Preparation and Evaluation of Novel Nutritious Fish Snacks Using Sand Smelt (*Atherina boyeri*) Fish

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ABSTRACT

The present work was designed to highlight recipes of snacks using sand smelt fish (*Atherina boyeri*) in baked and pre-cooked baked fish snack products. The results showed improvement the chemical components with increasing the percentage of added minced fish. The results of all minerals in baked samples as compared with pre-cooked baked ones. The TBAS’s and TVB-N’s values increased by extending the storage time and the percentage of added minced fish. The total bacteria, yeast and molds count in samples showed limit activity and extending with increasing the storage period. The bio-evaluation indicated that the food intake, protein consumed, true digestibility, net protein utilization were the highest in pre-cooked baked snacks contained 30% fish meat. The protein efficiency ratio and the corrected protein efficiency ratio were higher in casein diet followed by both of pre-cooked baked and baked control samples then baked snack sample contained 20% smelt sand meat, respectively. The biological values were 97.09%, 93.66% and 92.89% in S30, B30 and casein groups, respectively. Whereas, these values ranged from 75.99% to 88.05% in the rest samples.

Key words:-Fish snacks, sand smelt fish, chemical composition, quality parameters, biological values..

INTRODUCTION

Snacks have been widely accepted by the consumer market. One of the developing countries such as Indonesia, it has parallel consideration of snacks production due to its continually growing population. There is many fish-based snacks (FBS) such as fish balls, fish-dough sticks, fried fish-dough, pre-cooked baked fish dumplings, octopus ball snack and seafood satay (Rahayu et al., 2018).

It is worth to mention that the WHO report states that there is deficiency in dietary fat intake, being less than ten percent of the total caloric, which has harmful effects at humans and fetal growth (Alves & Grossmann, 2002 and Elevevoli & James, 2010). The use of sand smelt fish as a replacer for both of oat and corn flour in the preparation of FBS responds to the demand for improvement of the nutritional value of snacks. Small fish has an expected growing nutritional future in the snacks industry, whole fish, fish bone, fish meat, fish protein-isolate and fish protein concentrate were used in several types of food including snacks. Moreover, a lot of producers utilized the frying method which caused immoderate amount of absorbed oil and this takes place in fish meat snacks that’s why the baking method can be a top in properties of fish snacks (Nawaz et al., 2021). In this context, the sand smelt (*Atherina boyeri*) which is common in the Mediterranean and its adjacent seas as well as the Northeast Atlantic (from the Azores to the Northwest coast of Scotland). The Euryhaline fish is small and short-lived; it lives in coastal and estuarine waters and rarely inland waters. The stock of sand smelt species has also been cultivated in fresh water lakes. It is a good and a rich source of protein, which makes it digestible as well as being a good source of polyunsaturated fatty acids, vitamins, and minerals for healthy diet (Bartulovic et al., 2004). Adding fish to snacks in various levels is considered as a way of its fortification which causes increase in the fat, protein and ash components, it has a good effect on nutritional value (Nawaz et al., 2019). Meanwhile, Izci et al. (2011) found that the chemical composition of *Atherina boyeri* Risso 1810 fresh fish has 79.53% moisture, 16.42% crude protein, 2.05% crude fat ; 2.03% ash 1.42% C18:3, 8.82% C20:5, 2.28% C22:5 as omega -3 fatty acids, 6.52 pH, 17.4 mg/100g total volatile basic nitrogen, 0.33 µg malonaldehyde/g, 5.64 log cfu/g total plate count and finally 0.89 log cfu/g yeasts and molds.
Therefore, the objective of the present work was to evaluate the best technological formulation in terms of sensorial acceptance, chemical composition, nutritional value, and microbiological quality, also it introduced snacks that have different levels of sand smelt paste as a substitution of the cereal flour.

MATERIALS AND METHODS

Materials
The sand smelt (*Atherina boyeri*) was purchased from Abou Qeer fish market, Alexandria, Egypt. The other ingredients such as oat, corn flour, and corn starch, mixture of fish spices, salt, sucrose and baking powder were purchased from Alexandria market, Egypt.

Methods

The fish preparation
Fish was prepared following the procedure of Abou-Taleb *et al.* (2019) that can be summarized as follows:- The heads and internal organs were thrown, and their trunk was minced with the back bone. The minced fish (MF) was divided into two parts. The first part was used for chemical and microbiological analysis as a raw fish, and the second part was for used for different treatments. Minced sand smelt was added at different ratios (0%, 20% and 30%) and used for baked (BC, B20 and B30) and pre-cooked baked (SC, S20 and S30) as given in (Table 1).

The snacks preparation
The minced fish was mixed with oat flour, corn flour, starch, spices, salt, sucrose, baking powder and water, manually until homogeneous dough was obtained. The dough of each treatment was divided into two parts. The first part was spreaded and cut into triangular shapes then baked at 120°C for 15 min to produce the baked fish snacks. The second part was shaped into rolls around wooden stick and packed in thermal polyethylene at cylinder form and covered with aluminum foil, then soaked in boiled water for 15 min, then cooled in a refrigerator at 4°C for 20 min. The wrapper was removed and the roll was cut to fine circles by knife. Subsequently, these circles were roasted at 120°C for 15 min to prepare the pre-cooked baked fish snacks. All products were kept within plastic cases at room temperature (25±2°C) until analysis.

