A study on the quality changes during baking of Indian mackerel, *Rastrelliger kanagurta*

S.R. SENAPATI, R. MISHRA AND H.S. SWAIN

ABSTRACT. Indian mackerel, *Rastrelliger kanagurta*, available along Odisha coast in abundance was considered for baking and effect of baking on quality changes has been studied in the present paper. The dressed fish pieces of 50 to 60 g each were marinated with spice mixture at room temperature for 1 hr for spices to penetrate into the fish muscle. The heat processing time of fish pieces were standardised for 75 min at 15 psi (121.2°C) so as to make the fish bones soft and palatable. Baking time was standardised at 160°C for a period of 60 min. The proximate composition of fish and baked fish revealed that moisture content decreased by 20.65 per cent whereas crude protein and lipid content increased significantly by 59.28 per cent and 19.56 per cent, respectively (p<0.05). The chemical and microbiological changes due to baking the fish were also analysed and discussed. The organoleptic evaluation of baked mackerel fish samples was conducted in a 5-point hedonic scale. Besides, the softness of the bones its palatability improved the overall acceptability of baked product to a higher degree.

KEY WORDS. Baking, Mackerel, Quality changes

INTRODUCTION

Fish species provide high contents of important constituents for the human diet such as nutritional and readily digestible proteins, lipid soluble vitamins, microelements and poly unsaturated fatty acids (Friedman, 1996 and Simopoulos, 1997). However, fishes are known to easily deteriorate during post-mortem storage and processing as a result of different damage mechanisms such as autolytic degradation, microbiological spoilage and lipid oxidation (Whittle et al., 1990 and Olafsdottir et al., 1997).

Although fish are known as a rich source of protein, they are not easily acceptable by the consumers because of their small bones. In recent years, fish technologists have increasingly prompted more attention to develop such a value added product where the most problematic bones of fish can be palatable. Baking is a method of processing where fish is exposed to very high temperature under dry condition. In this many damage pathways are inhibited extending shelf–life, thus minimising the post process loss.

Indian mackerel, *Rastrelliger kanagurta* though small in size is an important marine fish which is very much appreciated by the consumers and is plentifully available along Odisha coast. Although previous research concerning the baking of marine fish has observed non-palatability of bones (Ninawe and Rathnakumar, 2008), standardisation of the process of development of baked fish in such that fish bones can be made palatable is in fact need of the hour. This will help enhancing the consumption of calcium along with the fish meat which will improve the health of mankind. Looking to this, the present study aims at standardisation of baking of mackerel and its effect on quality changes.
RESEARCH METHODS

Raw fish processing and chemicals:
Indian mackerel (Rastrelliger kanagurta) (each individual of average length of 21.2 cm) were obtained in December 2010 from Gopalpur landing centre in Ganjam district of Odisha and transported in ice to the Fish processing laboratory (College of Fisheries, Berhampur, Ganjam). Individual fishes (average weight 143.5 ± 8.5 g) were gutted, dressed and were cut to piece of about 50 to 60 g each of dimension (7.5 cm x 6 cm x 3 cm). Fish pieces were washed thoroughly to remove any visual organ and peritoneal organ.

The raw fish meat was analysed for proximate composition (moisture, crude protein, lipid and ash), quality parameters such as Tri-methyl amine nitrogen (TMAN), 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.

Marinading the fish:
The fish pieces were marinated with spices (turmeric powder, chilli powder, salt, garlic paste, ginger paste, curd) (Table 1) by mixing thoroughly and kept at room temperature for 1 hr for the spices to penetrate into the fish muscle.

Heat processing:
The fish pieces after marinading were subjected to heat processing in a retort at 15 psi for 30, 45, 60, 75 and 90 min so as to make the bones palatable and meat to be tougher. The heat processed fish portions were analysed for organoleptic properties as well as softness of bones. Thus, the optimum time for heat processing for mackerel pieces was observed.

Baking:
After heat processing, pastes of spices with corn flour (Table 1) fried at low temperature were coated onto the fish portions. They were then baked in microwave oven to a dry heat temperature of 160°C (combination of convection and grilling) for 30, 45, 60, 75 and 90 min.

