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Original Article

Development of fish stick from silver carp (*Hypophthalmichthys molitrix*) mince and its quality changes at room temperature (28 to 32°C)

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A B S T R A C T

Fish stick was developed from silver carp (*Hypophthalmichthys molitrix*) by using different kinds of food additives (0, 10, 15 and 20% mashed potato, wheat flour, 1.5% NaCl, 2% oil, 5% spices such as onion, ginger, garlic, green chili paste, hot spices (garam masala), 1.0% MSG and 1.0% sugar). Sensory, chemical and microbiological changes of silver carp fish stick were determined to evaluate it's quality changes at ambient temperature (28 to 32°C) during storage. It was observed that, the moisture, pH and protein contents in silver carp fish stick decreased than those parameters for fish mince but lipid and ash contents increased. Among the variable levels of mashed potato, 10% showed the best sensory performance and was recommended for further production. At room temperature, the sensory quality parameters deceased significantly ($p<0.05$) but the TVB-N value increased progressively in fish stick samples during storage. The microbial load also increased significantly ($p<0.05$) at this temperature. Therefore, the study was concluded as- at room temperature silver carp fish stick remain in acceptable condition for a very shorter period, in fact less than 72 hours.

Introduction

Fish is a good source of animal protein and valuable for providing high quality protein in the diet. Undoubtedly it is playing a significant role in overcoming the protein malnutrition in Bangladesh. Fish protein is 85-95% digestible and all dietary essential amino acids are present in fish flesh (Nelson, 1946). Besides protein, fish also contains essential minerals like calcium, potassium, sodium, phosphorus, magnesium which are found in large quantities in fish muscles. Due to increasing awareness of the consumers on health issues, consumption of fish and fishery products are increasing day by day. It is very important to develop new techniques of processing of protein resources to make them useful and palatable food for human consumption. Fish mince is a sort of fish product which has drawn much attention. Mince based value added products will bring immediate benefit to the existing fish processing industries of the country (Nowsad *et al*., 1994). In the world market, there are many fish mince based products having different shapes, flavors, color and texture. In Japan there are numerous varieties of fish mince based products. Among these products, (i) steamed kamaboko (generally known as kamaboko); (ii) boiled kamaboko (hampen) (iii) fired kamaboko (deep fired) (iv) broiled kamaboko (chikuwa) (v) fish ham (vi) fish ball and (vii) sausage etc. are the chief products. Appearance and flavor of these products can be altered easily to meet the consumer's demand by adding various ingredients to the fish mince. As far as Bangladesh is concerned, relatively acceptable products can be manufactured according to our own taste and flavor preference for domestic consumption. The initial requirement for the preparation of minced based products would be the abundance of low valued white fleshed meso-pelagic or demarsal species with good gelling capacity. A rigid but less elastic gel is formed when the mince is cooked at 80-90°C without prior setting at low temperature (Niwa *et al*., 1991).

Shelf life study of the product is an important consideration in respect of business aspects and consumers health issues. Sensory, chemical and microbial assessment is necessary in order to determine the shelf life of the product. Determination of bacterial population of fish and fishery products are very important to asses the acceptable level and the extent of spoilage as well as contamination.

Fisheries scientists introduced several exotic carps in order to obtain more production at minimum cost and the shortest possible period. They are now being cultured combined with the local carps. Among those, silver carp

(*Hypophthalmichthys molitrix*) has got popularity due to its fast growth and unique food habit. They are mainly phytoplankton feeder and can control water body from obnoxious bloom formation. Moreover production of silver carp is relatively higher than other carps (i.e. rohu, catla, mrigal etc.) but market value is lesser than these carps. Therefore, preparation of value added food products from silver carp minces is more profitable.

