Advance Journal of Food Science and Technology 6(4): 468-479, 2014
DOI:10.19026/ajfst.6.56
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: November 26, 2013 Accepted: December 10, 2013 Published: April 10, 2014

Research Article

Effect of Cooking Methods and Freezing Storage on the Quality Characteristics of Fish Cutlets

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Abstract: The aim of the study was to evaluate the effect of different cooking methods (frying, microwave and halogen oven cooking) on physicochemical, microbiological and sensory quality characteristics of carp fish cutlets during frozen storage at -18°C. The results revealed that cooking methods had considerable effect on physicochemical, microbiological and sensory quality characteristics of carp fish cutlets. A significant ($p<0.05$) decrease were observed in moisture, pH value, TVB-N, TMA, TBA, peroxide value, FFA, total plate count, total *Coliform*, *Psychrophilic* bacteria and yeasts counts of cooked fish cutlets with increase of protein, fat and ash contents after cooking. On the other hand, a slightly increase was observed in physicochemical parameters during frozen storage period but this increase was not exceeded the permissible limit. Microbial and organoleptic characters were good and fish cutlets are safe for human consumption up to 5 months and the halogen cooker can be recommended as the best cooking method for healthy diet.

Keywords: Fish cutlets, halogen oven, sensory evaluation, shelf life, TBA, TMA, TVBN

INTRODUCTION

Thermal processing techniques are widely used to improve eating quality and safety of food products and to extend the shelf life of the products. Fish and fishery products are cooked in different ways to improve its hygienic quality by inactivation of pathogenic microorganisms and to enhance its flavor and taste. During cooking, chemical and physical reactions take place which either improve or impair the food nutritional value (e.g., digestibility is increased because of protein denaturation in food) but the content of thermolabile compounds, fat-soluble vitamins or polyunsaturated fatty acids is often reduced (Bognár, 1998; Garcia-Arias *et al*., 2003; Alizade *et al*., 2009).

Fish frying is one of the oldest methods of food preparation. It improves the sensory quality of food by formation of aroma compounds, attractive color, crust and texture. Present consumers are concerned about health hazards such as obesity and heart diseases, which are linked with consumption of excess of oil. These concerns can have a negative effect on the marketability of coated products, which can absorb cooking oil as much as 15 to 30% of its weight during the flash-frying process. Furthermore, repeated use of oil for frying and its overheating can produce a wide variety of lipid-degradation compounds, which can have adverse influence on consumer health (Garcia-Arias *et al*., 2003; Venugopal, 2006). Microwave ovens change regular electricity into high-frequency microwaves that water, fat and sugar can absorb causing food particle vibration and therefore results in heating of food (Garcia-Arias *et al*., 2003). Halogen oven heating is a new technology that combines the time saving advantage of microwave heating with the browning and crisping advantages of halogen lamp heating (Ranjan *et al*., 2002). Uses of different types of electromagnetic waves, for heating food and in food preservation have also been reported by various researchers. Heating of foods by microwave heating has been studied in detail but infrared heating has not been explored (Sepulveda and Barbosa-Canovas, 2003). Some of the advantages of infrared radiation as compared to conventional heating are reduced heating time, equipment compactness, rapid processing, decreased chance of flavor loss, preservation of vitamins in food products and absence of solute migration from inner to outer regions (Ranjan *et al*., 2002).

Freezing is a much preferred technique to preserve fish and fish products for long period of time. It permits to preserve the flavor and the nutritional properties of foods better than storage above the initial freezing temperature. It also has the advantage of minimizing microbial or enzymatic activity (Martino *et al*., 1998). Frozen storage of fish cutlet, fish finger and fish burger are commonly used because of the consistent, reliable quality, ease of transportation and the fact that they are very close to fresh equivalents (Sharma *et al*., 2000; Tokur *et al*., 2004; Vanitha *et al*., 2013).

The current situation in fish processing industry demands a need to introduce new products based on fish mince which are stable, acceptable and nutritious.

Addition of fish in the diet not only improves the nutritional quality but also results in increased consumption of meal. Therefore, fish products as a condiment in 'ready-to-cook' or 'ready-to-eat' form appear to have a good potential (Reddy *et al*., 2012). Fish cutlet is a fishery product consists of cooked fish mince which mixed with cooked potato, fried onion, spices and other optional ingredients. The mass is then formed into desired shapes having an average weight of about 40 g. The formed cutlets are battered, breaded and flash fried before packing and freezing (Venugopal, 2006).

Common carp (*Cyprinus carpio*) is one of the most cultured fish in the world however has low consumer preference and hence limited market due to the presence of intramuscular bones. Hence, there is a need to develop some convenience products from the meat of carps to enhance their consumer acceptability (Gopakumar, 1997; FAO, 2011; Sehgal *et al*., 2011; Vanitha *et al*., 2013). Processing and value addition to carps is a need to sustain carp culture system and to make it more profitable. Fish products, such as fish fingers, fish cutlets and fish burgers could supply a variety of healthy food to increase the per capita consumption (Elyasi *et al*., 2010; Vanitha *et al*., 2013).

There is a continuing need for research in the development of new fish products that are acceptable to the local consumers and that will increase storage life. Underutilized fish, especially carp fish, are obvious targets for development of fish cutlets, so the effects of different traditional cooking methods (boiling, grilling, baking and microwave) on proximate and mineral composition of fish products have been previously studied but there is little information on the using of the halogen oven which has increased greatly during recent decades for cooking fish and fishery products. Therefore, it is important to determine the quality characteristics of fish and fish products cooked using common domestic practices, frying and microwaving and comparing with novel practices, halogen oven. So, the aim of this work was to evaluate the effect of both different cooking methods (frying, microwave and halogen oven) and freezing storage at -18°C on the proximate composition, physiochemical, microbiological and sensory quality characteristics of carp fish cutlet.

