour was reported earlier [20]. This paper aims to control the wastage protein rich small sized *Leiognathus* species.

MATERIALS AND METHODS

The juvenile *Leiognathus* species of 3 to 6 Cm length and 2 to 4 Cm width were normally fished as by catches in shrimp trawlers and are discarded along with trash fishes (Fig. 1) due to its size. The juvenile *Leiognathus* (Fig. 2) were collected from Tuticorin fishing harbor and brought to the laboratory in clean polythene bags kept in ice box under hygienic condition.

Preparation of Edible Fish Powder: Edible fish powder was prepared as per method described [15, 21] with some modifications. The fins, head and viscera were removed. The sample was washed thoroughly in running tap water and minced in a mincer. About 0.5% acetic acid was added to the meat. It was heated for 30 minutes and then filtered and pressed. The pressed cake was heated at 70-80°C in a water bath with ethanol (1:2) for 1 hour to remove fat and moisture from the meat. The solvent was drained and the extraction was repeated twice. The fish powder (Fig. 3) was dried properly and packed in 100 g in 200 gauge low-density polyethylene (LDPE) sachets and stored at room temperature. The powders were analyzed at monthly intervals for a period of five months.

Proximate Composition: The proximate composition such as moisture content, protein, lipid and ash were determined according to AOAC [22] standard method.

Fig. 1: *Leiognathus* sp.. as trash fishes

Fig. 2: Juvenile *Leiognathus* sp.

Fig. 3: Edible fish powder

The moisture content was determined by drying the samples in a hot air oven at 100 -105°C for 16 hours until a constant weight was obtained. Protein content was estimated by following Lowry's method [23]. Lipid content is determined by using gravimetric method of Folch *et al*. [24]. Total ash content was determined by

combusting the samples in the furnace at 550°C until the white color of samples. Carbohydrate content was determined by the method of Hedge and Hofreiter [25] using anthron and hydrochloric acid.

Mineral Analysis: The samples were digested with concentrated nitric acid and perchloric acid (3:1, v/v) until a clear and transparent solution was obtained. The digested samples were filtered using Whatman no.1filter paper and diluted with double distilled water and made as 500 ml in a volumetric flask. After wet digestion, samples were analyzed for Calcium, Iron, Sodium and Potassium concentrations according to APHA [26] through Atomic Absorption Spectrometry (ELICO, SL 194 Model).

Biochemical and Microbial Changes: Free fatty acid (% of oleic acid) were analyzed by using standard method [27] and changes in biogenic amine such as TMA-N, TVB-N (mg N /100g) was determined by the Conway micro diffusion method [28]. pH of the edible fish powder was measured in a slurry made with distilled water (1:10) and measured using pH meter (Hanna pH meter 213). Peroxide Value (PV) expressed as mEq of peroxide oxygen/kg of fat, was determining according to the Egan *et al*. [29] method. The Thiobarbituric acid (TBA) (mg malondialdehyde/kg fish flesh) was analysed according to Kirk and Sawyer [30] method. The microbiological characteristics such as Total Plate Count (CFU/g) and Total Fungal Count (Cfu/g) were done by the APHA [31] method using Plate Count Agar and Potato Dextrose Agar respectively. Pathogenic bacteria like *Escherichia coli* (MPN value); *Salmonella* and *Vibrio* (25 g) were enumerated by following the method of USFDA [32].

Sensory Quality Evaluation: Sensory quality such as intensity of fish flavor and taste of edible fish powder prepared from *Leiognathus* sp. was tested separately. Fresh edible fish powder and at monthly storage intervals 10% edible fish powder was added to boiling water continued boiling for 10 minutes, after which the panel members (n=5) were asked to judge the intensity of the fish flavor and taste. The assessment was given on a 5 point score (0 to 5) by the panel members with a score of 2 being the limit of acceptability.

