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

Hoda, H. Emara[1], Osheba, A. S.[2] & Rehab A. Mostafa[3]

(1) Meat and Fish Technol. Res. Dept., Food Technol. Res. Inst., Agric. Research Center, El-Sabahia, Alexandria, Egypt.

(2) Meat and Fish Technol. Res. Dept., Food Technol. Res. Inst., Agric. Research Center, Giza, Egypt.

(3) Food Technology Research Institute. Agricultural Research Center ARC, Giza, Egypt

Received: 8 November, 2022 ***Revised: 6 December, 2022*** ***Accepted: 20 December, 2022***

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 contained20% 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% $C_{18:3}$, 8.82% $C_{20:5}$, 2.28% $C_{22:5}$ 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 fl our.

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^{o}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^{o}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, cupper, 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

Ingredients	Samples (%)			Ingredients	Samples (%)		
	BC or SC	B20 or S20	B30 or S30		BC or SC	B20 or S20	B30 or S30
Minced fish (MF)	0	20	30	Starch	7	7	7
Oat flour	40	30	25	Spices	5	5	5
Corn flour	18	18	18	Salt	2.5	2.5	2.5
Sucrose	1.5	1.5	1.5	Water	25	15	10
Backing powder	1.0	1.0	1.0	-	-	-	-

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 (T_o,T_1, T_2 and T_3 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 = N absorbed (I- F) / N intake, NPU = N retained (I - F -U)/ N intake, BV = N retained/ N absorbed, PER = Weight gain of test group/ Protein consumed,

CPER = PER × (2.5/ PER for casein), NPR= (Weight gain of test group + weight loss of control group) / 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,

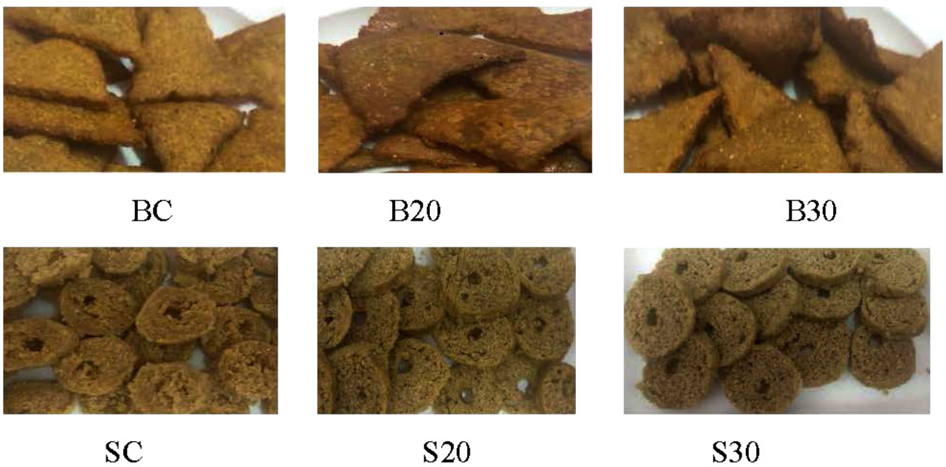

Fig (1). The appearance of baked (BC, B20 and B30) and the pre-cooked baked (SC, S20 and S30) fish snack samples stored at room temperature (25±2°C)

Table 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)