Sensory analysis
Fish snack samples were presented at room temperature under white lighting to ten trained panelists for sensory evaluation based on colour, flavour, taste, crunchiness, and overall acceptability using a nine-point hedonic scale varying from «extremely dislike 1» to «extremely like 9», according to Stone & Sidel (1993).

Chemical composition
The chemical composition of all fish snack samples were determined as described in the AOAC (2007) including moisture, crude protein, other extract, ash, and carbohydrates. Crude fat was determined according to Bligh and Dyer (1959) and carbohydrates was calculated by difference. Energy was determined using the following equation; - Energy = (9× Fat content) + (4× Protein content) + (4× Carbohydrate content).

Minerals analysis
Minerals (zinc, iron, magnesium, manganese, calcium, potassium, sodium, copper, selenium and phosphore) contents were determined following the procedures given in the AOAC (2007) using an

Table 1: The ingredients percentage of baked and pre-cooked baked fish snack formulae

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>BC SC or</th>
<th>B20 or</th>
<th>B30 or</th>
<th>S30</th>
<th>Ingredients</th>
<th>BC SC or</th>
<th>B20 or</th>
<th>B30 or</th>
<th>S30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minced fish (MF)</td>
<td>0</td>
<td>20</td>
<td>30</td>
<td></td>
<td>Starch</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Oat flour</td>
<td>40</td>
<td>30</td>
<td>25</td>
<td></td>
<td>Spices</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Corn flour</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td></td>
<td>Salt</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Sucrose</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
<td>Water</td>
<td>25</td>
<td>15</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Backing powder</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
inductively coupled plasma atomic emission spectroscopy (ICP-OES).

Thiobarbituric acid reactive substances (TBARs), Total volatile base nitrogen (TVB-N) and Microbiological analysis

The baked and pre-cooked baked fish snacks were stored in plastic packages made from polyethylene, at room temperature (25±2°C) and evaluated at zero time and after 30, 60, and 90 days of storage (T₀, T₁, T₂, and T₃ respectively). Thiobarbituric acid reactive substances (TBARS) were evaluated according to Tarladgis et al. (1960) and total volatile basic nitrogen (TVB-N) was measured according to Antonacopoulos and Vyncke (1989) monthly for 4 months, which were used as parameters of oxidative stability. The analysis of total count, as well as, molds and yeasts counts were determined monthly for 4 months, according to Downes and Ito (2001).

**Biological analysis**

Basal diet consisted of 70% corn starch, 15% casein, 5% corn oil, 4% salt mixture, 1% vitamin mixture and 5% cellulose as given in the (AOAC, 2007). Experimental animal design:- Male Albino rats (24 rats) were individually housed in aerated cages under hygienic conditions and feed on basal diet for one week for adaptation. After this week all rats were weighed and divided to seven groups of eight rats for each. The seven groups were divided as follow:- the first group was employed as the casein group which was fed on the basal diet, the other six groups were BC, B20, B30, SC, S20 and S30, respectively and the experiment was carried out for one month (30 days) through which it was determined the consumed food and the amount of feces and urine regularly, then later the body weight gain, protein consumed, the protein efficiency ratio (PER), corrected protein efficiency ratio (CPER), net protein ratio (NPR), the true digestibility (TD), net protein utilization (NPU) and biological value (BV) were calculated according to Ranhotra et al. (1993) using the following equations :-

\[
TD = \frac{N \text{ absorbed} (I - F)}{N \text{ intake}}, \quad NPU = \frac{N \text{ retained} (I - F - U)}{N \text{ intake}}, \quad BV = \frac{N \text{ retained}}{N \text{ absorbed}}, \quad \text{PER} = \frac{\text{Weight gain of test group/ Protein consumed}}, \]

\[
\text{CPER} = \text{PER} \times \frac{2.5}{\text{PER for casein}}, \quad \text{NPR} = \frac{(\text{Weight gain of test group} + \text{weight loss of control group})}{\text{Protein consumed by test group}}.
\]

Where: I = intake nitrogen, F = Fecal nitrogen, U = urinary nitrogen.

**Statistical analysis**

Data were subjected to one and two way analysis of variance (ANOVA) and Duncan’s multiple range test to separate the treatment means as outlined by Steel and Torrie 1980.