MATERIALS AND METHODS

Fish samples preparation: Fresh common Carp (*Cyprinus carpio*) fish samples ranging between 2.5 to 5.5 kg were obtained from local fish market washed immediately thoroughly with potable water then packed in ice boxes and transported to Fish Processing and Technology Laboratory, National Institute of Oceanography and Fisheries, El-Kanater El-Khiria City, El-Qaluobia Governorate, Egypt. Upon arrival fish samples were re-washed thoroughly with potable water then beheaded, gutted and again washed to get their fillets giving 55% yield, the fillets were boiled for 10 min and flesh was separated manually from those cooked fillets which yielded 40% of meat based on total weight of fish.

Table 1: Carp fish cutlets recipe

Ingredients	(%)	Spices mixture	(%)
Cooked carp fish flesh	75.00	Black pepper	32.00
Palm oil	9.00	Cardamom	10.00
Starch	8.00	Cloves	4.00
Sugar	0.61	Coriander	20.00
Sodium chloride	2.00	Cubeb	3.50
Onion	2.00	Cumin	15.00
Garlic	1.50	Ginger	3.50
Sodium bicarbonate	0.40	Red pepper	9.00
Sodium polyphosphate	0.17	Turmeric	2.50
Ascorbic acid	0.02		
Spices mixture	1.50		

Fish cutlets preparation: Carp fish cutlets were prepared using recipe described by Pawar *et al*. (2012) with some modifications Table 1. Edible batter was prepared according to Abdou *et al*. (2012) by mixing 94% wheat flour, 2% egg yolk, 2% skimmed milk, 1.8% salt and 0.2% cumin with water by 1:3 (w:w) and this ingredients were homogenized for 2 min. After the batter coating, it was covered with bread crumbs then fish cutlets divided to four batches. The first batch was raw fish cutlet which was used as a control. The other three batches were cooked by frying, microwave oven and halogen oven.

Cooking methods: Frying process was performed using an electrical fryer pan Moulinex brand in sunflower oil heated at 180°C for 5 min of each side of fish cutlet samples, then drained in basket to remove excess oil. The mean core temperature immediately after frying was 94±5°C. Microwave cooking process was prepared by using microwave oven Samsung, 980 watt for 5 min for each side of fish cutlet samples. The mean core temperature immediately after microwave cooking was 90±5°C. Halogen cooking process was performed using electric Halogen oven (LENTEL, model KYR-912A, 1300C watt) heated at 180°C for 5 min of each side of fish cutlet samples. The mean core temperature immediately after halogen cooking was 88±4°C. Finally all fish cutlet batches were separately packaged in polyethylene bags and subjected to frozen stored at -18°C till the onset of spoilage. Biochemical and sensory quality was assessed during storage study at 30 days interval.

Analysis: Moisture, protein, fat, ash, Trimethylamine (TMA) and pH of fresh fish, cooked and uncooked fish cutlet were analyzed according to AOAC (2005). Total Volatile Basic Nitrogen (TVB-N) content and Thiobarbituric Acid (TBA) number were determined according to Pearson (1976). The Peroxide Value (PV) was determined according to PORIM (1995). The Free Fatty Acid (FFA) content was determined as described by Takagi *et al*. (1984). Microbial examinations were carried out as per APHA (1992) methods. Sensory quality of fish cutlets were evaluated directly by 10 trained panelists, using a nine point hedonic scale according to the procedure of Fey and Regenstein (1982). Data were analyzed to test significant difference by applying Analysis of Variances (ANOVA) tool available in MS-Excel 2007. The significant differences were tested by 5% level of significance and are mentioned as $p<0.05$ for significances difference by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Proximate composition of fresh fish flesh: The chemical composition could influence the post-harvest processing and storage and could assist in determining the suitability of the different species to specific processing and storage techniques (Askary Sary *et al*., 2012). The moisture, crude protein, fat, ash contents in fresh common carp (*Cyprinus carpio*) fish flesh were 73.24, 17.68, 6.14 and 1.60%, respectively. These results are in agreement with Handjinikolova (2008). Whereas Askary Sary *et al*. (2012) reported higher moisture and protein contents and lower fat and ash contents of common carp fish when the results compared to the present study.