Samples	Storage period (month)					Mean treatment
	0	1	2	3	4	
			Colour			
BC	8.60±0.92	8.45±0.87	8.30±0.95	8.15±0.94	7.80±0.70	8.26[a]
B20	8.35±0.95	8.30±0.84	7.85±1.05	7.40±0.95	7.20±0.87	7.82[b]
B30	8.00±0.70	7.80±0.82	7.30±0.70	7.30±0.92	7.00±0.47	7.48[c]
SC	8.40±1.40	7.60±0.70	7.40±0.52	7.20±0.95	6.90±0.70	7.50[c]
S20	7.80±0.84	7.50±0.88	7.30±0.85	7.00±0.94	6.90±0.88	7.30[cd]
S30	7.50±1.05	7.30±0.97	7.20±0.84	7.00±0.94	6.90±0.78	7.18[d]
Mean time	8.11[a]	7.83[b]	7.56[c]	7.34[cd]	7.12[d]	LSD=0.57
			Crunchiness			
BC	8.75±0.67	8.55±0.56	8.35±0.74	8.00±0.52	8.50±0.56	8.43[a]
B20	8.50±0.52	8.25±1.00	7.80±0.67	7.40±0.82	7.20±0.85	7.83[c]
B30	8.50±0.48	8.25±0.56	7.60±0.47	7.40±0.63	6.80±0.52	7.71[cd]
SC	8.65±0.32	8.35±0.85	8.10±0.92	7.90±0.70	7.80±0.94	8.16[b]
S20	8.45±0.87	8.30±0.74	7.85±0.94	7.70±0.52	7.10±0.92	7.88[c]
S30	8.30±0.84	8.05±0.79	7.90±0..70	7.00±0.52	6.70±0.63	7.59[d]
Mean time	8.53[a]	8.29[b]	7.93[c]	7.57[d]	7.35[e]	LSD=0.38
			Flavor			
BC	7.50±0.52	7.30±0.59	7.00±0.48	6.70±0.47	6.50±0.52	7.00[c]
B20	7.60±0.48	7.40±8.5	7.20±0.75	6.90±0.70	6.70±0.53	7.16[c]
B30	7.80±0.85	7.65±0.97	7.50±0.69	7.40±1.03	7.20±1.17	7.51[b]
SC	7.60±0.67	7.45±0.53	7.10±0.63	6.80±0.66	6.55±0.67	7.10[c]
S20	8.20±0.74	8.10±0.47	8.00±0.87	7.80±0.48	7.60±0.63	7.94[a]
S30	8.30±0.96	8.20±0.54	8.10±0.42	8.00±0.21	7.70±0.65	8.06[a]
Mean time	7.83[a]	7.68[a]	7.48[b]	7.27[c]	7.04[c]	LSD=0.40
			Overall acceptability			
BC	8.50±0.79	8.30±0.88	8.00±0.81	7.80±0.87	7.60±0.82	8.04[a]
B20	8.30±0.67	8.00±0.95	7.70±0.97	7.50±0.92	7.30±0.67	7.76[b]
B30	8.10±0.84	7.80±0.70	7.50±0.79	7.30±0.84	7.10±0.70	7.56[c]
SC	8.20±0.97	8.00±1.05	7.50±0.88	7.40±1.10	7.20±1.08	7.66[bc]
S20	8.00±0.81	7.70±0.88	7.50±0.54	7.40±0.82	7.00±0.87	7.52[c]
S30	7.80±0.84	7.40 ±40	7.00±0.67	6.80±0.59	6.70±0.44	7.14[d]
Mean time	8.15[a]	7.87[b]	7.53[c]	7.37[d]	7.15[e]	LSD=0.36

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 sensorial 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

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).

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

The same letter in a 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.

flavour as a prime sensorial parameter, the results showed that S30 exhibited significantly ($P≤0.05$) 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 Lizerd 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 microwaved baked crackers, which their overall acceptability ranged from 6 (little liked) to 9 (extremely liked). On the other hand, Izci *et al*. (2011) stated that overall acceptability values for fish snacks prepared from sand smelt decreased significantly ($P≤0.05$) when extending the storage time.

Each chemical composition of the different samples of snacks recorded significant differences at $P≤0.05$ 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 ($P≤0.05$) 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, were 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 $P≤0.05$ 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 ($P≤0.05$) 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 5.47% to 6.58%, 62.31% to 77.34% and 392.08 Kcal/100g to 410.68 Kcal/100g for pre-cooked bak ed snacks, respectively. Ashand 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.