**RESULTS AND DISCUSSION**

The appearance of fish snacks samples are showing in Fig (1) and the data of sensorial evaluation are given in Table (2). The results showed that there are significant differences at P≤0.05 between sensory properties of different treatments of fish snacks. The highest scores were found in control samples (BC & SC) which were free from minced sand smelt meat but the other samples showed sensorial values ranging from 8.40 to 6.90 for colour,
Table 2: Sensory properties of the baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Storage period (month)</th>
<th>Mean treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>8.60±0.92</td>
<td>8.45±0.87</td>
</tr>
<tr>
<td>B20</td>
<td>8.35±0.95</td>
<td>8.30±0.84</td>
</tr>
<tr>
<td>B30</td>
<td>8.00±0.70</td>
<td>7.80±0.82</td>
</tr>
<tr>
<td>SC</td>
<td>8.40±1.40</td>
<td>7.60±0.70</td>
</tr>
<tr>
<td>S20</td>
<td>7.80±0.84</td>
<td>7.50±0.88</td>
</tr>
<tr>
<td>S30</td>
<td>7.50±1.05</td>
<td>7.30±0.97</td>
</tr>
<tr>
<td>Mean</td>
<td>8.11a</td>
<td>7.83b</td>
</tr>
<tr>
<td>Crunchiness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>8.75±0.67</td>
<td>8.55±0.56</td>
</tr>
<tr>
<td>B20</td>
<td>8.50±0.52</td>
<td>8.25±1.00</td>
</tr>
<tr>
<td>B30</td>
<td>8.50±0.48</td>
<td>8.25±0.56</td>
</tr>
<tr>
<td>SC</td>
<td>8.65±0.32</td>
<td>8.35±0.85</td>
</tr>
<tr>
<td>S20</td>
<td>8.45±0.87</td>
<td>8.30±0.74</td>
</tr>
<tr>
<td>S30</td>
<td>8.30±0.84</td>
<td>8.05±0.79</td>
</tr>
<tr>
<td>Mean</td>
<td>8.53a</td>
<td>8.29b</td>
</tr>
<tr>
<td>Flavor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>7.50±0.52</td>
<td>7.30±0.59</td>
</tr>
<tr>
<td>B20</td>
<td>7.60±0.48</td>
<td>7.40±8.5</td>
</tr>
<tr>
<td>B30</td>
<td>7.80±0.85</td>
<td>7.65±0.97</td>
</tr>
<tr>
<td>SC</td>
<td>7.60±0.67</td>
<td>7.45±0.53</td>
</tr>
<tr>
<td>S20</td>
<td>8.20±0.74</td>
<td>8.10±0.47</td>
</tr>
<tr>
<td>S30</td>
<td>8.30±0.96</td>
<td>8.20±0.54</td>
</tr>
<tr>
<td>Mean</td>
<td>7.83a</td>
<td>7.68a</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>8.50±0.79</td>
<td>8.30±0.88</td>
</tr>
<tr>
<td>B20</td>
<td>8.30±0.67</td>
<td>8.00±0.95</td>
</tr>
<tr>
<td>B30</td>
<td>8.10±0.84</td>
<td>7.80±0.70</td>
</tr>
<tr>
<td>SC</td>
<td>8.20±0.97</td>
<td>8.00±1.05</td>
</tr>
<tr>
<td>S20</td>
<td>8.00±0.81</td>
<td>7.70±0.88</td>
</tr>
<tr>
<td>S30</td>
<td>7.80±0.84</td>
<td>7.40±40</td>
</tr>
<tr>
<td>Mean</td>
<td>8.15a</td>
<td>7.87b</td>
</tr>
</tbody>
</table>

The same letter in a row or column is not significantly different at $P \leq 0.05$.

BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.

8.50 to 6.70 for crunchiness and 8.30 to 6.70 for overall acceptability during storage period. It was found a noticed significant gradual decrease ($P \leq 0.05$) in the score of different sensory properties during the storage duration. This may be due to the high ratios of fish snack and thereby moisture which has a high effect on the crunchiness parameter scores of fish samples rather than the free fish snacks control. Also, the dark colour of fish tissues played a negative role in the colour values of samples but still in the acceptance zone. The results of...
flavour as a prime sensorial parameter, the results showed that S30 exhibited significantly ($P \leq 0.05$) the highest main flavor value through the storage time (8.06) followed by S20, B30, B20, SC while BC (7.49, 7.51, 7.16, 7.10 & 7.00, respectively) were tailed behind. Ganesan et al. (2017) found that the control extruded sample was more preferred by the panelists compared with the other products which contained Sardine or Lizard fish powder at ratios of (10, 20 and 30%), the control snacks had bright yellow colour while adding of fish powder caused a change in colour along with fishy taste and odor. Moreover, Netto et al. (2014) explained that snacks which contain 40% of minced Nile tilapia had the lowest scores for colour and texture compared with that, contain 20% and 30% due to the darker colour which was emphasized during baking or roasting. Neiva et al. (2011) reported that all panelists agreed to purchase both the fried and the microwave baked crackers, which their overall acceptability ranged from 6 (little liked) to 9 (extremely liked). On the other hand, İzci et al. (2011) stated that overall acceptability values for fish snacks prepared from sand smelt decreased significantly ($P \leq 0.05$) when extending the storage time.

