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RESEARCH PAPER

Effect of baking on quality characteristics of fish steak prepared from grass carp

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SUMMARY :

Low cost fresh water exotic carp, the grass carp (*Ctenopharyngodon idella*) which is cultivated in abundant in Odisha was considered for fish steak production through frying in oil and baking in microwave oven (Combination of convection and grilling) and effect of heat processing on quality changes of the product has been studied in the present paper. The study was conducted at the fish processing laboratory of College of Fisheries, Odisha during 2013. The fish steaks of about 50 g each were marinated with spice mixture at room temperature for 60 min for spices to penetrate into the fish muscle. One lot of the marinated fish steaks were fried following high temperature short time (HTST) method using mustard oil at a temperature of about 160^{0}C for 6 to 8 mins and the other lot was baked in microwave oven at a dry heat temperature of 160^{0}C (combination of convection and grilling) for a period of 18 mins following the method of Swain *et al.*, 2012. The proximate composition of raw fish steak, oil fried and baked fish steak samples revealed that moisture content fried and baked steaks decreased by 21.97 per cent where as crude protein and lipid content increased significantly by 70.01 per cent and 471.77 per cent, respectively ($p<0.05$) over that of raw fish steak sample. The chemical and micro biological changes due to frying and baking of the fish steaks were also analysed and discussed. From the organoleptic evaluation conducted in a 5-point hedonic scale, it was observed that the overall acceptability of baked fish steak product was at a higher degree over the oil fried fish steak sample.

KEY WORDS : Grass carp, Fish steak, Baking, Quality changes

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Fish being a rich source of protein, around 60 per cent of people in many developing countries depend on fish for over 30 per cent of their animal protein requirement. With increased awareness of health benefits of eating fish, there is increase in demand of fish (Ayyappan, 2006). Being basically a carp country, both indigenous and exotic carps account for the bulk of the production. Among the exotic carps, silver carp (*Hypophthalmichthys molitrix*) and grass carp (*Ctenopharyngodon idella*) are less preferred by the consumers and hence, considered as low cost fish and the fish farmers get very low return (Jena and Das, 2006). As because more and more women are getting educated and taking up employment, there is a great demand for value addition to those low cost fishes in ready to eat convenience form (Ramachandran, 2006). Mishra and Dora (2010) have developed various value added fish based products from low cost fish for nutritional security and public health. Though several suitable methods for the value addition to low cost fish have been

developed, these need to be implemented which will help in providing nutrition security, preventing them from waste, enhancing the livelihood of the poor people and providing an ample scope for the farmers to get a better return from the produce. The study was conducted at the fish processing laboratory of College of Fisheries, Odisha during 2013 with an objective to develop value added products namely oil fried and microwave oven baked fish steaks from low cost fresh water grass carp, to compare their quality characteristics and to study the consumer acceptability.

EXPERIMENTAL METHODS

Raw fish, processing and chemicals:

Grass carp, *Ctenopharyngodon idella* (Each individual of average length of 34.6 cm) were obtained in December 2013 from Berhampur local market of Ganjam district of Odisha and transported in ice to the fish processing laboratory (College of Fisheries, Berhampur, Ganjam). Individual fishes (Average weight 1185.0 ± 18.5 g) were gutted, dressed and cut to steaks of about 47.4 ± 1.85 g each of thickness about 1.75 ± 0.12 cm. Fish steaks were washed thoroughly to remove any visual organ and peritoneal organ (Fig. A).