Proximate composition of fish cutlets: The proximate composition of raw fish cutlets was as follows: moisture 65.70%, crude protein 17.06%, fat 3.74% and ash 2.20% (Table 2). The proximate composition of raw fish cutlet is similar to that observed by other researchers. Joseph *et al*. (1984) reported that, (moisture, protein, fat and ash contents) of raw fish cutlet were (66.39, 16.51, 3.74 and 1.99%, respectively), while in flash fried fish cutlets were (62.65, 15.41, 5.92 and 1.88%, respectively). Raju *et al*. (1998) found that, moisture, protein, fat and ash of Crab cutlets were 67.72, 17.07, 8.36 and 4.00%, respectively. Kamat (1999) reported that, moisture, protein, fat and ash of fish cutlet prepared from bleached and unbleached fish meat were (65.01, 12.06, 6.31 and 1.39%) and (60.21, 16.20, 14.32 and 1.43%), respectively. Ninan *et al*. (2008) reported that, (moisture, protein, carbohydrate, fat and ash) of tilapia fish cutlet were (65.10, 17.51, 13.47, 2.14 and 1.78%), respectively. Pawar *et al*. (2012) found that, moisture, protein, fat, ash and carbohydrate contents in catla fish cutlets were 58.22, 16.41, 17.28, 3.56 and 4.53%, respectively. Reddy *et al*. (2012) reported that, the proximate compositions of fresh fish landed reef cod (*Epinephelus diacanthus*) cutlet before and after frying were (68.47-56.50) moisture; (11.54-13.58) protein; (1.80-6.68) fat and (3.22-3.61) ash. Vanitha *et al*. (2013) found that moisture; protein, fat and ash contents in *Catla catla* fish cutlets were 65.89, 17.66, 3.41 and 2.58%, respectively. Rathod and Pagarkar (2013) reported that, moisture, crude protein, lipid and crude ash contents of Pangasius (*Pangasianodon hypophthalmus*) fish cutlets were found to be 53.34, 18.43, 21.02, 4.43 and 2.78%, respectively. Pawar *et al*. (2013) reported that *Catla* fish cutlet kept in frozen storage showed slight reduction in moisture (65.71 to 64.86%) and protein (16.57 to 15.86%) throughout the storage. The fat (14.50 to 15.20%) and ash (3.22 to 4.08%) contents were increased in the same sample.

Effect of cooking methods on proximate composition of fish cutlets: The changes in protein, moisture, fat and ash contents of fish cutlets after cooking processes are shown in Table 2. The proximate composition of fried, microwave and halogen cooked fish cutlets were as follows: moisture (60.85, 59.32 and 61.50%, respectively), crude protein (21.26, 20.82 and 19.35%, respectively), fat (6.02, 3.75 and 3.27%, respectively) and ash (2.95, 2.50 and 2.25 %, respectively).

The proximate composition of carp fish cutlet was significantly affected by all the cooking methods

Table 2: Changes in proximate composition of raw and cooked carp fish cutlets during frozen storage

Proximate composition (%)	Cooking methods	Storage time (month) 0	1	2	3	4	5
Moisture	A	65.70	63.60	64.29	63.05	62.45	62.11
	B	60.85	60.45	60.19	59.50	58.33	57.85
	C	59.32	58.80	58.30	57.12	57.05	57.01
	D	61.50	60.20	61.15	59.40	59.11	58.29
Crude protein	A	17.06	17.75	18.12	18.55	18.75	18.90
	B	21.26	21.47	21.68	22.26	22.51	22.88
	C	20.82	20.90	21.01	21.75	21.80	21.90
	D	19.35	20.12	20.45	21.18	21.50	22.20
Crude fat	A	3.14	3.84	4.09	4.85	5.50	6.25
	B	6.02	7.15	7.44	8.25	8.58	8.65
	C	3.75	3.90	3.95	4.80	5.50	5.52
	D	3.27	3.68	4.49	5.64	5.75	6.18
Ash	A	2.20	2.47	2.60	3.50	3.66	3.76
	B	2.95	3.23	3.67	4.30	4.65	4.71
	C	2.50	2.87	3.09	3.18	3.69	3.85
	D	2.25	3.15	4.38	4.66	4.70	4.78

A: Raw (control) fish cutlets; B: Fried fish cutlets; C: Microwave cooked fish cutlets; D: Halogen cooked fish cutlets (p<0.05). The moisture content of the carp fish cutlet decreased after cooking, while the protein and ash contents increased in all cooking methods; the fat content showed slightly increased only in fried fish cutlet and this may be due to the cooking methods induced water loss in the food that in turn increases its lipid content in most cases and only some fat is lost in the case of oiliest fish. Also, this effect is dependent on the type of cooking (Gall *et al*., 1983). The decrease in the moisture content has been described as the most prominent change that makes the protein, fat and ash contents increase significantly in cooked fish fillets (Garcia-Arias *et al*., 2003). The greatest water loss was found in microwave cooking samples and this caused higher protein content. These results agree with Talab (2011) who found a significant water loss after microwave cooking of fish luncheon.

Fish cutlets coating process provides a moisture barrier to the product, helping in reduction of weight loss during frozen storage and also while reheating before consumption (Joseph, 2003). The increases in protein, fat and ash contents observed in cooked fish cutlet are explained by the reduction in moisture. However, the decrease in the moisture content has been described as the change that makes the protein, fat and ash contents increase significantly in cooked fish cutlet (Garcia-Arias *et al*., 2003). Fried fish cutlet had a higher level of fat than raw or other cooked fish cutlet. The increase in fat content of the fried fish cutlet is also related to oil absorption during the cooking process. Fat increase can be due to the oil penetration into the food after water is partially lost by evaporation Saguy and Dana (2003). Similar results have been reported for fried fish luncheon by Talab (2011) and Saguy and Dana (2003) who reported that the high increase in fat content of fried burgers may be attributed not only to water loss but also due to oil absorption during cooking process. The fat, protein and ash contents of grilled samples increased with respect to the uncooked samples. This increase may be due to a concentration effect caused by moisture loss (Rosa *et al*., 2007).