Each chemical composition of the different samples of snacks recorded significant differences at $P \leq 0.05$ in both treatments and their formulae. The moisture contents ranged from 3.19% to 4.28% for the baked samples and from 3.96% to 5.28% for the pre-cooked baked ones. Therefore the pre-cooked baked snacks had moisture content significantly ($P \leq 0.05$) higher than the baked ones due to their exposure to the water vapor through the pre-cooked treatment. Moreover, the crude protein contents ranged from 8.33% to 15.57% for baked snacks and from 7.27% to 14.26% for the pre-cooked baked snacks, in agreement with the values of FAO (2001) which recommends that the non-fried snacks should contain at least 12% crude protein. The percentage of protein significantly at $P \leq 0.05$ was higher in the baked samples than the pre-cooked baked snacks, this may be referred to the step of pre-cooking. The same results were noted of the percentage regarding the crude ether extract which was significantly ($P \leq 0.05$) higher in the baked samples (7.19%, 14.04% and 14.77%) than the pre-cooked baked ones (5.96%, 9.58% and 13.60%). It was obvious that both of crude protein and ether extract content increased with increasing the percentage of minced fish in the formulae. On the other hand, ash, carbohydrates and energy values ranged from 7.40% to 7.84%, 57.54% to 74.43% and 395.75 Kcal/100g to 425.37Kcal/100g for baked samples and from 7.47% to 6.55%, 62.31% to 77.34% and 392.08 Kcal/100g to 410.68 Kcal/100g for pre-cooked baked snacks, respectively. Ash and energy values increased by increasing the ratio of minced fish in the samples. In similar product, İzci et al. (2011) who produced pre-fried chips from sand smelt (Atherina boyeri) found that the gross chemical composition was 6.24% moisture, 11.68% crude protein, 5.24% crude fat and 3.22% ash.

### Table 3: Gross chemical composition (%) of the baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C).

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture (±SD)</th>
<th>Crude protein (N×6.25) (±SD)</th>
<th>Crude ether extract (±SD)</th>
<th>Ash (±SD)</th>
<th>Carbohydrates (±SD)</th>
<th>Energy value (Kcal/100g) (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>3.19±0.021</td>
<td>8.33±0.280</td>
<td>7.19±0.015</td>
<td>7.40±0.125</td>
<td>73.89±0.180</td>
<td>395.75±0.137</td>
</tr>
<tr>
<td>B20</td>
<td>4.07±0.036</td>
<td>12.41±0.331</td>
<td>10.04±0.010</td>
<td>7.64±0.036</td>
<td>65.84±0.157</td>
<td>423.36±0.751</td>
</tr>
<tr>
<td>B30</td>
<td>4.28±0.036</td>
<td>15.57±0.282</td>
<td>14.77±0.232</td>
<td>7.84±0.125</td>
<td>57.54±0.167</td>
<td>425.37±2.58</td>
</tr>
<tr>
<td>SC</td>
<td>3.96±0.182</td>
<td>7.27±0.165</td>
<td>5.96±0.006</td>
<td>5.47±0.020</td>
<td>77.34±0.360</td>
<td>392.08±1.25</td>
</tr>
<tr>
<td>S20</td>
<td>4.37±0.051</td>
<td>10.88±0.219</td>
<td>9.58±0.367</td>
<td>5.94±0.190</td>
<td>69.23±0.292</td>
<td>306.66±0.412</td>
</tr>
<tr>
<td>S30</td>
<td>5.28±0.105</td>
<td>14.26±0.315</td>
<td>13.60±0.087</td>
<td>6.55±0.382</td>
<td>60.31±0.267</td>
<td>410.68±1.59</td>
</tr>
</tbody>
</table>

The same letter in a column is not significantly different at $P \leq 0.05$. BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
Meanwhile, Shaviklo et al. (2011a) found that the protein and moisture of corn snacks fortified with 15% minced carp or minced trout or 7% freeze dried Saithe protein was ranged from 9.3 to 9.8% compared with 6.5% in the control snacks, while moisture content ranged from 2.5 to 2.8%. Controlling the moisture content in snacks is necessary to optimize the quality of the final products, (Nurul et al., 2010). These results are in accordance with those of Shaviklo et al. (2011) with respect to protein, moisture, fat and ash contents in fortified corn snacks (FCS) at 7% fish protein powder being 11.8%, 2.3%, 3.2% and 3.1%, respectively. On the other hand, King (2002) indicated that protein, fat and ash contents elevated with the rising ratio of minced big-eye fish from 40% to 60% in production of fried crackers, protein ranged from (8.3-16.9%), fat ranged from (19.8-21.4%) and moisture ranged from (3.0-4.0%). Fish ball products were produced from either remains of pike-perch (Sander lucioperca) or boiled minced carp (Cyprinus carpio) and cracks from tench (Tinca tinca), these products were found to contain 7.40%, 7.89% and 7.69% moisture, 11.38%, 15.34% and 10.26% crude protein, 6.76%, 6.98% and 6.60% crude fat and 2.53%, 1.09% and 4.15% crude ash (Yanar and Fenercioğlu, 1999 and Ünlüsayin et al., 2002). Finally, Shaltout (1993) showed that the moisture, protein, fat, ash and carbohydrates of dried chip-like fish crackers (40% maize-40% wheat-20% cod) were 7.42%, 17.5%, 1.17%, 3.65% and 70.26%, respectively.