Organoleptic Analysis: The organoleptic quality of edible fish powder was assessed by adding 50% of the ingredients of the common foods items such as Ragi fish bajji, cauliflower fish bajji, dal fish bajji, fish chappathi and seafood pondas with edible fish powder and the food items were prepared (Fig. 4 to 8) and vegetable curry was

Fig. 4: Sea food ragi bajji

Fig. 5: Sea food Cauliflower bajji

Fig. 6: Sea food dal bajji

Fig. 7: Sea food chappathi

Fig. 8: Sea food ponda

Fig. 9: Seafood vegetable curry

prepared with 25% of seafood powder (Fig. 9) and all the dishes were served to a taste panel of 6 to 8 members and appearance, color, odor, taste texture and overall acceptability was determined by using hedonic scale of 1 to 9 [33] and the dishes were rated as 9 for excellent 6 for good and below 4 for poor or unacceptable.

RESULTS AND DISCUSSION

The prepared edible fish powder was colorless and odorless and almost contained 90% protein. This is also known as fish flour or edible fishmeal. Most of the food items contains high percentage of carbohydrates and fat both of which are needed for energy production and source of calories. Other nutrients like vitamins, mineral and protein are relatively in small proportion. Edible fish powder had good protein and mineral content. It can also be used in the preparation of food items by partially removing carbohydrates from food for making bread, biscuits, chappathies etc. More over steam cooking for 30 minutes destroys microorganisms and their spores [34]. Acetic acid was used by preserving the product for longer time. Filter and pressing using a hand extruder removed excess water from the steam cooked product. Then the press cake was treated with ethanol to remove the fat and moisture from meat using a water bath at 70 - 80°C. The protein concentrate was dried in a hot air oven at 50°C for five hours. The moisture content of the dried product was reduced below 6% level for microbial safety. The dried product was ground and packed in LDPE pouches.

Nutritional composition and quality of fresh and edible fish powder made out of *Leiognathus* species is given in Table 1. Edible fish powder was rich in protein and minerals like calcium, potassium, sodium, zinc.

Table 1: Biochemical composition of *Leiognathus* sp. fresh meat and edible fish powder

Biochemical composition	Raw *Leioganthus* Sp.	Edible fish powder from *Leiognathus* sp.
Moisture (%)	71.85	3.28
Protein (%)	20.06	55.6
Lipid (%)	5.21	0.5
Total ash (%)	3.63	12.41
Carbohydrate (%)	0	0
TMA-N mg/100g	0.01	0.02
TVB-N mg/100g	0.09	0.6
FFA (% of oleic acid)	1.1	-
Calcium (mg/100g)	66.1	121.97
Potassium (mg/100g)	60.0	109.31
Iron (mg/100g)	42.4	110.05
Sodium (mg/100g)	54.3	115.23
pH	7.0	7.1
TPC (cfu/g)	2.2×10^3	2.0×10^2
TFC (cfu/g)	-	-
E.coli (MPN/G)	7	-
Salmonella (25g)	Absent	Absent
Vibrio (25g)	Absent	Absent
Peroxide value(meqo2/kg fat)	1.1	-
TBA(malondialdehydemg/1000g)	-	-