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*) fillets, 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 phosphors (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

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)

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

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 lion (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 $P\leq0.05$ 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 $P\leq0.05$ 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: Thiobarbeturic 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)

Samples	Storage period (month)					Mean treatment
	0	1	2	3	4	
			TBA (mg MAD/kg)			
BC	0.600±0.05	0.740±.05	1.11±0.10	1.23±0.04	1.59±0.03	1.05e
B20	0.920±0.04	1.06±0.02	1.26±0.06	1.57±0.06	1.89±0.11	1. 34c
B30	1.15±0.28	1.38±0.06	1.49±0.13	1.75±0.05	2.11±0.06	1.58b
SC	0.660±0.06	0.880±0.06	1.38±0.04	1.52±0.12	1.80±0.03	1.25d
S20	1.09±0.18	1.27±0.06	1.63±0.05	2.02±0.19	2.32±0.08	1.67b
S30	1.33±0.05	1.52±0.02	1.73±0.04	2.39±0.04	2.92±0.27	1.80a
Mean Time	0.95 e	1.14 d	1.44 c	1.75 b	2.11 a	LSD=0.046
			TVB-N (mg N/100g)			
BC	3.38±0.31	3.45±0.13	4.02±0.34	4.66±0.48	6.65±0.11	4.43 f
B20	9.56±0.22	10.24±0.22	11.63±0.64	14.14±0.41	16.24±0.68	12.36d
B30	9.95±0.06	12.34±0.19	14.04±0.49	17.08±0.23	18.11±0.32	14.30 c
SC	5.19±0.07	5.50±0.31	5.91±0.17	6.35±0.24	8.71±0.10	6.33e
S20	9.94±0.08	13.03±0.43	14.75±0.86	17.52±0.52	21.14±0.28	15.28b
S30	10.18±0.09	14.71±0.13	16.16±0.47	20.77±036	23.03±0.58	16.97a
Mean Time	8.03 e	9.88 d	11.08c	13.42 b	15.65 a	LSD=0.432

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.

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 after processing to 17.25 mg N/100g after 3month of storage. On the other hand, TBA value was 0.20 mg MAD/kg (0 day) and reached to 1.22 mg MDA/kg at the end of 15 days storage in pre-cooked fish ball (Boran and Köse, 2007). Ersoy and Yılmaz (2003) reported that TVB-N values of fish ball made from *Clarias gariepinus* without vacuum increased during the storage period and reached to 18.2mg N/100 g (at the end of the storage period). There was a significant at $P\leq0.05$ increase in the levels of total volatile base nitrogen (TVB-N) after 90 days of storage at room temperature (from 1.54mg N/100g to18.16 mg N/100g) and there was no significant at $P\leq0.05$ 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 ($P\leq0.05$) increasing by prolonging the storage period. As for the yeasts and molds counts, they were increased significantly ($P\leq0.05$) for both treatments and non-significantly ($P\leq0.05$) by time in the first two month then they increased significant-

Table 6: Total bacterial count, and Yeast & Molds changes (log cfu/g) in 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)

Samples	Storage period (month)					Mean treatment
	0	1	2	3	4	
			Total bacterial count (log cfu/g)			
BC	1.48±0.01	1.48±0.02	2.54±0.09	2.79±0.06	3.74±0.09	2.41^{a}
B20	1.48±0.05	1.48±0.06	2.69±0.06	2.87±0.06	3.16±0.06	2.36^{a}
B30	1.48±0.10	1.48±0.06	2.79±0.06	2.85±0.06	3.18±0.06	2.36^{a}
SC	1.48±0.01	1.48±0.02	1.48±0.02	2.65±0.17	2.82±0.07	1.98^{c}
S20	1.48±0.01	1.48±0.06	1.48±0.06	3.02±0.86	2.89±0.06	2.07^{b}
S30	1.48±0.01	1.48±0.01	1.48±0.01	2.88±0.09	2.98±0.03	2.06^{bc}
Mean Time	1.48^{d}	1.48^{d}	2.08^{c}	2.84 ^{b}	3.13^{a}	LSD=0.178
			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 ^{c}
B20	1.00± 0.01	1.00±0.03	1.00±0.40	2.31±0.11	2.53±0.07	1.57^{b}
B30	1.00±0.00	1.00±0.02	1.00±0.00	2.40±0.03	2.63±0.05	1.61^{a}
SC	1.00±0.01	1.00±0.01	1.00±0.00	1.00±0.04	2.11±0.11	1.22^{f}
S20	1.00±0.01	1.00±0.01	1.00±0.00	1.00±0.01	2.24±0.10	1.25^{e}
S30	1.00±0.01	1.00±0.01	1.00±0.01	1.00±0.01	2.36±0.08	1.27^{d}
Mean Time	1.00^{c}	1.00 ^{c}	1.00^{c}	1.63^{b}	2.38^{a}	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 ($P \leq 0.05$) 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) x10^3cfu/g in fish pies sold in Nigeria. Also, the count of microorganism 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 ($P \leq 0.05$) 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)