Results given in Table (4) indicated that the prepared fish snacks contained high amounts of different minerals such as phosphorus (591.58-1744.77 mg/100g), potassium (473.93-3838.10 mg/100g), sodium (3011.39 - 4227.54 mg/100g), calcium (134.03-564.77 mg/100g) and magnesium (164.33-382.27 mg/100g) and moderate amounts of iron (8.23-21.11 mg/100g), zinc (2.84-5.08 mg/100g) and manganese (1.75-3.58 mg/100g) and small amount of copper (0.587-1.54 mg/100g) and selenium (0.623-0.990 mg/100g). It was obvious that the minerals content of baked samples were higher than those of pre-cooked baked ones. Finally the content of minerals increased with increasing ratio of fish meat in snacks. Goes et al. (2015) produced snacks with 9% finless tilapia carcasses (Oreochromis niloticus), tuna torsos (Thunnus spp.) without fins (with bones, skin and muscles, from non-standard fish classification), salmon finless carcasses (Salmo salar) and sardine tails (Sardinella brasiliensis). It was found that the values of calcium, phosphorus and iron were as follows; 630 mg/100g, 520 mg/100g, 120 mg/100g and 470 mg/100g, 460 mg/100g, 390 mg/100g, 200 mg/100g and 370 mg/100g and 14.84 mg/100g, 15.61 mg/100g, 20.94 mg/100g and 18.41 mg/100g, respectively. Also, Justen et al. (2011) found that snacks fortified with 9% smoked tilapia had levels of 0.344 mg/100g, 0.544 mg/100g and 9.08 mg/100g.

Table 4: Minerals content (mg/100g) of the baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C)

<table>
<thead>
<tr>
<th>Elements</th>
<th>Samples (mg/100g)</th>
<th>BC</th>
<th>B20</th>
<th>B30</th>
<th>SC</th>
<th>S20</th>
<th>S30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphore</td>
<td></td>
<td>1033.53</td>
<td>1239.41</td>
<td>1744.77</td>
<td>448.31</td>
<td>591.58</td>
<td>1159.14</td>
</tr>
<tr>
<td>Sodium</td>
<td></td>
<td>1428.49</td>
<td>3011.39</td>
<td>3838.10</td>
<td>594.40</td>
<td>3325.71</td>
<td>4227.54</td>
</tr>
<tr>
<td>Potassium</td>
<td></td>
<td>967.45</td>
<td>982.59</td>
<td>1464.51</td>
<td>407.10</td>
<td>473.93</td>
<td>984.59</td>
</tr>
<tr>
<td>Calcium</td>
<td></td>
<td>379.17</td>
<td>460.70</td>
<td>564.77</td>
<td>101.83</td>
<td>134.03</td>
<td>189.73</td>
</tr>
<tr>
<td>Magnesium</td>
<td></td>
<td>131.58</td>
<td>236.66</td>
<td>382.27</td>
<td>84.27</td>
<td>198.34</td>
<td>164.33</td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td>10.03</td>
<td>11.88</td>
<td>21.11</td>
<td>5.42</td>
<td>8.23</td>
<td>10.70</td>
</tr>
<tr>
<td>Zinc</td>
<td></td>
<td>4.46</td>
<td>4.63</td>
<td>5.08</td>
<td>2.52</td>
<td>2.84</td>
<td>5.04</td>
</tr>
<tr>
<td>Manganese</td>
<td></td>
<td>2.69</td>
<td>3.35</td>
<td>3.58</td>
<td>2.28</td>
<td>1.75</td>
<td>3.33</td>
</tr>
<tr>
<td>Copper</td>
<td></td>
<td>0.750</td>
<td>1.00</td>
<td>1.54</td>
<td>0.364</td>
<td>0.587</td>
<td>0.841</td>
</tr>
<tr>
<td>Selenium</td>
<td></td>
<td>0.817</td>
<td>0.940</td>
<td>0.990</td>
<td>0.112</td>
<td>0.623</td>
<td>0.867</td>
</tr>
</tbody>
</table>

BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
mg/100g, for phosphorus, calcium and iron respectively. Eventually, Sarcinelli et al. (2007) stated that the addition of fish meat or meal was effective in supporting snacks with calcium, phosphorus, and iron. For instance, the iron content in snacks with fish meal and meat, was higher than that in pork, chicken thighs or bovine loin (0.77, 0.99 or 1.58 mg/100 g) chicken thighs (0.99 mg/100 g) and bovine loin (1.58 mg/100 g).

