Effect of chilled storage on quality characteristics of battered and breaded snack product from large sized Catla (*Catla catla*)

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Abstract This study was performed to determine quality changes of battered and breaded pre-fried snack product developed from large sized (5.5–10.5 kg) Catla (*Catla catla*) fish stored at chilled temperature (− 2 to − 4 °C). Quality changes were assessed based on biochemical, microbiological and sensory quality evaluation at 2 days interval for a period of 18 days. Results of biochemical analysis showed increase in total volatile base-nitrogen (TVB-N) values from initial value of 4.15–13.74 mg/100 g, free fatty acid (FFA) increased from 0.95 to 2.98% in terms of oleic acid, peroxide value (PV) increased from 2.6 to 3.9 meq of O₂/kg of fat and pH increased from 6.5 to 6.79 during 18 days chilled storage. Linearity (r^2) of TVB-N, FFA, PV and pH values during storage were found to be 0.98, 0.99, 0.97 and 0.99 respectively. In microbiological quality evaluation total plate count (Log. Values) increased from 2.17 to 4.65, while *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* and spore count were not detected during storage period. Results of sensory analysis reported a negative correlation with storage period concluding the shelf life of battered and breaded fish cutlet from Catla fish to be 12 days at chilled storage conditions.

Keywords Catla (*Catla catla*) · Battered and breaded · Fish cutlet · Biochemical changes · Shelf life

Introduction

Fish consumption has increased globally making fish a best source of animal protein, due to their high nutritional value, several health benefits and affordable to general public (FAO 2006; Xavier et al. 2018; Sriket and La-ongnual 2018). The production of cultured freshwater fish is showing an increasing trend. Catla (*Catla catla*) a prominent member of Indian major carps (IMC), major aquaculture fresh water food fish in India, their lower tropic feeding behaviour reduces its cost of production. Catla is low fat fish rich in omega-3-fatty acid with quality proteins rich in several amino acids (Mohanty et al. 2014; Paul et al. 2018) making it a best choice among other fresh water fish species. Catla is usually sold fresh or transported to nearby urban fish deficit markets 2000–3000 km from production site. India being largest producer of Catla (*Catla catla*) accounts for 71% (3.87 million tonnes) of global production, with an incremental production of 40% during last 10 years (FAO 2012; FAO-FishStat 2019).

Low consumer preferences was observed in large sized Catla (*Catla catla*) due to presence of intramuscular spines, coarse texture with muddy flavour and decline in taste with increase in size limiting the fresh consumption. Hence to make large sized Catla production more sustainable and profitable there is urgent need to utilize large sized Catla for developing novel value added product.

Rapid urbanization has led to changed eating habits of consumers, with increased preferences for “Ready-to-cook or Ready-to-eat” foods, making it a growing segment in the food industry having great demand and with wide base for

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aquatic snack food. Battered and breaded group is most favoured, with highly attractive sensory attributes as crunchy exterior and juicy interior (Nasiri et al. 2012; Xavier et al. 2018). Keeping all these factors in consideration present study was undertaken to prepare and evaluate the shelf life of battered and breaded fish cutlet from large sized Catla (*Catla catla*) stored under the chilled (-2 to -4 °C) conditions.

Materials and methods

Sample collection

Freshly caught Catla (*Catla catla*) fishes within weight group 5.5–10.5 kg were procured from fish market in Kolhapur district, Maharashtra, India. Fishes were immediately iced (1:1) and transported to laboratory using insulated boxes. The samples upon arrival were washed with potable water, beheaded by cutting head off, gutted manually followed by washing. Fishes were cooked for 10–12 min under normal atmospheric pressure in boiling water Abraha et al. (2017). Cooked fishes were deskinning, deboned and meat lumps were separated manually, further cooked meat was packed in polythene bag and stored in deep freezer at -18 °C until use.

Chemicals and other

All the media and chemicals used in the study were either of bacteriological or analytical grades, purchased from Himedia Pvt. Ltd., Mumbai. Other materials used for product development were of food grade.