The calcium and phosphorus content of the muscle portion of silver belly was already reported to be 720.1 mg/100mg and 735.3 mg/100g respectively [35]. The calcium and phosphorus content of edible fish powder made from silver belly was 1310.96 mg/100g and 2859.02 mg/100g respectively [15]. Where as calcium, potassium, zinc, sodium content of the edible fish powder was 121.97mg/100g, 109.31 mg/100g, 110.05 mg/100g and 115.23 mg/100g respectively. The source of high mineral content of this product was mainly from bones of the fish, which were otherwise discarded. The proximate composition of fresh Leiognathus species value was similar to those reported [36]. The quality of raw fish was found to be good as the chemical and microbiological parameters were within acceptable limit [37, 38]. The moisture content of the edible fish powder was 3.28. Moisture content below 10% level was good for microbial safety of the fishery products [39]. The fresh edible fish powder did not contain *E. coli, Salmonella, Vibrio*. Fungal count was not detected for fresh fish and edible fish powder. Biogenic amines such as TMA-N, TVB-N are produced from degradation of proteins and non protein nitrogenous compounds mainly as a result of microbial activity [37]. TVB-N and TMA-N value were well with in the acceptable limit of 30 - 35 mg N /100g and 10 -15 mg N/100g for fishery products [40-42]. Lipid hydrolysis occurs in fresh fish muscle with the release of FFA 1.1% oleic acid but FFA formation does not occur in fresh edible fish powder. Hydrolysis of lipid does not occur in fresh powder because most of the lipid was already extracted. The relationship between FFA release and loss of freshness was already reported [43, 44]. Initial total plate count of fresh fish had 2.2×10^3 cfu/g but fresh edible fish powder had 2.0×10^2 cfu/g. If 10^6 microorganisms/g are considered as the TPC limit of acceptability [44]. Our fresh fish and edible powder had bacterial count within the limit of acceptability. The pH of the live fish muscle is close to the value ranging from 6.0 to 7.1 [45]. This pH is an important index for determining the quality of fish [46]. Edible fish powder had pH 7.0 and 7.1 for which indicates a good quality product. Fish contain less carbohydrate than foods of plant origin. The small amounts present can be ignored as far as their nutritional value is concerned, but they have important consequences for fish quality during processing. The major carbohydrate in fish muscle is glycogen which is a polymer of glucose [47]. Our experimental fish showed no carbohydrates. The ash content of species is an indication of the mineral concentration in the organisms [38, 48, 49]. Edible fish powder contained good essential mineral composition. Peroxide Value indicates very early stage of development of rancidity [50]. Primary lipid oxidation was evaluated by means of PV. Thiobarbituric acid (TBA) is a widely used indicator for the assessment of degree of secondary lipid oxidation [51]. However the PV values were very low in fresh fish but not found in fresh edible fish powder. This indicates primary lipid oxidation occurs initially but in the case of edible fish powder there was no lipid oxidation. TBA values were also absent both in fresh fish and edible fish powder because of the absence of secondary lipid oxidation. The results of biochemical and microbial qualities indicates that our raw material and product such as edible fish powder was good in nutrition and quality.

Biochemical and microbiological changes that occurred during the storage of edible fish powder at room temperature for 5 months storage intervals is presented in Table 2. The product was acceptable even up to five months of storage. The moisture content of the edible fish powder was low and varied between 3.28 and 6.5%. Moisture content seemed to be an exact indicator of the susceptibility of the product to undergo microbial spoilage. Moisture content above 10% is essential for the growth of micro organisms [52]. Our results shows moisture content <10, so microbial load was also limited through out the storage period. There was no significant variation in crude protein, lipid and mineral contents during the storage. TMA-N increased from 0.09 mg/100g to 6.33 mg/100g and TVB-N increased from 0.6 mg/100g to 18.0 mg/100g, which was well with in the limit of acceptability [40]. There was no significant changes in FFA, PV and TBA. Free fatty acid was not detected up to the 2nd month of storage. High level of free fatty acids is an indication of microbial spoilage activity [53-55]. Formation of FFA is a well established post mortem feature of products resulting from enzymatic hydrolysis of esterified lipids [56, 57]. FFA formation has been found to be inhibited by heating and it may be due to the hydrolysis of lipids by phospholipids [58]. During initial processing of the edible fish powder heating and drying process presumably inhibited enzymatic lipolysis. During the 3rd month of storage FFA increased from 0.02 to 0.04 and in 5th month of storage period it did not exceed the acceptable limit. Most of the acidity begins to be noticeable to the palate when the free fatty acid values calculated as oleic acid is about 0.5 -1.5% [55]. Rancidity developments is a major problem in the storage of fishery products but in our study fat was already pressed out and so oxidative and hydrolytic rancidity were low in the edible fish powder during the period of storage.