The baked fish samples were analysed for proximate composition, quality parameters and organoleptic properties. The baked mackerel pieces, thus prepared were wrapped in aluminium foil having a thickness of 0.05 mm.

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/100 g 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:
TMAN 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 O₂ per kg lipid. Free fatty acid (FFA) content was analysed in the lipid extract according to the improved titrimetric method of Ke et al. (1976). FFA content was calculated as g oleic acid/100g lipid.

Microbiological analyses:
Microbial analysis of the fresh and baked fish 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 panellists who were selected from students and staff of the College having same ethnic (Larmond, 1977).

Statistical analyses:
Data were 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).

RESEARCH FINDINGS AND ANALYSIS

The mackerel sample pieces were marinated by mixing with spice mixture thoroughly and keeping at room temperature for 1 hr for the spices to penetrate into the fish muscle.

Standardization of heat processing time:
Five different time periods at 15 psi (121.2°C) such as 30, 45, 60, 75, and 90 min were used to determine the optimum time for heat processing so that the bones of marinated fish becomes soft and palatable. The effect of different temperatures on the organoleptic quality of heat processed fish portions along with bone softness is presented in Table 2. It was observed that the fish bones became soft and palatable when heat processed from 75 mins onwards and the sensory score was rated excellent by panellists. Hence, the
heat processing of 75 min at 15 psi being the shortest time period was considered optimum for marinaded mackerel fish.

**Standardisation of baking time:**

The standardisation of baking time for heat processed fish samples after coating with a spice mixture paste and brushing with refined oil over it was conducted by subjecting them to baking at 160°C for 5 different time periods such as 30, 45, 60, 75, and 90 min in microwave oven with combination of convection and grilling. The baked fish samples were analysed for organoleptic test and the scores were presented in Table 3. Considering the highest score, the baking time of 60 min was considered best for the preparation of baked product for mackerel fish.

**Table 1 : Ingredients used for marinading and baking**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Ingredients</th>
<th>% used for marinading</th>
<th>% used for baking</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Lemon juice</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>2.</td>
<td>Chilli powder</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>3.</td>
<td>Curd</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>4.</td>
<td>Garlic paste</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>5.</td>
<td>Ginger paste</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>6.</td>
<td>Green chilli paste</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>7.</td>
<td>Garam masala powder</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>8.</td>
<td>Arrowroot powder</td>
<td>-</td>
<td>17</td>
</tr>
</tbody>
</table>

**Table 2 : Mean organoleptic score of mackerel samples during standardisation of heat processing time**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Organoleptic characteristics</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Appearance</td>
<td>4.23</td>
<td>4.62</td>
<td>4.71</td>
<td>4.75</td>
<td>4.50</td>
</tr>
<tr>
<td>2.</td>
<td>Colour</td>
<td>4.58</td>
<td>4.65</td>
<td>4.68</td>
<td>4.62</td>
<td>4.58</td>
</tr>
<tr>
<td>3.</td>
<td>Flavour</td>
<td>4.77</td>
<td>4.65</td>
<td>4.74</td>
<td>4.76</td>
<td>4.76</td>
</tr>
<tr>
<td>4.</td>
<td>Texture</td>
<td>4.34</td>
<td>4.40</td>
<td>4.90</td>
<td>4.87</td>
<td>4.87</td>
</tr>
<tr>
<td>5.</td>
<td>Odour</td>
<td>4.80</td>
<td>4.74</td>
<td>4.75</td>
<td>4.58</td>
<td>4.46</td>
</tr>
<tr>
<td>6.</td>
<td>Taste</td>
<td>4.90</td>
<td>4.75</td>
<td>4.80</td>
<td>4.76</td>
<td>3.95</td>
</tr>
<tr>
<td>7.</td>
<td>Bone softness</td>
<td>1.70</td>
<td>2.10</td>
<td>3.70</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>8.</td>
<td>Overall acceptance</td>
<td>4.61</td>
<td>4.79</td>
<td>4.78</td>
<td>4.82</td>
<td>4.65</td>
</tr>
</tbody>
</table>