Sample preparation

Battered and breaded cutlets were prepared from Catla (*Catla catla*) having 30 g weight, 5 cm diameter and 1 cm thickness. Cutlets were prepared using cooked Catla meat (40.16%), cooked potato (28.11%), onion (10.04%), bread powder (8.03%), oil for frying (4.02%), green chili (2.01%), coriander leaves (2.01%), ginger (2.01%), garlic (2.01%), table salt (1.20%), pepper powder (0.12%), clove powder (0.12%), cinnamon powder (0.08%) and turmeric powder (0.08%) as standardized by Pawar et al. (2012). All easily available ingredients were used in formulation were specifically standardised for Catla cutlets, with highest overall acceptability. Coated in standardized batter mix developed by Pagarkar et al. (2012) containing 77.5% refined wheat flour, 9.7% corn flour, 9.7% Bengal gram flour, 1.20% salt, 0.47% sodium tri polyphosphate (STTP), 0.47% turmeric powder and 0.96% carboxy methyl cellulose (CMC) mixed with water in the proportion of 1:2

(Solid: Liquid) and blended to homogeneity. Further rolled in bread crumbs and flash fried in sunflower oil at 180 °C for 30 s., later packed aerobically in polypropylene pouches and chilled stored for further analysis (Fig. 1).

Biochemical composition

The developed battered and breaded Catla (*Catla catla*) cutlets were analysed for proximate composition viz., moisture by difference method, crude protein by Kjeldahl method, crude fat by soxhlet extraction and ash content by charring sample using muffle furnace following standard methods (AOAC 2005). Total volatile base nitrogen (TVB-N) contents of battered and breaded Catla fish cutlet was determined as procedure suggested by Beatty and Gibbons (1937) using Conway micro-diffusion units. Free fatty acid (FFA) content was evaluated, according to AOAC (2005) results were calculated and expressed as percentage of oleic acid. Peroxide value (PV) an excellent indicator of lipid rancidity, was measured by titrimetric method and results expressed as equivalent of O_2/kg (AOAC 2005) indicating degree of lipid oxidation. pH was measured from the homogenate of sample with distilled water (5:20) by using pH meter according to method described by (AOAC 2005). Samples were analysed at 2 days interval period and results expressed as mean values of triplicates with standard deviation.

Sensory analysis

Sensory analysis based on appearance, colour, texture, odour, taste and overall acceptability were evaluated by semi trained panel, on 9-point hedonic scale with 9 (Like extremely) to 1 (dislike extremely) and 5 (being borderline of acceptability). Cutlets were deep fat fried in refined sunflower oil at 180 °C for 3 min. prior to sensory analysis and were considered unfit for consumption when average overall acceptability was below 5 (Peryam and Pilgrim 1957).

Microbiological analysis

The product samples (10 g) were aseptically homogenized with physiological saline (0.85% NaCl) 90 ml. The obtained homogenized sample were serially diluted to (1:10) in physiological saline as needed. Total plate count (TPC) was enumerated by spreading (1 ml) of homogenate on plate count agar and incubated at 35 °C for 48 h. For *Escherichia coli*, Tergitol-7 agar was used with incubation at 35 °C for 24 h. *Staphylococcus aureus* and *Salmonella* was estimated using Baird Parker and Bismuth Sulphate agar respectively followed by incubation at 35 °C for 48 h. Spore count was estimated using Dextrose tryptone agar.

Fig. 1 Pictorials for different stages in development of Battered and breaded product from large sized Catla fish

After incubation plates showing typical colonies were counted and calculated by multiplying the number of counted colonies with reciprocal of dilution factor and depicted as log cfu/g as per (AOAC 1995).

Statistical methods

Data were analysed to test significant difference by applying analysis of variances (ANOVA) tool available in MS-Excel 2013. The significant differences were tested at 5% level of significances and are mentioned as $p < 0.05$ for significant difference (Snedecor and Cochran 1967).

Result and discussion

Storage characteristics of battered and breaded fish cutlet

Proximate composition

Changes in proximate composition of battered and breaded Catla cutlets are shown in Table 1. The moisture, protein, fat and ash content of freshly made fish cutlets were 64.60 ± 0.10 , 14.56 ± 0.11 , 13.23 ± 0.04 and $3.20 \pm 0.06\%$ respectively among which moisture and protein content decreased significantly to $63.86 \pm 0.04\%$ and $13.53 \pm 0.10\%$ respectively. On the contrary fat and

ash content increased to $14.05 \pm 0.06\%$ and $3.92 \pm 0.03\%$ during storage. The increase in fat may be contributed to deep fat frying at elevated temperatures leading to fat absorption, due moisture loss as suggested by Ninan et al. (2008). Leaching of moisture containing dissolved nitrogenous compounds can lead to decrease in protein and moisture content (Vanitha et al. 2015). Results similar to our findings were also reported by Praneetha et al. (2015) and Gupta et al. (2015). A strong linear relationship among the proximate composition with time were found in moisture ($R^2 = 0.95$), protein ($R^2 = 0.99$), fat ($R^2 = 0.98$) and ash ($R^2 = 0.95$) during storage period as depicted in Fig. 2.