Fish stick is one kind of important mince product in South Asian market. The product attains a meaty texture and can conceal the fishy odor so that one can hardly recognize fishy element in these products. The technology for producing fish sticks is very simple and it requires less complex machinery. Beside the commercial producer, coastal and rural poor can also produce the products in homestead kitchen using kitchen utensils for domestic consumption as well as for marketing locally. Considering these facts, the present study was, therefore, conducted to achieve the following objectives- to formulate and develop fish sticks from silver carp for better utilization of this species of fish and to investigate the changes in different quality parameters of fish sticks at ambient temperature (28 to 32°C).

Materials and Methods

Laboratory used for the study

The experiments were conducted in the laboratories of Department of Fisheries Technology under the Faculty of Fisheries, Bangladesh Agricultural University (BAU).

Collection of fish species

Fresh silver carps (total 16 fishes) were collected from Kamal Ronjit (K.R) Market**.** Immediately after collection, the fish was iced properly with crushed ice in an insulated box (Cosmos Ltd., Seol, Korea, 20 kg capacity) and transported to the laboratory. The average size and weight of the fish was 32± 2.50 cm and 750± 0.35 g.

Preservation of raw materials

In the laboratory, the fishes were washed thoroughly, either minced immediately for use or packed in polyethylene pouch and then frozen stored in a deep freezer (-20°C).

Preparation of the product

The preparation of the fish stick can be divided into two steps. First, preparation of mince from the raw fish and then preparation of fish sticks from the prepared mince. The steps are described as below-

Preparation of the mince from the fish species

The fishes were weighed and then washed with clean water, beheaded, eviscerated, skinned and washed with chilled water. The skinned fishes were filleted and deboned manually in iced condition. Then mince was prepared by a mechanical mincer (National Meat Grinder, MK-G3NS, Matsushita Electric Industrial. Co. Ltd., Osaka, Japan) through a 1mm orifice diameter so that all bones and connective tissues were removed from the muscles. All the utensils used in the experiment were cleaned with adequate washing and kept cool (around 5°C). Mince recovery from each fish was recorded. Huge amount of crushed ice was made available through an ice maker (Lab Tech Ice Macker, Series L cm-200m, R4044A, UK) to maintain adequate temperature throughout the product preparation. After mincing, the mince was kept in a small bowl that is fixed in a big plastic bowl around which huge amount of ice was kept.

Preparation of the fish stick from the mince

The ingredients used for the preparation of fish stick were: fish mince (55.0%); variable levels (0, 10, 15 and 20%) of potato smash, wheat flour; NaCl (1.5%); Monosodium glulamate (MSG) (1.0%); spices (onion + garlic + ginger + green chili paste = 5.0%); sugar (1.0%); and chilled water (15%). All these ingredients in appropriate quantities were thoroughly mixed together by hand wearing hand gloves and dough was made. The dough was formed into flat block in a frame and cut into small pieces of 3 inch × 1 inch × ½ inch (l×w×d). The fish stick was kept under chilled condition until used for further experiment.

The battering solution was prepared by mixing egg white, spices, salt and MSG. The fish sticks were dipped into the battering solution and rolled in bread crumb. Battered and breaded fish sticks were then dip fried in soybean oil until the surface of the stick become golden brown color. Finally, prepared fish sticks were then kept on the paper towels in order to soak the extra oil from the surface of the fried fish sticks.

Ingredients used for fish stick preparation

Potatoes were used for gel enhancing along with different spices for the preparation of fish sticks from silver carp fish to attract local consumer's acceptance. The list of the ingredients used for fish stick preparation and their percentages are shown in Table 1, 2 and 3.

Table 1. Ingredients and the amounts used for the preparation of fish stick

Ingredients	Percentage (%)
Mashed potato	0, 10, 15, 20
Salt (NaCl)	1.5
Oil	2.0
Sugar	1.0
Spices (onion, garlic, ginger, green chili paste, hot spices/garam masala)	5.0
MSG	1.0

Table 2. Spices and the amounts used for the preparation of fish stick

Spices	Percentage (%) out of 5% of all spices
Garlic powder	20
Onion powder	20
Ginger powder	15
Green chili paste	10
Mixture of hot spices/garam masala	35

Table 3. Ingredients and the amounts used for the battering solution for fish stick

Ingredient	Percentage (%)
Wheat flour	34.0
Salt (NaCl)	1.0
MSG	1.0
Spices (green pepper, ginger, garlic, cumin, onion paste)	1.0
Egg	19.0
Water	44.0

The mashed potato was used in variable levels in order to determine the effect of mashed potato on the quality of the product.