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

*Heat processing temperature : 15 psi (121.2 °C)*

**Table 3 : Mean organoleptic score of mackerel pieces during standardisation of baking time**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Organoleptic characteristics</th>
<th>30</th>
<th>45</th>
<th>60</th>
<th>75</th>
<th>90</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Appearance</td>
<td>3.24</td>
<td>3.59</td>
<td>4.35</td>
<td>4.76</td>
<td>4.55</td>
</tr>
<tr>
<td>2.</td>
<td>Colour</td>
<td>3.25</td>
<td>3.60</td>
<td>4.81</td>
<td>4.65</td>
<td>4.28</td>
</tr>
<tr>
<td>3.</td>
<td>Flavour</td>
<td>4.55</td>
<td>4.19</td>
<td>4.37</td>
<td>4.80</td>
<td>4.21</td>
</tr>
<tr>
<td>4.</td>
<td>Texture</td>
<td>4.65</td>
<td>4.80</td>
<td>5.00</td>
<td>5.00</td>
<td>3.75</td>
</tr>
<tr>
<td>5.</td>
<td>Odour</td>
<td>3.80</td>
<td>3.72</td>
<td>4.72</td>
<td>4.70</td>
<td>4.34</td>
</tr>
<tr>
<td>7.</td>
<td>Overall acceptance</td>
<td>4.06</td>
<td>4.53</td>
<td>4.72</td>
<td>4.80</td>
<td>4.70</td>
</tr>
</tbody>
</table>

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

**Proximate analysis:**

Table 4 presents the proximate composition of mackerel piece samples before and after baking. The proximate composition of fresh mackerel samples were moisture 67.8 ± 1.64 per cent, crude protein 16.7 ± 0.47 per cent, total lipids 14.6 ± 0.22 per cent and total ash 1.1 ± 0.03 per cent. Nair and Suseela (2000) had presented the proximate composition of the species which is in agreement with the present result. However, the proximate composition of fish differs with species, sex, body size, season, environmental factors and nutritional status and even on the type of muscle sample (Love, 1974).

The moisture content of the baked fish decreased by 20.65 per cent from that of the fresh raw fish during baking (p<0.05). It is usual to find reduction in moisture content in...
The changes in chemical and microbiological qualities of mackerel pieces during the process of baking are presented in Table 5. The TMAN content of fresh mackerel meat was 0.53 mg per cent which was well within the acceptable limit of 1.5 mg per cent as reported by Gopakumar (2006). Tri-methyl amine nitrogen is the most known compound to indicate freshness and spoilage of marine fish (Sen, 2005). TMAN is a breakdown product of TMAO which serves as a good index of textural changes during processing (Regenstein, 1984). TMAN is believed to react with fat and produced typical spoilage odour. Increasing TMAN content is indication of bacterial spoilage (Sen, 2005). In the present study, the TMAN content increased significantly by 133.96 per cent during baking. This increase can be explained as a result of the breakdown of endogenous compounds into non-protein N-compounds. Similar observations were made in fish fingers and fish balls prepared from croaker by Reddy et al. (1992) and Ninawe and Rathnakumar (2008), respectively. Raw starting value of FFA content (2.91 ± 0.1% of total lipid as Oleic acid) in mackerel pieces can be considered within the acceptable limit of freshness which falls in the range of those reported for marine fish (Mishra and Dora, 2010). In the present experiment, the FFA content of mackerel pieces increased significantly by 145.02 per cent during the process of baking (p<0.05) which might be explained as a result of hydrolytic enzymes present in the meat leading to lipid hydrolysis. While

#### Table 4: Proximate analysis* of mackerel samples before and after baking

<table>
<thead>
<tr>
<th>Samples</th>
<th>Moisture%</th>
<th>Crude protein %</th>
<th>Lipid %</th>
<th>Ash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fish portions</td>
<td>67.8a(1.64)</td>
<td>16.7b(0.47)</td>
<td>14.6b(0.22)</td>
<td>1.1b(0.03)</td>
</tr>
<tr>
<td>Baked fish portions</td>
<td>53.8b(1.21)</td>
<td>26.6b(0.56)</td>
<td>17.5b(0.24)</td>
<td>1.9b(0.02)</td>
</tr>
</tbody>
</table>

*Mean values of 5 different determinations (n=5). Standard errors of means are indicated in brackets.