Parameters	Groups						
	Casein	BC	B20	B30	SC	S20	S30
food intake (g/30 days)	188.48 ±7.77^b	136.73±3.53^d	160.71±8.15^c	174.33±3.93^c	98.32±2.57^e	113.05±9.05^e	204.69±5.80^a
Body weight gain (g/30 days)	81.51±1.13^a	26.80±1.00^e	47.03±0.75^b	40.63±1.87^c	16.72±0.333^f	22.30±1.01^g	35.52±1.40^d
Protein consumed (g/30 days)	14.14±0.082^d	11. 39±0.072^e	19.94±0.11^c	27.14±0.055^b	7.15±0.050^f	12.30±0.040^e	29.18±0.067^a
Protein efficiency ratio (PER)	5.77±0.011^a	2.35±0.004^b	2.36±0.036^b	1.50±0.064^d	2.34±0.005^b	1.81±0.026^c	1.22±0.057^e
Corrected protein efficiency ratio (CPER)	2.50±0.020^a	1.02±0.020^b	1.02±0.011^b	0.650±0.005^d	1.01±0.005^b	0.784±0.010^c	0.528±0.032^e
Net protein ratio (NPR)	7.17±0.027^a	4.11±0.007^c	3.36±0.021^d	2.23±0.004^e	5.14±0.034^b	3.44±0.010^d	1.90±0.010^f
True digestibility (TD%)	87.25±0.574^b	77.53±0.257^e	78.72±0.078^d	79.96±1.35^c	59.92±0.258^g	74.00±0.055^f	88.52±0.119^a
Net protein utilization (NPU%)	80.92±0.110^b	65.37±0.107^f	69.25±0.218^e	74.90±0.065^c	45.55±0.061^g	69.94±0.060^d	85.95±0.050^a
Biological value (BV%)	92.89±0.070^d	84.40±0.102^f	88.05±0.150^e	93.66±0.078^c	75.99±0.071^g	94.52±0.116^b	97.09±0.081^a

The same letter in a row 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.

recorded for S30 group. The true digestibility values were 88.52%, 87.25% and79.96 % 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.

REFFERENCES

Abou-Taleb, M., Talab, A. S., Ibrahim,M. A., Genina, M. E., Anees, F. A., Mahmoud, M. M. & Abou-Taleb, S. M. **2019**. Frozen fish chips properties processed from some economic underutilized fish species. Egyptian Journal of Aquatic Biology and Fisheries, **23**: 493-502.

Alves, R.M.L. & Grossmann, M.V.E. **2002**. Parâmetros de extrusão paraprodução de "snacks" de farinha de cará. Food Science and Technology, **22**:32-38.

Antonacopoulos, N. & Vyncke, W. **1989**. Determination of volatile basic nitrogen: a third collaborative study by The West European Fish Technologists Association (WEFTA). Zeitschrift für Lebensmittel-Untersuchung und -Forschung, **189**: 309-316.

AOAC **2007**. Official Methods of Analysis of the A.O.A.C. International 18th Ed. Gaithersburg, Maryland, USA.

Bartulovic, V.´, Lucˇic, D.´, Conides, A., Glamuzina. B., Dulcˇic´, J., Hafner, D. & Batistic, M. **2004**. Food of sand smelt, Atherina boyeri Risso, 1810 (Pisces: *Atherinidae*) in the estuary of the Mala Neretva River (middle-eastern Adriatic, Croatia). Scientia Marina, **68**: 597-603.

Bligh, E.G. & Dyer, W. J. **1959**. A rapid method of total lipid Extraction and Purification. Canadian Journal of Biochemistry and Physiology, **37**: 911-917.