Quality analyses
The quality of the fish stick was analyzed by sensory, physical and chemical analysis.

Sensory parameters analysis
A panel of nine-person of students, teachers and staffs of the Department of Fisheries Technology provided the sensory assessments of the products (as Nowsad *et al.*, 2000 described). Prior to testing, panelists were familiarized with the properties of meat gel and the instructions relating to the scoring of the sample. Pretests were under taken with selected samples to familiarize the panelists with the measurement procedure. Three discs of gel (0.5 cm thick) were supplied to each panelist to recognize every attribute.

Softness/Firmness and Chewiness/Rubberiness tests
Softness/firmness (S/F) was defined as the amount of force required to bite through the sample with incisors and chewiness/rubbriness (C/R) was defined as the amount of effort the panelist had to exert in chewing to prepare the sample for swallowing. The quality was evaluated by the numerical scores up to 10, where for S/F, 1=very soft; 10=extremely firm and for C/R, 1= not chewy/rubbery; 10= extremely chewy/rubbery. The panel scores were recorded in the score sheet shown in Table 4.

Table 4. Scoring for Softness/Firmness (S/F) and Chewiness/Rubberiness (C/R) tests

Variable / (Levels of mashed potato)	S/F score (1-10)	C/R score (1-10)	Comments on quality
0%			
10%			
15%			
20%			

**The average of the 7 scores were used S/F and C/R*

Color and flavor test
Color and flavor were evaluated organoleptically. Scores used were from the range of 10 to1; where 10 = desired color and flavor; 1 = absent of color and flavor. The panel scores were recorded in the score sheet shown in Table 5 and 6.

Table 5. Scoring for color test

Score	Description	Comment on color quality
1 to 3	Content considerably colored (Dark gray)	Poor color
4 to 7	Content moderately colored (Brown/Light gray)	Moderately good color
8 to 10	Contents finally colored (Bright brown)	Excellent color

Table 6. Scoring for flavor test

Score	Description	Comment on flavor quality
1 to 3	Contents have strong abnormal odor and a markedly poor flavor.	Poor flavor
4 to 7	Contents have slightly raw or scorched odor or flavor; seasoning seems to be somewhat inadequate.	Moderately Good flavor
8 to 10	Contents have no abnormal flavor and have a good characteristics flavor and seasoning.	Excellent flavor

Physical parameters analysis
Folding test
A folding test was carried out by folding a 2mm thick sample disc into halves and quarters as per the method developed by Nowsad *et al.*, (2000). The scale was A^{++} = no crack when folded into quarters, A^{+} = no crack when folded into half but crack when folded into quarter, A = crack when folded into half, B^{+} = broke and split into halves. The products quality was graded as per Table .7.

Table 7. Grading for the folding test

Grade	Result of folding the disc	Stick quality
A++	No crack visible when disc is folded into quarter	Excellent: soft but very elastic
A+	No crack when disc is folded into half but one or more cracks when folded into quarter	Good: Moderate elasticity prevails, resistance loses
A	One or more cracks are visible when disc is folded into half	Poor: Poor elasticity prevails loss of elasticity
B+	Broke and split into halves	Very poor/ Fragile: complete loss of elasticity

Chemical parameters analysis
pH
pH was determined for the homogeneous mixtures of sample and distillated water (1:10, w/v) using a digital Mettler Toledo pH meter and pH was measured at room temperature (AOAC, 1990). Analyses were made in three replicates.

Proximate composition
Proximate composition of fish mince and fish stick was determined as moisture (Ludorff and Meyer, 1973), crude protein (AOAC, 1990), crude fat (Bligh and Dyer, 1959) and crude ash (AOAC, 1990).