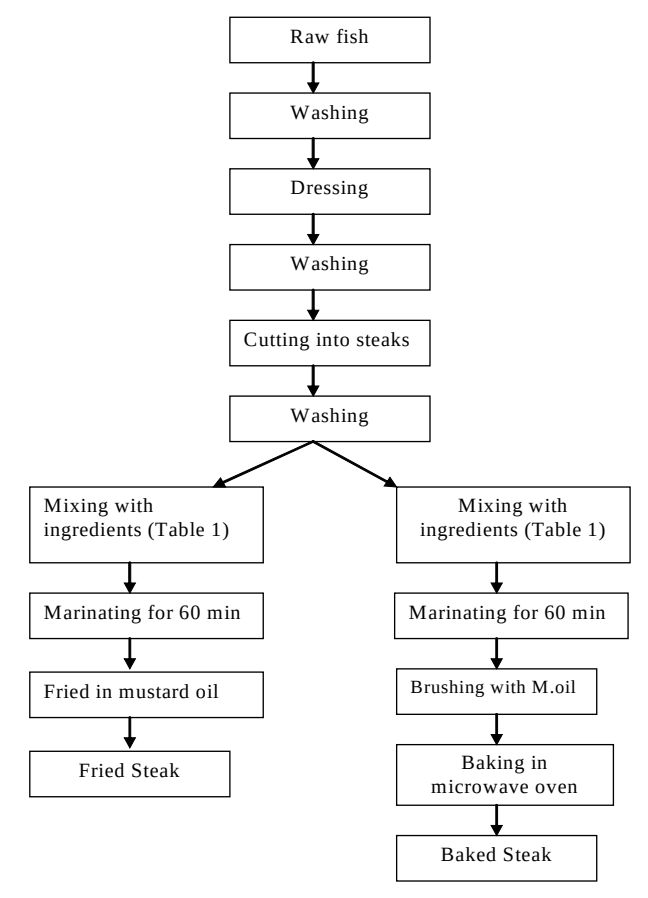

Fig. A : Preparation procedure for fried and baked fish steak

The raw fish steak was analysed for proximate composition (moisture, crude protein, lipid and ash), quality parameters such as Total volatile base nitrogen (TVBN), peroxide value (PV) and free fatty acids (FFA) and organoleptic properties (appearance, colour, flavour, odour, taste, texture and overall acceptability). Taste and odour of the meat was analysed by hot blanching in 2 per cent salt solution for 8-10 min.

Marinating the fish steaks:

The fish steaks were marinated in two lots with spices as mentioned in Table A for both oil frying and microwave baking by mixing thoroughly and was kept at room temperature for 60 min for the spices to penetrate into the fish muscle.

Table A: Ingredients used for marinating fish steak prepared from grass carp

Sr. No.	Ingredients	For marinating fish steaks (Percentage)
1.	Lemon juice	25
2.	Chilli powder	17
3.	Curd	30
4.	Garlic paste	8
5.	Ginger paste	8
6.	Green chilli paste	8
7.	Garam masala powder	4

Oil frying:

One lot of fish steaks after marinating were subjected to oil frying following HTST method using mustard oil at a temperature of about 160^0 C for 6 to 8 mins in a frying pan to obtain oil fried fish steaks. The oil fried fish steaks were analysed for chemical, micro biological and organoleptic properties.

Microwave baking:

Pastes of spices (Table B) after frying at low temperature were mixed thoroughly with corn flour and they were coated

Table B : Ingredients used for spice mixture for microwave oven baked fish steak prepared from grass carp

Sr. No.	Ingredients	Percentage
1.	Lemon juice	20
2.	Chilli powder	10
3.	Curd	25
4.	Garlic paste	8
5.	Ginger paste	8
6.	Green chilli paste	8
7.	Garam masala powder	4
8.	Arrowroot powder	17

onto the 2nd lot of marinated fish steaks. They were then baked in microwave oven to a dry heat temperature of 160^{0}C (combination of convection and grilling) for a period of 18 min. (Swain *et al.,* 2012). The baked fish samples were analysed for chemical and micro biological quality parameters and organoleptic properties.

Chemicals (solvents and reactants) employed throughout the study were of reagent grade (E. Merck, Darmstadt, Germany).