#### Table 5: Chemical and microbiological changes* of mackerel samples before and after baking

<table>
<thead>
<tr>
<th>Samples</th>
<th>TMAN mg%</th>
<th>PV millimoles of O₂/kg fat</th>
<th>FFA</th>
<th>TPC cfu/g meat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fish portions</td>
<td>0.53a (0.63)</td>
<td>2.86a(0.11)</td>
<td>2.91a(0.10)</td>
<td>1.5 x 10⁶</td>
</tr>
<tr>
<td>Baked fish portions</td>
<td>1.24b (0.53)</td>
<td>6.58b(1.76)</td>
<td>7.13b(0.73)</td>
<td>3.1 x 10⁴</td>
</tr>
</tbody>
</table>

*Mean values of 3 different determinations (n=3). Standard errors of means are indicated in brackets.

#### Table 6: Changes in organoleptic quality* of mackerel samples due to baking

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Organoleptic characteristics</th>
<th>Fresh fish portions</th>
<th>Baked fish portions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Appearance</td>
<td>4.89 (0.03)</td>
<td>4.88 (0.08)</td>
</tr>
<tr>
<td>2.</td>
<td>Colour</td>
<td>4.64 (0.07)</td>
<td>4.78 (0.09)</td>
</tr>
<tr>
<td>3.</td>
<td>Flavour</td>
<td>4.79 (0.06)</td>
<td>4.94 (0.03)</td>
</tr>
<tr>
<td>4.</td>
<td>Texture</td>
<td>4.85 (0.02)</td>
<td>4.92 (0.07)</td>
</tr>
<tr>
<td>5.</td>
<td>Odour</td>
<td>4.76 (0.05)</td>
<td>4.90 (0.04)</td>
</tr>
<tr>
<td>6.</td>
<td>Taste</td>
<td>4.91 (0.04)</td>
<td>4.97 (0.02)</td>
</tr>
<tr>
<td>7.</td>
<td>Overall acceptance</td>
<td>4.88 (0.06)</td>
<td>4.96 (0.01)</td>
</tr>
</tbody>
</table>

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

*Mean values of 5 different determinations (n=5). Standard errors of means are indicated in brackets.
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). The fresh raw fish showed a low PV (2.86 ± 0.11 millimoles of O₃ per kg fat) indicating a good quality fish. The PV should be much below 10 millimoles of O₃ per kg fat (Gopakumar, 2006). In the present study, the PV of baked fish portions (6.58 ± 1.76) 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).

The total plate count (TPC) of fresh mackerel samples was 1.5 x 10⁵ cfu/g and that of baked mackerel sample was 3.1 x 10³ cfu/g. Initially the TPC of fresh fish portion was higher which may be attributed to the higher load of bacteria in the meat. During baking, TPC of the baked fish samples reduced significantly (p<0.05) which might be due to injury caused to the bacterial cells during the process of baking. The number of bacteria in fish is markedly reduced by any process probably because the flora contains such a large proportion of gm-ve bacteria which are quite sensitive to heat processing (Marth, 1973).

Table 6 shows the organoleptic evaluation scores of the fresh and baked mackerel samples for appearance, colour, flavour, odour, taste, texture and overall acceptability in a 5-point hedonic scale. The quality of the baked fish samples showed higher overall acceptability (OAA) over that of fresh fish samples. In all the sensory attributes, the baked fish samples showed higher scores. Besides, the softness of the bones and its palatability improved the OAA to a higher degree.

Looking to the advantages of fish meat from the quantitative and qualitative point of protein, lipid, vitamins and minerals, the baked mackerel as a value added fish product will certainly bring nutritional security for the people.

LITERATURE CITED