Effect of frozen storage on proximate composition of fish cutlets: The proximate composition of raw fish cutlet was changed during frozen storage (Table 2). The moisture content showed slight decrease in all batches during frozen storage and recorded (65.70 to 62.11) for control samples, (60.85 to 57.85) for fried samples, (59.32 to 57.01) for microwave cooked samples and (61.50 to 58.29) for halogen samples. The protein content showed slight increase in all batches during frozen storage and recorded (17.06 to 18.90) for uncooked samples, (21.26 to 22.88) for fried samples, (20.82 to 21.90) for microwave cooked samples and (19.35 to 22.20) for halogen samples. The fat content showed slight increase in all batches during frozen storage and recorded (3.14 to 6.25) for uncooked samples, (6.02 to 8.65) for fried samples, (3.75 to 5.52) for microwave cooked samples and (3.27 to 6.18) for halogen samples. The ash content showed slight increase in all batches during frozen storage and recorded (2.50 to 3.76) for uncooked samples, (2.95 to 4.71) for fried samples, (2.50 to 3.85) for microwave cooked samples and (2.25 to 4.78) for halogen samples.

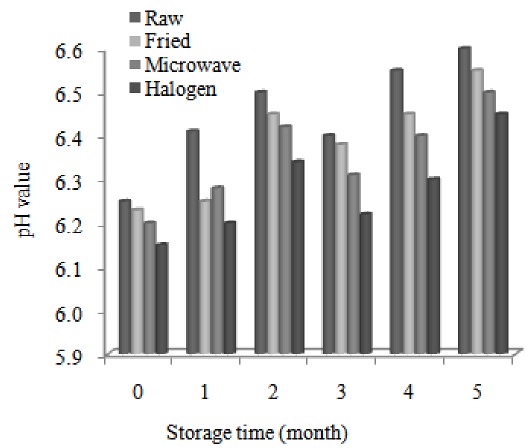

Fig. 1: Changes in pH value of fish cutlets during frozen storage

The obtained results are in agreement with Surabhi and Das (2007) who found a decrease in moisture content in carp fish cutlets during storage at -18°C for six months. Also, Vanitha *et al*. (2013) who reported that, the moisture content of *Catla* fish cutlet decreased while protein, fat and ash were increased during frozen storage.

Physicochemical quality characteristics of fish cutlets: pH value of fish muscle is usually a good index for quality assessment. It is important determining of fish quality as texture of fish (Rathod and Pagarkar, 2013). The changes in pH value of raw and cooked fish cutlets during frozen storage are presented in Fig. 1. The pH value showed slightly increase after cooking process and during frozen storage. The pH value of raw, fried, microwave and halogen fish cutlets at zero time recorded 6.15, 6.23, 6.20 and 6.25, respectively. The frozen storage caused increase in pH value at 1st, 2nd months and then decreased at the 3rd month and then increase again at the 4th month in fish cutlet samples.

The obtained results similar to those finding by Bett and Dionigi (1997) who reported that, decomposition of nitrogenous components in post mortem period causes to increase in pH in fish flesh. The increasing pH values could be associated with the production of basic components induced by the growth of bacteria (Simeonidou *et al*., 1998). Turhan *et al*. (2001) reported that pH values of anchovy patties increased from 6.33 to 6.56 after 10 days of storage. According to Grigorakis *et al*. (2003) post mortem pH

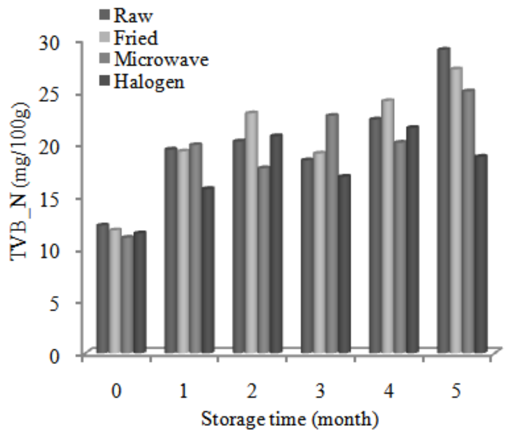

Fig. 2: Changes in Total Volatile Basic Nitrogen (TVB-N) value of fish cutlets during frozen storage

can vary from 5.4-7.2, depending on fish species. Several authors have reported different results about decreasing or increasing of pH in various fish species. The pH value between 6.8 and 7 was proposed as acceptance limit of fish and values above 7 were considered to be spoiled (Kose *et al*., 2006; Orak and Kayisoglu, 2008). In addition Kilinc (2009) determined that pH value of anchovy patties was 6.14 at first day of storage and then increased to 6.36 at the end of the storage period of 5 days. Pawar (2011) reported the cutlet made from *Catla* fish showed increasing trend of pH from 6.50 to 6.79 when stored at -2 to -4°C. The pH value of steam cooked tilapia meat increased from 6.8 (raw) to 6.83. The increase in pH of the samples may be due to breakage of hydrogen bond and electrostatic interactions (Dhanapal *et al*., 2012). Rathod and Pagarkar (2013) found that fish cutlet showed slightly increased pH from 6.30 to 6.60 during storage period from 1 to 18 days when stored in refrigerated display unit (-15 to -18°C).

Total Volatile Basic Nitrogen (TVB-N) that is mainly composed of ammonia, Trimethylamine (TMA) and Dimethylamine (DMA), is widely used as an indicator of meat deterioration (Fan *et al*., 2008). TVBN value is not stable during frozen storage and could be changed according to species, processing methods and storage temperature (Tokur *et al*., 2006). Total Volatile Basic Nitrogen (TVB-N) of raw and cooked fish cutlets during frozen storage are represented in Fig. 2. The TVB-N of raw and cooked carp fish cutlets at zero time recorded 12.21, 11.75, 11.04 and 11.46 mg/100 g for raw, fried, microwave and halogen cooked samples, respectively. The highest content of TVB-N (12.21 mg/100 g) was recorded in raw fish cutlets and the lowest (11.04 mg/100 g) in microwave cooked samples. TVB-N values increased significantly ($p<0.05$) during frozen storage of Carp fish cutlets.