Proximate composition:

Moisture content was determined by weight difference between the fresh muscle and the heated muscle according to AOAC (2006) method. Results were calculated as g water / 100g meat. Total lipid content of the meat was determined by soxhlet extraction method (AOAC, 2006) and was expressed as g/100g meat. Total protein was measured by employing the kjeldahl method according to the AOAC (2006) method. Results were calculated as g protein/100g meat. Total ash content of the meat was determined by the method described by (AOAC, 2006) and was expressed as g/100g meat.

Quality analyses:

TVBN content was analysed taking the TCA extract by the method of Beatty and Gibbons (1937) using Conway's Micro diffusion unit. The result was expressed as mg/100g of meat. Peroxide value (PV) was determined in the lipid extract by the method described by Jacobs (1958). Results were calculated as millimoles of O_2 per kg lipid. Free Fatty Acid (FFA) content was analysed in the lipid extract according to the improved titrimetric method according to Ke *et al.* (1976). FFA content was calculated as g Oleic acid/ 100g lipid.

Microbiological analyses:

Microbial analysis of the raw fish sample, fried fish steak and baked fish steak samples was done by quantifying the total plate count (TPC) by using spread plate technique (Mehlman, 1984).

Organoleptic analysis:

The sensory evaluation was conducted using a 5-point hedonic scale (1= Excellent, 5= Unacceptable) by ten semi-trained panelists who were selected from students and staff of the College having same ethnic (Larmond, 1977).

Statistical analyses:

Data are expressed as mean values (n=3) accompanied by the standard errors of means. Data of quality parameters were subjected to one-way ANOVA ($p < 0.05$). Comparison of means after the ANOVA test was performed using the Duncan's Multiple Range Test ($p < 0.05$) (Duncan, 1955).

EXPERIMENTAL FINDINGS AND ANALYSIS

Fried and baked fish steaks were prepared from grass carp, *Ctenopharyngodon idella* using simple ingredients for marinating (Table A) and baking (Table B) as mentioned in the Fig. A.

Proximate analysis:

The proximate analysis of grass carp raw, fried and microwave baked fish steak samples is presented in Table 1.

Table 1: Physical, chemical and microbiological characteristics* of the fish steak prepared from grass carp

Characteristics	Raw fish steak (mean ± S.E.)	Fish steak fried in oil (mean ± S.E.)	microwave oven baked fish (mean ± S.E.)
Physial characteristics			
Weight of the steak (g)	47.4^a ± 1.85	26.8^b ± 1.66	31.5^c ± 1.43
Thickness of the steak (cm)	1.75 ± 0.12	1.54 ± 0.10	1.64 ± 0.14
Chemical characteristics			
Moisture (%)	75.23^a ± 1.27	60.42^b ± 1.74	57.06^b ± 2.01
Crude protein (%)	16.89^a ± 0.93	26.56^b ± 1.12	30.87^c ± 1.83
Crude fat (%)	1.24^a ± 0.27	11.06^b ± 0.96	3.12^c ± 0.97
Ash (%)	2.94 ± 0.21	2.45 ± 0.27	3.53 ± 0.32
Peroxide value (PV) (millimoles of O_2/ kg fat)	2.76^a ± 0.54	6.86^b ± 0.72	6.94^b± 0.66
FFA (% of total lipid as Oleic acid)	2.21^a ± 0.87	4.64^b ± 0.22	3.72^c ± 0.02
TVBN (mg %)	8.40^a ± 0.17	14.98^a ± 0.26	13.35^b ± 0.25
Microbiological characteristics			
Total plate count (cfu/g)	4.13 x 10^{5a}	2.14 x 10^{1b}	1.26 x 10^{1b}

*Mean values ± Standard errors of means of 3 different determinations (n=3). For each parameter, mean values followed by different superscripts (a,b,c) denote significant differences ($p<0.05$)

The proximate composition of fresh raw fish steaks were moisture 75.23 ± 1.27 %, crude protein 16.89 ± 0.93%, total lipids 1.24 ± 0.27% and total ash 2.94 ± 0.21%. The results of proximate composition are in agreement with previous research carried out on this carp (Gopakumar, 1997 and Nair and Suseela, 2000). The slight difference in the values may be attributed to species, sex, body size, season, environmental factors and nutritional (Love, 1974).