The results given in Table (5) showed that the oxidative stability and fish snacks quality (TBA and TVB-N) of storage samples for four months were tabulated from zero to the fourth month and the results showed that these values were the lowest at zero time for both treatments and increased gradually and significantly at P≤0.05 with the extending of storage time and increasing the ratio of minced fish. The baked snacks had TBA values were ranged from 1.05 mg MAD/Kg to 1.80 mg MAD/Kg for the mean treatment and they ranged from 8.03 mg MAD/Kg to 15.65 mg MAD/Kg for mean time. Also, the TVB-N values ranged from 4.43 mg N/100g to 16.97 mg N/100g for mean treatment and these values ranged from 8.03 mg N/100g to 15.65 mg N/100g which indicated that the storage time has more pronounced effect on oxidative stability than that of the treatment or the ratio of minced fish in sand smelt snacks. Results given in this study were with those of Mahmoud et al. (2016) who showed that TBA value as optical density (O.D) of raw fish chips ranged between 0.02 µg MAD/g and 0.06 µg MAD/g, while TVB-N ranged from 11.07mg N/100g to 11.72 mg N/100g. Also, Izci et al. (2011) observed that the TBA values had an irregularity increase from 0.33 in raw sand smelt fish to 0.37 in pre-fried chips and reached to 0.48µg MAD/g) in the third month of storage at -18°C. However TVB-N was found to increase from 17.14 in raw sand smelt to 19.75 mg N/100g in pre-fried and significant at P≤0.05 increase occurred during frozen storage until reached to 22.46 after 6 months of storage. Moreover, Neiva et al. (2011) reported that the concentration of TBARS is widely used

Table 5: Thiobarbituric acid values (TBA mg MAD/Kg) and Total volatile base nitrogen values (TVB-N mg N/100g) of the baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Storage period (month)</th>
<th>Mean treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TBA (mg MAD/kg)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>0.600±0.05</td>
<td>0.740±0.05</td>
</tr>
<tr>
<td>B20</td>
<td>0.920±0.04</td>
<td>1.06±0.02</td>
</tr>
<tr>
<td>B30</td>
<td>1.15±0.28</td>
<td>1.38±0.06</td>
</tr>
<tr>
<td>SC</td>
<td>0.660±0.06</td>
<td>0.880±0.06</td>
</tr>
<tr>
<td>S20</td>
<td>1.09±0.18</td>
<td>1.27±0.06</td>
</tr>
<tr>
<td>S30</td>
<td>1.33±0.05</td>
<td>1.52±0.02</td>
</tr>
<tr>
<td>Mean Time</td>
<td>0.95 e</td>
<td>1.14 d</td>
</tr>
<tr>
<td>TVB-N (mg N/100g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>3.38±0.31</td>
<td>3.45±0.13</td>
</tr>
<tr>
<td>B20</td>
<td>9.56±0.22</td>
<td>10.24±0.22</td>
</tr>
<tr>
<td>B30</td>
<td>9.95±0.06</td>
<td>12.34±0.19</td>
</tr>
<tr>
<td>SC</td>
<td>5.19±0.07</td>
<td>5.50±0.31</td>
</tr>
<tr>
<td>S20</td>
<td>9.94±0.08</td>
<td>13.03±0.43</td>
</tr>
<tr>
<td>S30</td>
<td>10.18±0.09</td>
<td>14.71±0.13</td>
</tr>
<tr>
<td>Mean Time</td>
<td>8.03 e</td>
<td>9.88 d</td>
</tr>
</tbody>
</table>

The same letter in a row or column is not significantly different at P ≤ 0.05.

BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
as an indicator of the degree of lipid oxidation. However, the TBARs methodology lacks specificity since thiobarbituric acid can react with several different carbonyl compounds, which may explain the observed difference. The TVBN is an indicator of fish quality and freshness. Increased levels of TVBN indicate degradation of freshness and spoilage. Neiva et al. (2011) made dried non expanded fish crackers and found slight decrease in TBARs value from 1.14 mg MAD/Kg at zero time of storage to 1.19 mg MAD/Kg after 180 days of storage while the TVB-N value had a significant ($P<0.05$) increase from 1.54 mg N/100g to 18.16 mg N/100g and there was no significant at $P<0.05$ different after a storage period of 180 days (17.25 mg N /100 g), the TBARs value was found to decrease slightly at the end of the storage period.

The results of the microbiology test of the products at zero time and during storage time are given in Table (6). The data revealed that the total bacterial counts were non-significantly increasing for the baked samples and a significant increase was figured at the counts between the pre-cooked baked ones although the total counts in pre-cooked baked snacks being lower than the baked ones. On the other hand, the total counts were significantly ($P<0.05$) increasing by prolonging the storage period. As for the yeasts and molds counts, they were increased significantly ($P<0.05$) for both treatments and non-significantly ($P<0.05$) by time in the first two month then they increased significant-