Huss (1994) stated that totals on the TVN index include trimethylamine (result of bacterial spoilage), dimethylamine (result of their enzymatic digestion), ammonia and other amine volatile combinations that are related to spoilage of aquatic products. Therefore increasing trend of TVN can be attributed to a decreasing trend of volatile nitrogen analyzer enzymes or a decreasing amount of a substrate such as trimethylamine or dimethylamine or another non-protein nitrogen (there is no trimethylamine in freshwater fish, therefore, there are other substrates). Conell (1980) and Pearson (1997) reported that samples could be considered consumable if the TVN level is less than 20 mg/100 g fish and that a level of more than 30 mg determines the product as not consumable. The increasing of TVB-N value during storage is related to bacterial spoilage and activity of endogenous enzymes (Chomnawang *et al*., 2007). Irregular changes on TVB-N values in the study of Kilina *et al*. (2003) during the storage period of Sardine (*Sardina pilchardus*) were due to the elimination of dissolved volatile constituents through drip. Leaching out phenomena of volatile bases could be caused decreasing of TVB-N values if samples were stored in loose closed bags (Özogul and Özogul, 2000) also decreasing of TVB-N value may be result of hypothesis that mentioned for reduction of pH value. We believe, at least one of the above is responsible for the reduction of the TVB-N values.

There are some differences in quality classification according to TVB-N value for seafood in terms of different researchers. According to Varlik *et al*. (1993) seafood was evaluated as 'very good', if TVB-N value is lower than 25 mg/100 g; 'good', if TVB-N value is between 25-30 mg/100 g, 'marketable', if TVB-N value is between 30-35 mg/100 g and 'spoiled', if TVB-N value is 35 mg/100 g or higher than this value.

Trimethylamine (TMA) is produced by the decomposition of trimethylamine N-oxide caused by bacterial spoilage and enzymatic activity. Acceptable TMA value for fish is stated as 5-10 mg/100 g (Huidobro *et al*., 2002; Taskaya *et al*., 2003). Changes in Trimethylamine (TMA) value of raw and cooked fish cutlets during frozen storage are showed in Fig. 3. Carp fish cutlets showed decrease in Trimethylamine (TMA) value after cooking methods and increased in all samples during frozen storage but remained within the acceptable limit.

Trimethylamine (TMA) of raw fish cutlet recorded 2.48-5.15 mg/100 at the first day and at the end of frozen storage, respectively. Fried, microwave and halogen cooked fish cutlet recorded (2.48, 2.35 and 2.18 mg/100), respectively at zero time, while at end of frozen storage recorded (4.98, 4.75 and 3.75 mg/100), respectively. The obtained results are in parallel with Kaba *et al*. (2012) who reported that TMA of anchovy patties were founded to be 2.51 and 5.86 mg/100 g at

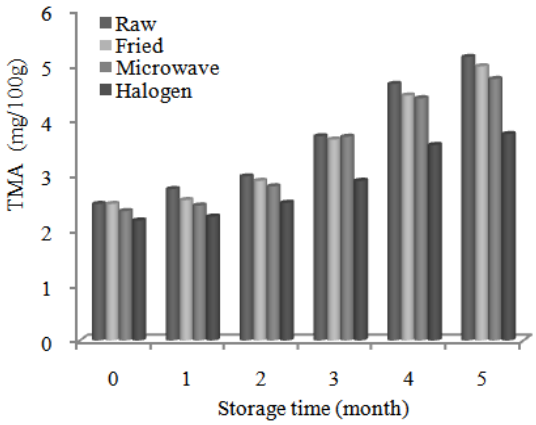

Fig. 3: Changes in Trimethylamine (TMA) value of fish cutlets during frozen storage

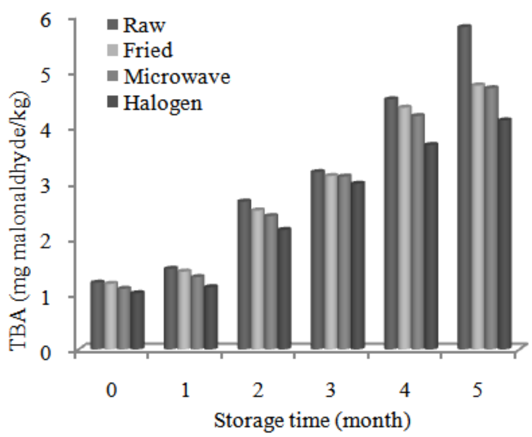

Fig. 4: Changes in Thiobarbituric Acid (TBA) value of fish cutlets during frozen storage

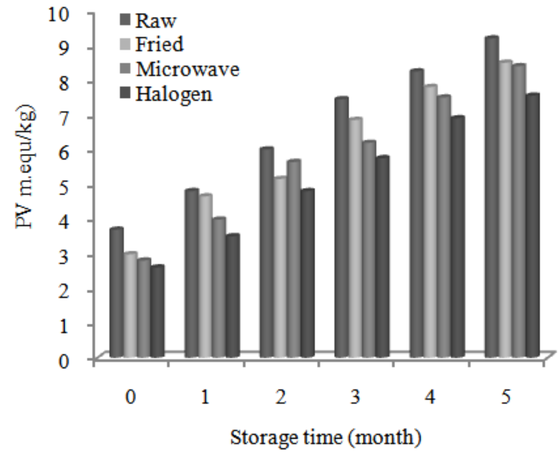

Fig. 5: Changes in peroxide value of fish cutlets during frozen storage

day 1 and at the end of storage period of 8 days, respectively.