Shelf life analysis
As fish stick prepared with 10% mashed potato scored highest by the panelists therefore fish stick prepared along with 10% smashed potato was further prepared for storage study. Fish sticks with 10% potato were stored at ambient temperature (28 to 32°C). Shelf life of the stored products was assessed by the determination of sensory, chemical and microbial analysis. Data was taken at the intervals of 24 hours.

Sensory evaluation
The sensory attributes of fish sticks were determined by scoring test (Paulus *et al*., 1979). All fish sticks were served to 9 panelists to evaluate the sensory attributes (color, odor, taste, texture, general acceptability) of the samples by using 9-points descriptive scale. According to the scoring table, scores between 7-9 indicated 'high quality', scores between 4-6 indicated moderate quality' and scores between 1- 3 indicated the limit of 'unacceptability'.

Total Volatile Base- Nitrogen (TVB-N) value determination
The shelf life, TVB-N were determined according to the methods given in AOAC (1984) with certain modification.

Determination of microbial load

In order to analyze the shelf life of fish stick, aerobic plate count was done by spread plate count method. Peptone diluent (0.2%) and plate count agar of commercial preparations or prepared in the laboratory as per method given in Cowan and Steel's Manual for the Identification of Medical Bacteria (edited by Barraw and Feltheam, 1993) were used in the shelf life study of fish stick. Aerobic plate count was done by consecutive decimal dilution technique. According to International Standard Organization (ISO, 1965) APC was calculated by the following formula:

APC/g = C × D × 10/S CFU/g

Where,
C = Number of colonies found
D = Dilution factor
S = Weight of sample in grams
CFU = Colony forming unit

Statistical analysis

One-way analysis of variance and the general linear model using Windows for SPSS 9.0 were used to analyze the data. The Duncan's New Multiple Range Test (DMRT) was used to find the significant differences between storage periods.

Results and Discussion

Evaluation of the quality of fish stick

Proximate composition and pH of fish mince and fish stick

The proximate composition i.e., moisture, protein, lipid and ash contents of fish mince and fish stick prepared from silver carp were determined and presented in Table 8. The moisture content in fish mince was 81.19% and in fish stick was 79.38%. Moisture content decrease in fish stick might be due to release of water from fish stick during cooking. Protein content of fish mince was found 17.37% and in fish stick 16.21%. Protein content in fish stick also reduced might be due to excessive heat generation during cooking that denaturized the protein and burned into ash. Taskaya *et al*. (2003) reported moisture and protein content 71.92% and 21.67%, respectively for fresh rainbow trout, but in fish burger they found moister content 63.61% and crude protein 17.50%. These results are in good agreement with the results of the present study. In this study, lipid content in fish mince was found 1.10% and in fish stick 3.08%. Lipid content increased in fish sticks as because of ingestion of vegetable oil during frying. The reason of increase in fat content in the study of Ihm *et al.*, (1992) was thought to be use of high amount of fat during the preparation of sardine burgers. In the present research, ash content was found 1.09% in fish mince and 2.10% in fish stick. This increase in ash content in fish stick might be due to addition of species and other ingredients (i.e. NaCl, Potato) in stick during preparation and some ash might produce during frying. Ihm *et al.* (1992) also determined the protein and moisture contents of sardine burgers, the values were lower than the values obtained for raw muscle. Ejaz *et al*., (2009) also found that the protein and moisture content of fish burger decreased but lipid and ash content increased in pangus fish burger than the values obtained for pangus fish mince, which is very similar with the results of present study.

The pH of the mince was found near to neutral as because prime quality fresh fish was used. A good quality product can be prepared from the mince with pH near neutral (Azad, 2001). Although a slight decrease in pH of the silver carp fish stick was observed than in fresh fish but still that indicated the good condition of muscle.