Table 2: Biochemical composition of edible fish powders storage period

Biochemical Parameters	Fresh	1st month	2nd month	3rd month	4th month	5th month
Moisture (%)	3.28	5.55	5.45	6.02	6.04	6.5
Protein (%)	55.6	52.01	51.52	50.67	48.99	48.72
Lipid (%)	0.5	0.3	0.3	0.3	0.2	0.2
TMA-N mg/100g	0.09	2.8	3.9	5.1	5.9	6.33
TVB-N mg/100g	0.6	0.15	3.12	11.4	15.7	18.0
FFA (% of oleic acid)	-	-	-	0.02	0.04	0.04
Calcium (mg/100g)	121.97	121.00	119.45	117.81	115.66	115.00
Potassium (mg/100g)	109.31	103.65	101.4	100.9	100.0	100.0
Iron (mg/100g)	110.05	110.00	110.0	108.22	107.00	107.00
Sodium (mg/100g)	115.23	113.11	113.00	111.98	111.24	110.75
pH	7.1	6.9	6.80	6.11	6.12	6.12
TPC (cfu/g)	2.0×10^2	2.0×10^2	1.4×10^2	1.2×10^2	1.0×10^2	1.0×10^2
TFC (cfu/g)	-	-	-	-	-	-
E.coli (MPN/G)	-	-	-	-	-	-
Salmonella (25g)	Absent	Absent	Absent	Absent	Absent	Absent
Vibrio (25g)	Absent	Absent	Absent	Absent	Absent	Absent
PV	0.9	2.8	3.2	3.9	3.3	4.0
TBA	-	-	-	-	-	-

Peroxide values were within the acceptable limit of 10 - 20 mEq/kg of fat [40] throughout the storage period. The Thiobarbituric acid value also was well with in the acceptable limit which was less than 3 mg malonaldehyde kg^{-1} of sample which indicates good quality fishery products [59]. This indicates that the level of quality indicators such as hydrolysis of lipid (FFA), primary and secondary lipid oxidation does not increase during storage. This is because there was low fat content in the sample and also there was increase in extraction of total lipids at the time of processing. Our results agreed with the results of Olayinka [39]. The pH of the fishery products has an important influence on its freshness of the product because of the loss of its freshness which in turn influences bacterial growth. The lower pH of the sample slows the bacterial growth [60]. In our study also, during the storage period the pH values decreased. Total plate count decreased throughout the storage period. Direct correlation was observed between bacterial count and pH value of the product. Considerable increase in the bacterial counts resulted in decreased organoleptic quality [46]. But in our result bacterial count did not increase and also sensory changes were excellent up to 5 months of storage.

Since *Leiognathus* species were steam cooked before drying and pulverization, the edible fish powder had very low bacterial count and pathogens such as *E.coli, Salmonella* and *Vibrio* were absent. Total fungal count was not detected up to the 5 months of storage. Dry foods owe to their durability of storage but get rapidly attack by moulds and bacteria when exposed to moist air with subsequent absorption of water and hence good packaging is essential to retain the original quality [16]. High density polyethylene sachets are good packaging material for food products [15]. In contrast our results shows low-density polyethylene (LDPE) sachets showed good results during the storage period. An LDPE pouch which was readily available packaging material preserve the quality of edible fish powder with out any adverse effect even up to 5 months.

Sensory scores of the edible fish powders storage period at ambient temperature was presented in Table 3. The product had better texture, odor, taste, appearance and improved storage characteristics. In the present study fish powder was incorporated as a supplement to five food formulations for humans and it was highly acceptable. Sensory quality such as intensity of the fish flavor were not detected up to 4 months storage period, sensory score above 5 and 4 was maximum up to 4 months storage period. In the fifth month storage period slight intensity were observed by sensory panel with scoring 3. The score <3 were not detected till the end of storage period.

The organoleptic quality of edible fish powder dishes were presented in Table 4A and 4B. The color of Ragi fish bajji scored below 4 for its ragi based color and this character is not acceptable. All the products are having excellent characters and all are accepted favorably by the consumers.