Biochemical changes of battered and breaded Catla fish cutlet

Biochemical changes are one of the major basic reason for fish spoilage. Several studies reported pH Abbas et al. (2008), peroxide value (PV) Shantha and Decker (1994), free fatty acid (FFA) Weber et al. (2008) and total volatile base nitrogen (TVB-N) Ocaño-Higuera et al. (2011) to be appropriate methods of fish spoilage estimation.

Total volatile basic nitrogen (TVB-N) The evolution of ammonia, trimethyl amine (TMA) and dimethyl amine (DMA) together supplements in building up of TVB-N value (Boziaris and Parlapani 2017), used to assess level of decomposition determining the shelf life of fish based

Table 1 Changes in the proximate composition of chilled stored battered and breaded fish cutlet

Attributes	Chilled stored cutlets						
	0	3	6	9	12	15	18
Moisture (%)	64.60 ± 0.10	64.52 ± 0.02	64.46 ± 0.08	64.38 ± 0.06	64.20 ± 0.05	63.97 ± 0.05	63.86 ± 0.04
Protein (%)	14.56 ± 0.11	14.46 ± 0.07	14.27 ± 0.07	14.04 ± 0.09	13.89 ± 0.05	13.72 ± 0.04	13.53 ± 0.10
Fat (%)	13.23 ± 0.04	13.41 ± 0.05	13.58 ± 0.05	13.72 ± 0.08	13.88 ± 0.04	13.96 ± 0.04	14.05 ± 0.06
Ash (%)	03.20 ± 0.06	03.48 ± 0.05	03.54 ± 0.06	03.66 ± 0.06	03.74 ± 0.05	03.85 ± 0.05	03.92 ± 0.03

n = 3 values expressed are average values ± standard deviation

Fig. 2 Regression equation of proximate analysis values of catla fish cutlet during chilled storage. Plot of linear regression with time

products (EEC 1995; Ocaño-Higuera et al. 2011; Xavier et al. 2018). Presence of total volatile base-nitrogen content less than 35–40 mg/100 g in fish muscle are regarded as fit for consumption. TVB-N values of fish cutlet increased from 4.15 ± 0.03 to 13.74 ± 0.03 mg N/100 g during 18 days storage, microbial catabolic activity and enzymatic action leads to protein disintegration leads to accumulation of ammonia and other volatile bases during storage as suggested by) may be the reason for increase in TVB-N.

Free fatty acids (FFA) Fats hydrolyse at much faster rate at elevated temperatures than lower temperature producing free fatty acids due to enzymatic or chemical action. FFA content of stored Catla fish cutlet increased from 0.95 ± 0.02 to $2.98 \pm 0.01\%$ oleic acid for Catla fish

cutlets (Table 2), this increase is due to action of enzyme lipases produced from microbial action causing lipid hydrolysis during storage (Hwang and Regenstien 1993; Kyrana and Lougovois 2002) contributing to off flavour development (Tokur et al. 2004; Özyurt et al. 2011). Inclusion of hydrocolloid in the batter coating of the formulated product seems to have reduced the intrusion of oil leading to slight change in FFA evolution during storage in comparison to findings of Rathod and Pagarkar (2013) in fish cutlet made from pangasius fish at refrigerated storage. Findings in similar line were reported by Vanitha et al. (2013).

Peroxide Value (PV) Peroxide value an index quality parameter measuring liberation of lipid hydroperoxides as

Table 2 Changes in biochemical parameters during chilled storage of Catla fish cutlet

Storage period (days)	pH	Peroxide value (meq of O ₂ /kg of fat)	Free fatty acid (% oleic acid)	TVB-N (mg/100 g of sample)
0	6.50 ± 0.02	2.6 ± 0.10	0.95 ± 0.02	4.15 ± 0.03
3	6.56 ± 0.03	2.9 ± 0.06	1.28 ± 0.03	5.56 ± 0.03
6	6.61 ± 0.02	3.0 ± 0.10	1.56 ± 0.05	6.85 ± 0.03
9	6.65 ± 0.01	3.2 ± 0.06	1.97 ± 0.03	7.96 ± 0.14
12	6.68 ± 0.01	3.4 ± 0.15	2.43 ± 0.01	9.19 ± 0.09
15	6.72 ± 0.03	3.5 ± 0.10	2.74 ± 0.03	11.67 ± 0.03
18	6.79 ± 0.01	3.9 ± 0.12	2.98 ± 0.01	13.74 ± 0.03

n = 3 values expressed are average values ± standard deviation

Table 3 Correlation coefficient (R) and regression equations for mean biochemical changes during storage period and shelf life of products stored at refrigerated temperature