<table>
<thead>
<tr>
<th>Samples</th>
<th>Storage period (month)</th>
<th>Mean treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total bacterial count (log cfu/g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>1.48±0.01</td>
<td>1.48±0.02</td>
</tr>
<tr>
<td>B20</td>
<td>1.48±0.05</td>
<td>1.48±0.06</td>
</tr>
<tr>
<td>B30</td>
<td>1.48±0.10</td>
<td>1.48±0.06</td>
</tr>
<tr>
<td>SC</td>
<td>1.48±0.01</td>
<td>1.48±0.02</td>
</tr>
<tr>
<td>S20</td>
<td>1.48±0.01</td>
<td>1.48±0.06</td>
</tr>
<tr>
<td>S30</td>
<td>1.48±0.01</td>
<td>1.48±0.01</td>
</tr>
<tr>
<td>Mean Time</td>
<td>1.48&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.48&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

| Yeasts & molds count (log cfu/g) |
| BC      | 1.00±0.01  | 1.00±0.03  | 1.00±0.06  | 2.10±0.06  | 2.43±0.06  | 1.51<sup>c</sup> |
| B20     | 1.00±0.01  | 1.00±0.03  | 1.00±0.40  | 2.31±0.11  | 2.53±0.07  | 1.57<sup>b</sup> |
| B30     | 1.00±0.00  | 1.00±0.02  | 1.00±0.00  | 2.40±0.03  | 2.63±0.05  | 1.61<sup>a</sup> |
| SC      | 1.00±0.01  | 1.00±0.01  | 1.00±0.00  | 1.00±0.04  | 2.11±0.11  | 1.22<sup>c</sup> |
| S20     | 1.00±0.01  | 1.00±0.01  | 1.00±0.00  | 1.00±0.01  | 2.24±0.10  | 1.25<sup>e</sup> |
| S30     | 1.00±0.01  | 1.00±0.01  | 1.00±0.01  | 1.00±0.01  | 2.36±0.08  | 1.27<sup>d</sup> |
| Mean Time | 1.00<sup>c</sup> | 1.00<sup>c</sup> | 1.00<sup>c</sup> | 1.63<sup>b</sup> | 2.38<sup>a</sup> | LSD=0.033 |

The same letter in a row or column is not significantly different at $P \leq 0.05$. BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
ly (P≤0.05) at the end of the storage period. However, the results showed that all the counts were in the safe limits where they ranged from 1.48 log cfu/g to 3.18 log cfu/g (after 120 days of storage) and from 1.00 log cfu/g to 2.63 log cfu/g for total count of yeast and molds counts, respectively. Furthermore, Mahmoud, et al. (2016) reported that the total bacterial count (TBC) of common carp fish chips was found to increase from 1.90 log cfu/g at zero time to 2.01 log cfu/g at the end of storage period. Ike, et al. (2015) stated that the fungal count was (1.2±0.90) x10³cfu/g in fish pies sold in Nigeria. Also, the count of microorganisms at zero time was 4.61 log cfu/g, 4.62 log cfu/g and 4.50 log cfu/g, respectively in fish fingers made from different species of fish (Pseudorhombus. pilchardus, Merlangius merlangus and Saurida lucioperca).

Biological quality was determined for all samples throw feeding study at animal laboratory for one month, the results showed that there were significant difference within test groups and casein group. The value of food intake was found the highest in group S30 (204.69g/30days) followed by casein group (188.48g/30days) then B30 (174.33g/30days). The second tested parameter was body weight gain, it was 81.51g for casein group followed by B20, B30 then S30 which their recorded body weight were 47.03g/30 days, 40.63g/days and 35.52g/30days along the experiment period. There was no significant differences between B20, BC and SC groups for the protein efficiency ratio (PER) or the corrected protein efficiency ratio (CPER) but casein group possessed the highest PER and CPER values (5.77 and 2.50, respectively) and S30 exhibited the lowest values (1.22 and 0.528, respectively). The net protein ratio (NPR) had significantly (P≤0.05) the highest value (7.17) for casein group and where the lowest value (1.90) was