The moisture content of the fried and baked fish steak samples decreased significantly by 19.69 per cent and 24.15 per cent, respectively from that of the fresh raw fish steak during processing ($p<0.05$). Further the baked fish steak samples showed 5.56 per cent reduction in moisture content from that of oil fried fish steak sample which is not significant. It is usual to find reduction in moisture content in fish and fishery products during heat processing because of dehydration (Joseph and Perigreen, 1988) and moisture slowly leaves the product during processing. Similar observation was recorded in fish cutlets prepared from croaker and ribbon fish (Mishra *et al.*, 2010) and in baked mullet (Swain *et al.*, 2012).

Starting protein content of raw fish steak (16.89 ± 0.93 %; Table 1) can be considered in the normal fish range and agrees with previous research concerning this species (Gopakumar, 1997). A significant increase in the protein content of 57.25 per cent and 82.77 per cent was observed as a result of oil frying and microwave baking, respectively ($p<0.05$). Besides, the protein content of baked fish steak was significantly increased by 16.23 per cent over that of oil fried fish steak sample. Such increasing protein content may be delineated to its relative increase resulting from the marginal decrease in moisture content. Hamm (1971) reported on the changes in fish protein content of product during heating due to thermal denaturation. Similar observations were made in case of fish ball when prepared from tilapia meat (Mishra and Dora, 2008), baked fish prepared from mullet (Swain *et al.*, 2012) and fish cutlets prepared from croakers (Mishra *et al.*, 2010).

The total lipid content of the oil fried and micro wave baked fish steak samples under study showed a significant increase of 791.94 per cent 151.61 per cent over that of the fresh fish steak sample during oil frying and baking, respectively ($p<0.05$). This might be attributed to the relative marginal decrease of moisture content in the meat and accumulation of oil in the meat during processing. However, when compared the baked fish steak sample showed a significant reduction in total lipid content (71.79%) over the oil fried fish steak samples ($p<0.05$). Similar trend was reported in fish cutlets prepared from croakers (Mishra *et al.*, 2010).

The ash content, a measure of total mineral in the fish meat, remained more or less stable without any significant change in all the processed fish samples. This corroborated well with the result of Gopakumar (2006) in minced fish based products and Swain *et al.* (2012) in fish baked mullet fish.

Quality analyses:

The changes in chemical and microbiological qualities of raw fish steaks during the process of oil frying and baking in microwave are presented in Table 1. The TVBN content of raw fish steak was 8.40 mg% which is well within the acceptable limit of 35 mg% as reported by Mathew (2003). Total volatile bases are the products formed by progressive hydrolysis and putrefactive processes under the influence of microbial enzymes. These volatile bases showed an exponential increase leading to a deterioration of odour and flavour in fish and shell fish (Kolakowski, 1986). The amount of TVBN depends upon the species and also on the degree of spoilage variability (Sen, 2005). TVBN content is one of the most common indices of quality accepted to universally for deciding the state of freshness of fishery products. In the present study, the TVBN content of raw fish steaks increased significantly by 78.33 per cent and 58.93 per cent during oil frying and baking, respectively ($p<0.01$). This increase can be explained as a result of the breakdown of endogenous compounds into non-protein N-compounds. However, there is no significant change in the TVBN content between oil fried