Thiobarbituric Acid (TBA) value is based on the reaction of malonaldehyde with TBA reagent to obtain a red pigment which results from the condensation of two molecules of TBA with one molecule of malonaldehyde and the probable elimination of two molecules of water. Thiobarbituric Acid (TBA) value should not be considered as general reference of rancid odor, because factors such as specie, dietary status, age and raw or cooked meats could be influenced the numbers of TBA (Fernandes *et al*., 1997). Schormuller (1969) stated that TBA amount that is used to determine oxidation level is less than 3 mg MA/kg in very good material, must not be higher than 5 mg MA/kg in good material and acceptability limit value is 7-8 mg MA/kg.

The effects of different cooking methods and frozen storage period on TBA value of raw, fried, microwave and halogen carp fish cutlets are shown in Fig. 4. The TBA value of raw, fried, microwave and halogen carp fish cutlets were (1.20, 1.18, 1.09 and 1.01 mg malonaldhyde/kg), respectively at zero time, while recorded (5.80, 4.75, 4.70 and 4.12 mg malonaldhyde/kg), respectively at the end of frozen storage. Carp fish cutlets that were stayed in acceptability limit values in the present study. The decrease of TBA values in fish cutlet as affected by cooking methods could be attributed to the interaction of decomposition products of protein with malonaldehyde to give tertiary products (Hernandez-Herrero *et al*., 1999). The obtained results go in parallel with those finding by Tokur *et al*. (2004) in fish burger made from tilapia and by Yanar and Fenercioglu (1999) in fish balls made from carps. Similar observations were made by the Ninan *et al*. (2008) in fish cutlet stored at -20°C for 21 weeks and by Vanitha *et al*. (2013) observed a steady increase in the TBA number in all samples of fish cutlet and fish burger during frozen storage.

Figure 5 illustrates the change in peroxide value of raw and cooked Carp fish cutlets during frozen storage. A significant increase in the peroxide value of the fish cutlets ($p<0.05$) were observed during frozen storage. Peroxide value of raw and cooked fish cutlets during frozen storage recorded 3.69, 2.98, 2.80 and 2.60 meqO_2/kg for raw, fried, microwave and halogen cooked samples, respectively at zero time, while it recorded 9.20, 8.50, 8.40 and 7.55 meqO_2/kg respectively, at the end of frozen storage. The increase in the peroxide value of the fish cutlets ($p<0.05$) during frozen storage might be due to mechanical mincing of fish meat which accelerates oxidation due to the incorporation of oxygen in the tissue or the disruption and intermixing of tissue components. A similar increase in the PV content was observed by Tokur *et al*. (2004), Al-Bulushi *et al*. (2005) and Ninan *et al*. (2010).

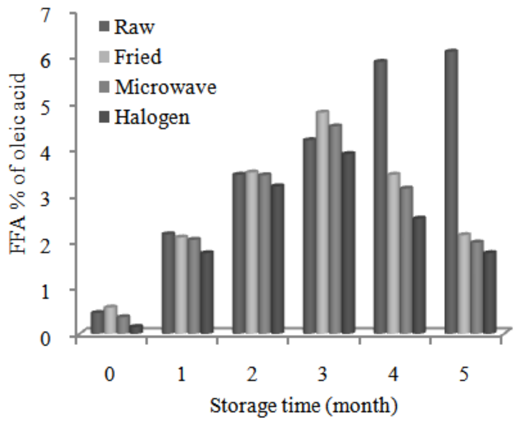

Fig. 6: Changes in free fatty acids of fish cutlets during frozen storage

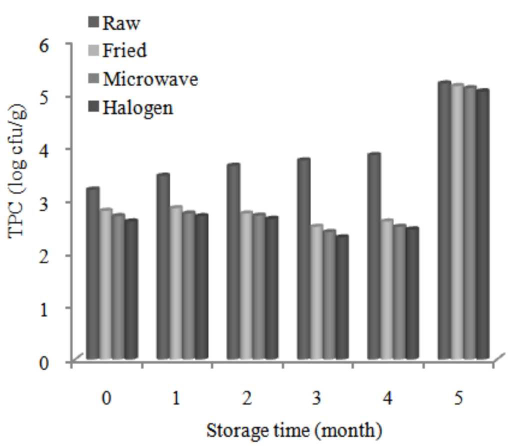

Fig. 7: Changes in total plate count (TPC log cfu/g) of fish cutlets during frozen storage

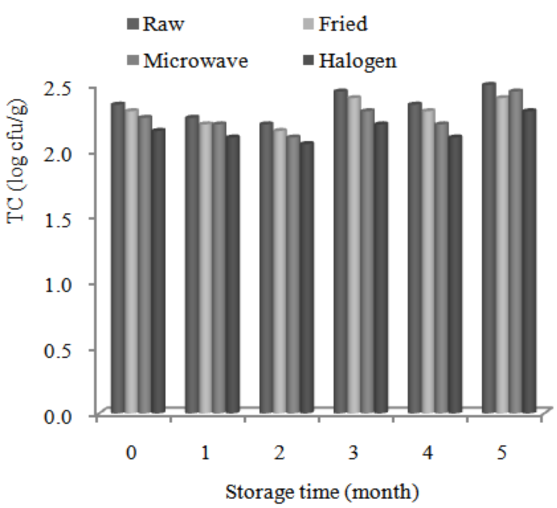

Fig. 8: Changes in total coliform (log cfu/g) of fish cutlets during frozen storage