### Table 7: Biological quality of the baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Casein</th>
<th>BC</th>
<th>B20</th>
<th>B30</th>
<th>SC</th>
<th>S20</th>
<th>S30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food intake (g/30 days)</td>
<td>188.48±7.77b</td>
<td>136.73±3.53d</td>
<td>160.71±8.15c</td>
<td>174.33±3.93c</td>
<td>98.32±2.57c</td>
<td>113.05±9.05c</td>
<td>204.69±5.80c</td>
</tr>
<tr>
<td>Body weight gain (g/30 days)</td>
<td>81.51±1.13c</td>
<td>26.80±1.00d</td>
<td>47.03±0.75b</td>
<td>40.63±1.87c</td>
<td>16.72±0.333c</td>
<td>22.30±1.01#</td>
<td>35.52±1.40d</td>
</tr>
<tr>
<td>Protein consumed (g/30 days)</td>
<td>14.14±0.082d</td>
<td>11.39±0.072e</td>
<td>19.94±0.11c</td>
<td>27.14±0.055b</td>
<td>7.15±0.050c</td>
<td>12.30±0.040c</td>
<td>29.18±0.067c</td>
</tr>
<tr>
<td>Protein efficiency ratio (PER)</td>
<td>5.77±0.011a</td>
<td>2.35±0.004b</td>
<td>2.36±0.036b</td>
<td>1.50±0.064d</td>
<td>2.34±0.005b</td>
<td>1.81±0.026c</td>
<td>1.22±0.057c</td>
</tr>
<tr>
<td>Corrected protein efficiency ratio (CPER)</td>
<td>2.50±0.020c</td>
<td>1.02±0.020b</td>
<td>1.02±0.011b</td>
<td>0.650±0.005d</td>
<td>1.01±0.005b</td>
<td>0.784±0.010c</td>
<td>0.528±0.032c</td>
</tr>
<tr>
<td>Net protein ratio (NPR)</td>
<td>7.17±0.027a</td>
<td>4.11±0.007c</td>
<td>3.36±0.021d</td>
<td>2.23±0.004c</td>
<td>5.14±0.034b</td>
<td>3.44±0.010d</td>
<td>1.90±0.010f</td>
</tr>
<tr>
<td>True digestibility (TD%)</td>
<td>87.25±0.574b</td>
<td>77.53±0.257c</td>
<td>78.72±0.078d</td>
<td>79.96±1.35c</td>
<td>59.92±0.258b</td>
<td>74.00±0.055c</td>
<td>88.52±0.119f</td>
</tr>
<tr>
<td>Net protein utilization (NPU%)</td>
<td>80.92±0.110b</td>
<td>65.37±0.107c</td>
<td>69.25±0.218c</td>
<td>74.90±0.065b</td>
<td>45.55±0.061#</td>
<td>69.94±0.060d</td>
<td>85.95±0.050c</td>
</tr>
<tr>
<td>Biological value (BV%)</td>
<td>92.89±0.070a</td>
<td>84.40±0.102c</td>
<td>88.05±0.150b</td>
<td>93.66±0.078c</td>
<td>75.99±0.071e</td>
<td>94.52±0.116b</td>
<td>97.09±0.081c</td>
</tr>
</tbody>
</table>

*The same letter in a row is not significantly different at P ≤ 0.05.*

BC and SC samples are free from minced fish, B20 and S20 samples contained 20% minced fish and B30 and S30 samples contained 30% minced fish.
recorded for S30 group. The true digestibility values were 88.52%, 87.25% and 79.96% for S30, casein and B30 groups, respectively. On the other hand, the lowest value of true digestibility (TD) was 59.92% for SC group. At the same manner, the net protein utilization (NPU) was significantly \( P<0.05 \) the lowest for SC (45.55%), and the highest at S30 (85.95%) followed by casein group (80.92%). Finally, the biological value BV was the highest for S30 (97.09%) followed by S20 and S30 (94.52% and 93.66%), respectively. Hussain et al. (2007) showed that net protein utilization, the protein efficiency ratio, biological value and true digestibility in traditional weaning food called Khitchri contained fish protein concentrates in various ratios (2.5%, 5% and 10%) were increased with increasing the previous mentioned concentrations. It is worth to mention that, this method of fortification is an ideal way for the weaning food fortification.

CONCLUSION

Based on the results given in this study, it should be concluded that the formulated snacks are easy to make and could be widely accepted. The overall concept of making these snacks provided wide range of snacks rich in good protein, healthy lipid, high calories and several minerals as well as high oxidative stability. Also, these snacks are considered as value added as a source of essential nutrients in good nutrition to our daily diets. Finally, similarities of these snacks can be used as alternatives and special food for people who suffer from protein deficiency.

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تحضير وتقييم وجبات معذبة خفيفة وجديدة

(Atherina boyeri)

الملخص العربي

سلط هذا البحث الضوء على وجبات غذائية خفيفة. تم تحضيرها باستخدام سمك اسماك البساريا (Atherina boyeri) في منتجات وجبات غذائية خفيفة سمنية مخبوزة ومخبوزة مسبقة الطهي. أظهرت النتائج عن وجود كميات أعلى من مضادات كل المعادن في العينات المخبوزة مقارنة بالعينات المخبوزة مسبقة الطهي. وجد أن هذه قيم مضادات الثيوبتوبيريك والقواعد النيتروجينية الطية في العينات المخبوزة. وأظهرت النتائج أيضاً استخدام اسماك المفرومة المسبقة الطهي في منتجات وجبات غذائية خفيفة المحتوية على وجبات الغذائي الخفيفة والمخبوزة مسبقة الطهي المحتوى 720/100 سمك. وكانت نسبة كفاءة البروتين ونسبة كفاءة البروتين المصححة هي الأعلى في حمية الكازين ثم الوجبات الغذائية الخفيفة المخبوزة والمخبوزة مسبقة الطهي الكنترول وBC SC المختبرية في المجاميع 30 الحالة الأولية على التوالي. وكانت نسبتة الببتيدية 9% 9% و7% 8% 7% في المجاميع B30 والكازين على التوالي. بينما تراوحت هذه القيم من 19% 8% إلى 6% 5% في باقي العينات.