Table 2: Organoleptic characteristics of the fish steak prepared from grass carp

Organoleptic characteristics	Raw fish steak Mean score* ± SE	Fish steak fried in oil Mean score* ± SE	Microwave oven baked fish Mean score* ± SE
Appearance	4.7 ± 0.30	4.6 ± 0.10	4.8 ± 0.10
Colour	4.6 ± 0.20	4.8 ± 0.05	5.0 ± 0.00
Odour	4.7 ± 0.20	5.0 ± 0.00	5.0 ± 0.00
Taste	4.8 ± 0.10	5.0 ± 0.00	5.0 ± 0.00
Flavour	4.7 ± 0.05	4.8 ± 0.10	5.0 ± 0.00
Texture	4.9 ± 0.05	4.5 ± 0.30	5.0 ± 0.00
Overall acceptability (OAA)	4.8 ± 0.05	4.8 ± 0.10	5.0 ± 0.00

Mean score of 5 panelists: Hedonic scale: Excellent – 5, Good – 4, Fair – 3, Acceptable – 2, Not acceptable – 1

*Mean values ± Standard errors of means of 5 different determinations (n=5).

and baked fish steak samples. Similar observations were made in baking of fish mullet (Swain *et al.*, 2012) and fish balls prepared from tilapia by Mishra and Dora (2008).

Raw starting value of FFA content (4.21 ± 0.87% of total lipid as Oleic acid) in fish steak prepared from grass carp can be considered within the acceptable limit of freshness which falls in the range of those reported for common carp (Mandal *et al.*, 2009) and for marine fish (Mishra and Dora, 2010). In the present experiment, the FFA content of fried and baked fish steak samples increased significantly by 109.95 per cent and 68.33 per cent, respectively during processing ($p<0.05$) which might be explained as a result of hydrolytic enzymes present in the meat leading to lipid hydrolysis. The significant low FFA content of baked fish steak sample has an advantage of consumer acceptance over that of fried one.

While the formation of FFA itself does not lead to nutritional losses, its assessment is deemed important when considering the development of rancidity. Thus, a pro-oxidant effect of FFA on lipid matter has been proposed and explained on the basis of a catalytic effect of the carboxyl group on the formation of free radicals by the decomposition of hydroperoxidase (Yoshida *et al.*, 1992 and Aubourg, 2001). In addition, FFA has shown to interact with proteins leading to fish texture deterioration during processing and storage (Mackie, 1993).

Starting raw fish steak sample showed a low peroxide value (PV) (2.76 ± 0.54 millimoles of O_2 per kg fat) indicating a good quality fish. According to Gopakumar (2006) the PV should be much below 10 millimoles of O_2 per kg fat. In the present study, the PV of oil fried and microwave oven baked fish steak samples as 6.86 ± 0.72 and 6.94 ± 0.66 millimoles of O_2 per kg fat, respectively also remained within the acceptable limit. However, a marked peroxide content increase could be explained as a result of the pro-oxidant enzymes (Lipoxygenases, peroxidises and so on) and chemical pro-oxidant molecules (*i.e.* hemoproteins and metal ions) (Sikorski and Kolakowski, 2000). Swain *et al*. (2012) reported similar observation in case of mullet during baking.

Microbiological analyses:

The total plate count (TPC) of fresh fish steak samples was 4.13×10^5 cfu/g and that of fried and baked fish steak sample was 2.14×10^1 cfu/g and 1.26×10^1 cfu/g, respectively. Initially the TPC of fresh fish steak was higher which may be attributed to the higher load of bacteria in the meat. During heat processing, TPC of the fried and baked fish steak samples reduced significantly ($p<0.05$) which might be due to injury caused to the bacterial cells during the process of baking. According to Marth (1973), the number of bacteria in fish is markedly reduced by any process probably because the flora contains such a large proportion of gm-ve acteria which are quite sensitive to heat processing.

Organoleptic analyses:

The organoleptic evaluation of the raw fresh fish steak, fried and baked fish steak samples for appearance, colour, flavour, odour, taste, texture and overall acceptability in a 5-point hedonic scale is shown in Table 2. The quality of the baked fish steak samples showed higher overall acceptability (OAA) over that of fried fish steak samples. In all the sensory attributes, the baked fish samples showed higher scores. This indicates the higher consumer acceptability of the microwave oven baked fish steak sample over fried fish steak sample.

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