Table 3: Sensory scores of the edible fish powders storage period at ambient temperature

	Organoleptic characters						
Storage period	Appearance	Colour	Odour	Taste	Texture	Flavour	Overall acceptability
Initial	8.8	8.9	9.0	8.4	8.9	8.1	9.0
1st Month	8.75	8.8	8.6	8.6	8.7	8.2	9.0
2nd Month	8.5	8.5	8.5	8.45	8.5	8.5	9.0
3rd Month	8.0	8.47	8.9	8.0	8.0	7.7	8.8
4 Month	7.8	8.15	8.4	7.8	8.1	7.6	8.62
5th Month	7.4	8.1	8.0	7.5	7.65	7.2	8.25

Each value represents the mean of 4 samples.

Scoring was >8= Excellent, 7= Good, 6= Acceptable, <5 = Reject.

Table 4A: Organoleptic analysis of edible fish powder products

Organoleptic parameters	Sea food ponda								Sea food Cauliflower bajji								Sea food ragi bajji							
Appearance	9	8.5	7.5	8	7	9	9	9	7	9	8	7.5	9	8	9	7	7	7	7	7	8	8	8	8
Colour	8	7	8	9	7.5	8	8	7	7	8	8	9	9	7	9	9	3	3	2	2	2	2	3	3
Odour	8	8	8	9	8	9	8	8	7	8	8	9	9	8	8	8	7	8	8	8	9	8	8	8
Taste	9	9	9	9	8	7	9	8	8	9	8	9	9	9	9	9	8	9	8	7	9	9	9	9
Texture	9	9	9	7	9	8	9	9	7	9	9	7	9	9	8	9	7	9	8	8	9	9	9	9
Flavour	8	8	7.5	9	8	6	8	9	7	9	8	8	9	8	8	9	7	9	8	8	9	8	8	9
Overall Acceptability	9	8	9	9	8	8	9	9	7	9	9	8.5	9	9	9	9	7	9	8	8	9	9	9	9

Table 4B: Organoleptic analysis of edible fish powder products

Organoleptic parameters	Sea food vegetable curry								Sea food dal bajji								Sea food chappathi							
Appearance	9	9	9	9	9	9	9	9	8	9	8	9	9	8	9	9	9	9	9	9	9	9	9	8
Colour	8	7	8	9	8	8	8	8	8	8	8	9	9	8	9	9	9	9	9	9	8	9	8	9
Odour	8	8	8	9	8	9	8	8	8	8	8	9	9	8	8	8	8	8	8	8	9	8	8	8
Taste	9	9	9	9	8	8	9	8	8	9	8	9	9	9	9	9	8	9	8	9	9	9	9	9
Texture	9	9	9	7	9	9	9	9	9	9	9	9	9	9	8	9	9	9	8	8	9	9	9	9
Flavour	8	8	9	9	8	8	8	9	8	9	8	8	9	8	8	9	8	9	8	8	9	8	8	9
Overall Acceptability	9	8	9	9	8	8	9	9	9	9	9	8.5	9	9	9	9	9	9	8	8	9	9	9	9

CONCLUSION

In the present study edible fish powder was processed from trash fish. This fish flour had attractive color, pleasant odor and reduced moisture content which makes it to have relatively longer shelf life. Nutritional studies showed that this edible fish powder can be added to food for growing infants and nursing mothers. Powder had rich in protein and mineral but low lipid and carbohydrate. Because of low lipid it was stored for long period. The dual advantage of the edible fish powder are finding ways for maximum utilization of the low valued trash fishes and providing protein rich convenience foods. Hygienic handling of the product during the process especially at the time of processing, extrusion grinding and packaging is essential to prevent external microbial contamination. It is suggested that the product could be an alternative source of protein and mineral for consumers and also used for those who are allergic to dairy products. However, further study is required to assess the commercial potential of the edible powder product.

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