The changes in free fatty acids of raw and cooked Carp fish cutlets during frozen storage are given in

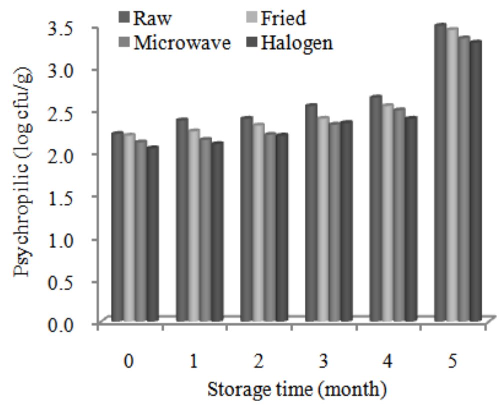

Fig. 9: Changes in *Psychropilic* bacteria (log cfu/g) of fish cutlets during frozen storage

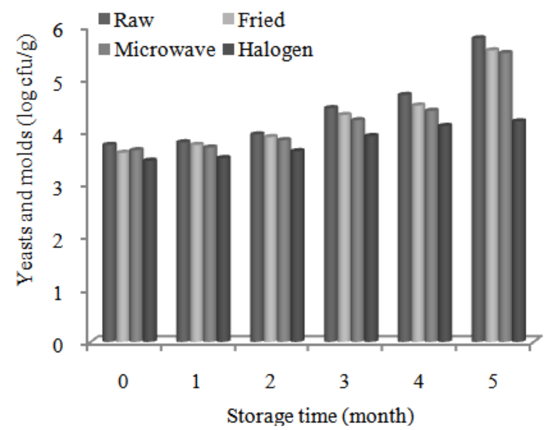

Fig. 10: Changes in yeasts and molds counts (log cfu/g) of fish cutlets during frozen storage

Fig. 6. Free fatty acids of raw and cooked Carp fish cutlets during frozen storage recorded 0.45, 0.57, 0.36 and 0.15 meqO_2/kg for raw, fried, microwave and halogen cooked samples, respectively at zero time, while it recorded 6.12, 2.14, 1.98 and 1.75 meqO_2/kg, respectively, at the end of frozen storage. It was also found that the FFA concentration in grass carp fish cutlet increased during the frozen storage for 6 months (Surabhi and Das, 2007).

Microbiological quality characteristics: The changes in Total Plate Count (TPC), total coliform, Psyhrophilic bacteria and yeast and mold counts of raw, fried, microwave and halogen cooked fish cutlet during frozen storage are showed in Fig. 7 to 10.

The results showed a decreasing trend after cooking methods while showed increasing trend during frozen storage period. Total Plate Count (TPC) of raw, fried, microwave and halogen cooked samples of Carp fish cutlets recorded 3.20, 2.80, 2.70 and 2.60 (log cfu/g), respectively at zero time, while it recorded 5.20, 5.15, 5.11 and 5.05 log cfu/g), respectively, at the end of frozen storage. Similar results have been reported by the many scientists during frozen storage.

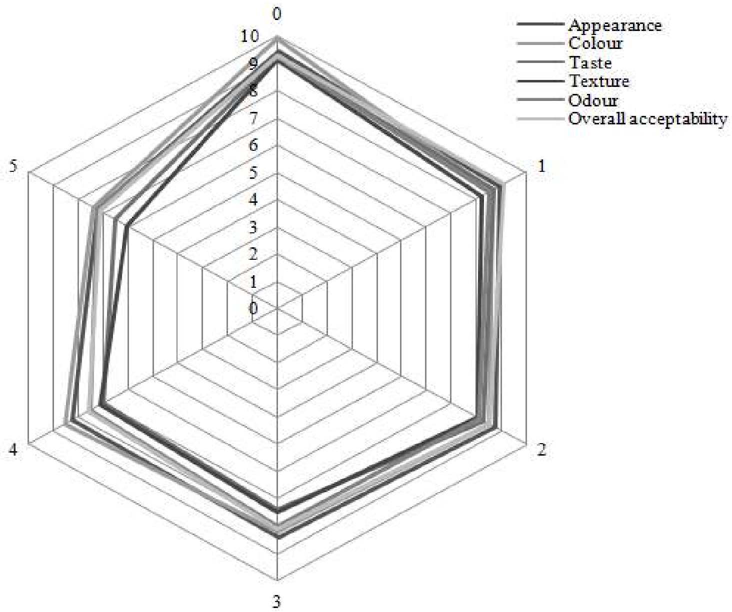

Fig. 11: Changes in sensory evaluation of fried cooked fish cutlets during frozen storage

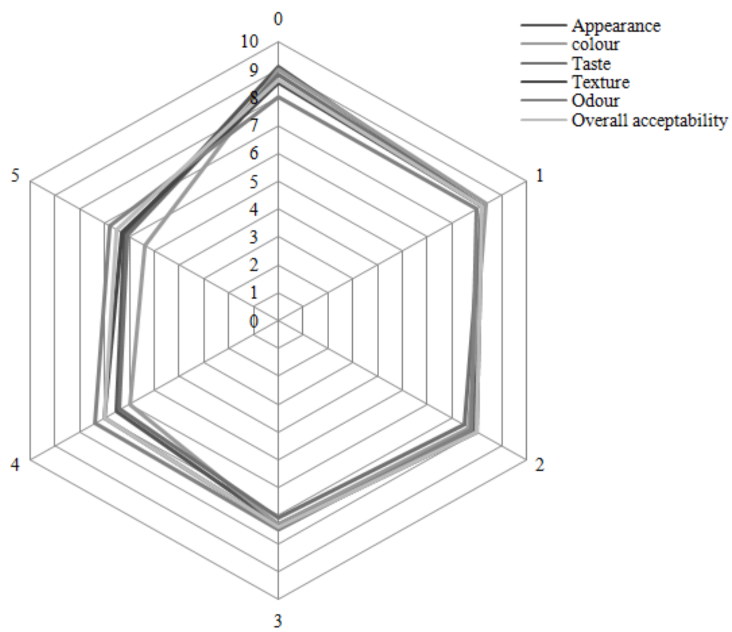

Fig. 12: Changes in sensory evaluation of microwave cooked fish cutlets during frozen storage