Biochemical parameter	Regression equation	Correlation coefficient (R)
pH	Y = 0.015x + 6.5093	0.988
Peroxide value (PV)	Y = 0.0655x + 2.625	0.974
Free fatty acid (FFA)	Y = 0.1176x + 0.9286	0.994
Total volatile base nitrogen (TVB-N)	Y = 0.5158x + 3.8032	0.978

products of primary lipid oxidation, determining the shelf life of food products (Durmus et al. 2014; Özyurt et al. 2011). Product starts to taste and smell rancid once the PV value increases over 10 as suggested by Srikar et al. (1993) on the contrary Lajolina et al. (1983) suggested PV value up to 30 meq of O₂/Kg of fat is acceptable for fishery products. Initial PV of developed battered and breaded Catla fish cutlets increased slowly from 2.6 ± 0.10 to 3.9 ± 0.12 meq of O₂/Kg during 18 days storage as presented in Table 2, which were well within the maximum limits. The main reason for high initial PV may be attributed to reaction of oxygen present in the sample with frying medium leading to their oxidation. Generally the rate of thermal oxidation is much faster than autoxidation as suggested by Oke et al. (2018), while the slower rise in the PV during storage may be property of oil to dissolve oxidation products as suggested by Secci and Parisi (2016). The lower increase in PV may be due to lower rate of lipid oxidation as effect of antioxidant properties of spices used in product formulation.

pH A slight increase in pH values of Catla fish cutlet during chilled storage are shown in Table 2. The pH of live fish muscle is around neutral while, post-mortem pH varies from 6.0 to 7.1 influenced by several factors. The initial pH of cutlets was 6.5 ± 0.02 which increased slightly to 6.79 ± 0.01 during 18 days storage. The slight increase in pH value may be a result of volatile compounds liberated as effect of enzymatic and microbial decay as reported by Chaijan et al. (2005), results are supported with increase in TVB-N and TPC. Ocaño-Higuera et al. (2011) reported similar values for ray fish during iced storage.

A strong linear correlation was observed in biochemical parameters in Catla fish cutlet during storage as shown in Table 3. pH (R² = 0.99), PV (R² = 0.97), FFA (R² = 0.99) and TVB-N (R² = 0.98).

Microbiological analysis The changes in the microbiological quality of battered and breaded Catla fish cutlet are depicted in Fig. 3. Total plate count showed a significant increase during storage from initial value of 1.5 × 10² cfu/g (Log. Value 2.17) to 2.9 × 10⁴ (Log. Value 4.46) during 18 days storage period, the value increased by more than 100% with an R² value of 0.86, while the values were within the permissible limit (7 Log. Cf/g of meat) as approved by International Commission in Microbial Specification for Foods (ICMSF) (1978). Similar observations were observed for fish patties prepared from carp (*Cyprinus carpio* Linn.) of three weight groups Sehgal et al. (2011). *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* and spore count were not detected in the battered and breaded Catla fish cutlet during 18 days storage period, this may be attributed to frying at high temperature 180 °C killing most bacteria and spores.

Sensory analysis Battered and breaded Catla fish cutlet was evaluated for appearance, colour, taste, texture, odour and overall acceptability (Fig. 4) during the storage period. The sensory values for overall acceptability showed a declining trend. The results also indicated that battered and breaded Catla fish cutlet had shelf life of 12 days, increased rate of metabolic activities can make product undesirable during storage. The shelf life of fish cutlet made from *Wallago attu* was found to be 10 days Gupta et al. (2015).

Fig. 3 Regression equation of storage period on microbial quality of battered and breaded catla fish cutlet during refrigerated storage. Plot of linear regression with time

Fig. 4 Sensorial quality changes for catla fish cutlet during storage

However, fish burgers from Catla (*Catla catla*) had shelf life of 15 days during chilled storage based on sensory evaluation made by Vanitha et al. (2015).

Conclusion

Large sized Catla (*Catla catla*) fishes can be effectively utilized for developing battered and breaded fish cutlet which are nutritious and healthy. Results of storage study reveal that biochemical and microbiological parameters were within the maximum permissible limits. While, sensory quality characteristics indicated that fish cutlets developed were unacceptable conditions for 12 days and started deteriorating onward. As the large sized Catla fish acceptability is low for fresh consumption due to several limiting factors, utilising them for development of novel battered and breaded snack food can serve a profitable alternative.

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