Table 8. Proximate composition and pH of fish stick prepared from silver carp fish

Type of product	Proximate composition				pH
	Moisture	Protein	Lipid	Ash	
Mince	81.19±0.87	17.37±0.45	1.10±0.98	1.09±0.56	6.7±0.12
Fish stick	79.38±0.99	16.21±0.34	3.08±0.73	2.10±0.28	6.5±0.08

** mean value ± standard deviation of 3 individual measurements*

Sensory evaluation

A sensory evaluation was made by a group of 12 untrained judges (students and teachers between the age range of 22-46 years) on the basis of hedonic ratings. Fish sticks were developed from silver carp mince using local gel enhancing ingredients and spices. Different sensory quality attributes of fish stick of variable mashed potato levels are presented in Table 9. The fish stick was prepared at the starch levels of 0, 5, 10 and 15% of the mince. Among the four levels of potato starch (0, 5, 10 and 15%), 10% potato starch levels showed best sensory attributes and mouth feel.

According to the statistical analysis results, there were significant differences ($p<0.05$) between S/F, C/R, color, flavor properties of fish stick. The value of S/F and C/F were higher in the fish stick at 10% mashed potato level compared to other levels (0, 5 and 15%). Although at different mashed potato level the flavor, general appearance differed significantly ($p<0.05$) but the color showed no significant differences ($p>0.05$). A similar kind of study was carried by Ejaz *et al*., (2009). The burger was prepared using mashed potato levels of 0, 10, 15%, 20% and 25% of the mince. Among them, 25% mashed potato level showed better sensory attributes and mouth feel.

Table 9. Effect of the mashed potato on sensory quality attributes of fish stick prepared from silver carp fish mince

Mashed potato level (%)	S/F[1]	C/R[1]	Color	Flavor	GA[1]
0	2.46 ± 0.51^{d}	2.98 ± 0.19^{d}	2.10 ± 0.98^{c}	2.00 ± 0.01^{d}	poor
5	6.12 ± 0.15^{c}	6.00 ± 0.17^{c}	7.15 ± 0.12^{b}	6.50 ± 0.47^{c}	good
10	8.30 ± 0.09^{a}	8.40 ± 0.21^{a}	8.58 ± 0.70^{a}	8.85 ± 0.10^{a}	Very good
15	7.40 ± 0.51^{b}	7.10 ± 0.06^{b}	8.40 ± 0.05^{a}	8.15 ± 0.20^{b}	Very good

[1]S/F = softness/firmness; C/R = chewiness / rubberiness; FT = folding test; GA = general appearance.

**Each value is mean ± standard deviation of triplicate determinations.*

**Data bearing different superscripts in the same column differ significantly ($p<0.05$)*

Physical evaluation

The result of folding test (FT) is presented in Table 10. According to the folding test, it was found that the fish stick with 10% mashed potato level showed the best performance although both 10% and 15% mashed potato levels were identical.

Table 10. Sensory quality attributes of fish stick on folding test

Mashed potato level (%)	FT[1]
0	B+
5	A
10	A+
15	A+

FT = folding test.
**Each value is mean ± standard deviation of triplicate determinations.*

Evaluation of the shelf life of the fish sticks at ambient (28 to 32°C) temperature

Sensory evaluation

The changes in color, odor, taste, texture and general appearance of fish stick at ambient temperatures (28 to 32°C) is shown in Table 11. All the sensory attributes decreased with the progress of storage period ($p<0.05$). Sensory analysis showed that even after 24 hours of storage at this temperature, the color, odor and texture of fish sticks were excellent though the taste was slightly pungent and general appearance decreased. Bad smell felt after 48 hours of storage and fungal growth was visible at the storage period of 72 hours (Plate 1). Statistical analysis showed that, there was no significant differences ($p>0.05$) in color, odor and texture between 0 hour to 24 hours of storage with exception of taste and general appearance. The results of this study are in accordance with the results of Ejaz *et al.* (2009) for pangus fish burger.