Fish cutlets samples were found to be free from and *Salmonella*. The total plate count decreased significantly in all cooked fish cutlets during till the 4^{th} month and then increased. The same trends was observed in total coliform, but decreases till the 2^{nd} month and then increase in the 3^{rd} month and again decrease at 4^{th} month then increase. However a significant increase ($p<0.05$) showed in the total counts of *Psychropilic* and yeasts, molds during frozen storage of fish cutlets. Reduction and fluctuation in the microbial load of processed fish cutlets may be explained initially due to the freezing and the powerful antimicrobial properties of food additives. Liston (1980) observed that freezing generally causes a reduction in bacterial count and the number will continue, in most cases, to fall during storage. A similar decrease in the TPC count was found by Ninan *et al*. (2010).

Sensory quality characteristics: The changes in sensory analysis of fish cutlets during frozen storage are shown in Fig. 11 to 13. The results revealed that fish

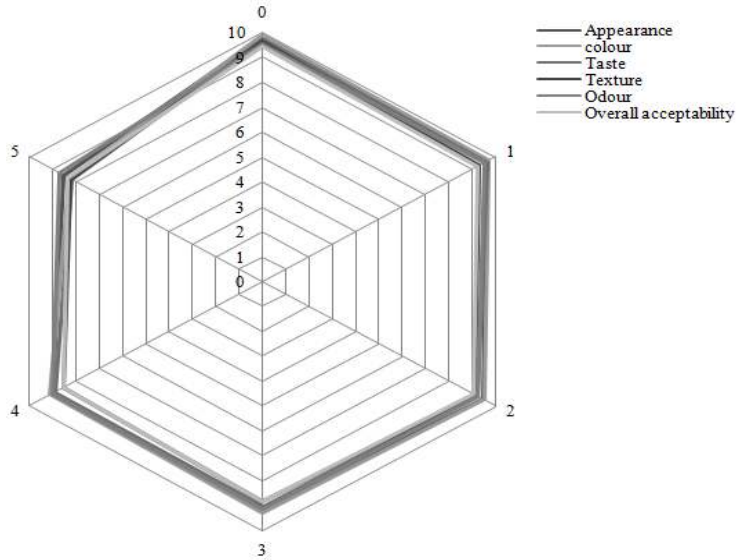

Fig. 13: Changes in sensory evaluation of halogen cooked fish cutlets during frozen storage

cutlets samples cooked by halogen oven had a good specific taste and was better than fried and microwave samples, while fried sample had a better appearance. Fish cutlets samples cooked by halogen and microwave oven were highly acceptable and sensory value event at the end of fifth month of frozen storage and this might be due to the coating process. These advantages offer consumer appeal for the product through improving sensory value of the processed items. Coating by battering and breading enhances a food product's characteristics such as appearance, flavor and texture. The process protects the natural juices of foods from the effects of freezing or reheating, thereby ensuring a final product that is tender and juicy on the inside and at the same time crisp on the outside (Joseph, 2003).

The sensorial scores decreased in all samples by increasing duration of frozen storage. Throughout the storage period there were decreases and significant changes ($p<0.05$) in all sensorial criteria. Average values showed that highest decreases were in odour and then taste among sensorial criteria.

The shelf life of raw fish cutlets prepared from the cooked mince of different marine fishes was 19 weeks in frozen conditions (Joseph *et al*., 1984). While, Raju *et al*. (1998) found that shelf life of crab cutlets and crab sticks were 24 weeks during frozen storage. Pandey and Kulkarni (2007) reported the shelf life of five months for fish cutlets and four months for the fish finger prepared from grass carp during the frozen storage for 6 months. Vanitha *et al*. (2013) found that *Catla catla* fish cutlets remained acceptable up to 180 days of frozen storage at -20°C.

CONCLUSION

Fish cutlet is a coated fishery product which is coated with another foodstuff. In this study three different cooking methods were used and their effects on the quality of fish cutlet were determined during frozen storage. All of the studied cooking methods evaluated changed proximate composition, oxidation parameters and microbial load fish cutlet. The results of sensory evaluation of fish cutlets showed that fish cutlets cooked by halogen cocker had a good specific taste and was better than fried and microwave samples, while fried sample had a better appearance. Halogen oven cooking appeared to be the best cooking methods concerning oxidative stability, microbial load and sensory evaluation.

The results showed that moisture content decreased during frozen storage of fish cutlets moisture content decreased, while protein, fat and ash, pH value, TVB-N, TMA, TBA, peroxide value, TPC, TC, YM and *Psychrophilic* bacteria had an increasing trend in all samples. Finally, the increasing interests in ready-to-prepare and ready-to-eat fishery products can be the driving forces for success of the coated seafood product industry. Apart from the popular species, the under-utilized fish can be an easy choice as raw material for coated products. The coating process can be a boon to these species, because of the scope of the process to enhance flavor and acceptability of these species even cooked in halogen oven.

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