Table 11. Changes in sensory quality parameters of fish stick prepared from silver carp fish mince at ambient (28 to 32°C) temperature

Storage temperature (◦C)	Storage period (hr)	Color	Odor	Taste	Texture	General appearance
28 to 32°	0	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.00^{a}	9.00±0.98^{a}	9.00±0.56^{a}
	24	8.95±0.46^{a}	8.80±0.34^{a}	8.59±0.30^{b}	8.68±0.10^{a}	8.00±0.12^{b}
	48	2.90±0.15^{b}	2.70±0.01^{b}	2.15±0.19^{c}	2.00±0.75^{b}	2.56±0.78^{c}
	72	1.10±0.32^{c}	1.50±0.05^{c}	1.00±0.00^{d}	1.00±0.00^{b}	1.00±0.00^{d}

**Each value is mean ± standard deviation of triplicate determinations.*
**Data bearing different superscripts in the same column differ significantly ($p<0.05$)*

(a) **(b)**

Plate 1. Fish sticks (a) just after preparation and (b) after 72 hrs of storage

Chemical evaluation

TVB-N value analysis

TVB-N is an important compound provides a measure of the progress of spoilage. The TVB-N in seawater fish comes from ammonia, trimethylamine, and dimethyl-amine, while the most of the TVB-N in freshwater fish and their products comes from ammonia (Clucas, 1982). Connell (1980) suggested that 30 mg TVB-N/100g are usually regarded as the acceptable value for fresh fish whereas for salted and dried products, he suggested that TVB-N value should not exceed 100-120 mg/100g.

In the present study, the TVB-N value increased progressively throughout the storage period ($p<0.05$) at ambient (28 to 32°C) temperature (Table 12). The rate of increase in TVB-N value was very high. Within 48 hrs of storage, the value reached to 35.05 mg/100g and to 42.07 mg/100g after 72 hours of storage. The obtained TVB-N value found higher than the acceptable limits reported by (Connel, 1980).

Table 12. Effect of the storage period on TVB-N value of fish stick prepared from silver carp fish stored at ambient temperature (28 to 32°C)

Storage period (hr)	Ambient temperature (28 to 32°C)
0	7.84±0.13^{d}
24	19.67±0.50^{c}
48	35.05±0.61^{b}
72	42.07±0.92^{a}

**Each value is mean ± standard deviation of triplicate determinations.*
**Data bearing different superscripts in the same column differ significantly ($p<0.05$)*

Determination of microbial load

In order to monitor the bacterial growth in fish sticks prepared from silver carp mince with 10% smashed potato stored at ambient temperature (28 to 32°C), aerobic plate count was done at every 24 hrs of interval (Table 13). Bacterial load in fish sticks increased ($p<0.05$) with the progress of storage time and within 24 hr. APC increased to 5.7×10^{6} CFU/g and to 5.1×10^{9} CFU/g after 72 hrs of storage.

Table 13. Effect of the storage period on bacterial load of fish stick prepared from silver carp fish stored at 28 to 32°C temperature

Product	Storage time (hrs)	Bacterial load (CFU/g)
Fish stick	0	1.5×10^{4}
	24	5.7×10^{6}
	48	2.0×10^{8}
	72	5.1×10^{9}

**Each value is mean ± standard deviation of triplicate determinations.*

Bashar (2004) observed that the bacterial growth in fish sticks prepared from washed queen fish mince kept at room temperature steadily increased with the progress of storage time. Shammi (2005) found that bacterial growth in fish ball, fish stick and fish sausage gradually increased throughout the storage period, both at room and refrigeration temperature. Ejaz *et al*., (2009) also found that bacterial load in fish burger gradually increased throughout the storage period, both at room and refrigeration temperature. However, the present result in shelf life study was more or less similar to the above findings except some dissimilarity that occurred might be due to differences in checking time interval, storage condition etc.

Conclusion

Among variable levels of smashes potatoes used in the preparation of silver carp fish stick, 10% smashes level was accepted by the panelists for further preparation. Sensory, chemical and microbial studies showed that, fish stick stored at ambient temperature (28 to 30°C) remains in acceptable condition less than 72 hrs. Storage of fish sticks at lower temperatures in different packs like air-tight pack or vacuum sealed pack might keep the product edible for weeks.

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