Boran, M. & Köse, S. **2007**. Storage properties of three types of fried whiting balls at refrigerated temperatures. Turkish Journal of Fisheries and Aquatic Sciences, **7**: 65-70.

Downes, F. P. & Ito, K. **2001**. Compedium of methods for the microbiological examination of foods. 4Ed. Washington: American Public Health Association.

Elevevoli E.O & James D.G. **2010**. Potential benefits of fish for maternal, fetal and neonatal nutrition: A review of literatures FAO Report 10.

Ersoy, B. & Yılmaz, A. B. **2003**. Frozen storage of African Catfish (*Clarias gariepinus* Burchell, 1822) mince ball. Turkish Journal of Veterinary and Animal Sciences, **27**:827-832.

Food and Agriculture Organization - FAO. **2001**. Codex Stan 222: norma para galletas de pescado marino y de agua dulce y de mariscos crustáceos y moluscos. Rome.

Ganesan, P., Rathnakumar, K., Brita Nicy, A. & Vijayarahavan, V. **2017**. Improvement of nutritional value of extruded snack product by incorporation of blanched dried fish powder from sardine and Lizard fish and selection by organoleptic evaluation Journal of Entomology and Zoology Studies, **5**: 2552-2554.

Goes, E. S. R., Souza,M. L. R., Campelo, D. A. V., Yoshida, G. M., Xavier,T. O., de-Moural, B. & Monteiro, A. R. G. **2015**. Extruded snacks with the addition of different fish meals.

Food Science and Technology,Campinas, **35**:683-689.

Hussain, I., Akhtar, N. & Hussain, S. **2007**. Evaluation of weaning food "Khitchri" incorporated with different levels of fish protein concentrate. Journal of Animal and Plant Science, **17**: 33-35.

Ike, C. C., Emeka-Ike, P. C., Nwokorie, C. C. & Anochie, C. C. **2015**. Microbiological quality evaluation of locally prepared snacks sold in ABA Metropolis, Abia state, Nigeria. International Journal of Scientific Engineering and Applied Science, **1**: 2395-3470.

İzci, L., Günlü, A. & Bilgin, S. **2011**. Production of fish chips from sand smelt (*Atherina boyeri*, *RISSO 1810*) and determination of some quality changes. Iranian Journal of Fisheries Sciences, **10**: 230-241.

João De Paula Cortez Netto, Paulo Roberto Campagnoli de Oliveira Filho, Judite Lapa-Guimarães & Elisabete Maria Macedo Viegas **2014**. Physicochemical and sensory characteristics of snack made with minced Nile tilapia. Food Science and Technology,Campinas, **34**: 591-596.

Justen, A. P., Franco, M. L. R. S., Monteiro, A. R. G.,Mikcha, J. M. G., Gasparino, E. & Delbem, A. B. **2011**. Inclusión de harina de pescado en snacks. Infopesca Internacional, **47**: 35-38.

King, M. A. **2002**. Development and sensory acceptability of crackers made from the big-eye fish (*Branchydeuterus auritus*). Food and Nutrition Bulletin, **23**: 317-340.

Mahmoud, M. M., Khallaf, M. F., Nessrien, M.N. & Abou-Taleb, M. **2016**. Quality Characteristics of Common Carp Fish Pastirma. Annals of Agricultural Science, Moshtohor, **54**: 95-104.

Nawaz, A., Khalifa, I., Walayat, N., Lorenzo, J. M., Irshad, S. Abdullah,, Ahmed, S., Simirgiotis, M. J., Ali, M. & Li, E. **2021**. Whole fish powder snacks: Evaluation of structural, textural pasting and water distribution properties. Sustainability,**13**: 6010- 6022.

Nawaz, A., Xiong, Z., Xiong, H., Chem, L.,Wang, P.K., Ahmad,I., Hu,C., Irshad, S. & Ali, S.W. **2019**. The effects of fish bone addition on nutritional value, texture and microstructure of optimized fried snacks. International Journal of Food Science and Technology, **54**:1045-1053.

Neiva,C., Machado, T., Tomita,R., Furlan, E., Lemos- Neto, M. & Bastos, D., **2011**. Fish crackers development from minced fish and starch: an innovative approach to a traditional product. Ciênc. Tecnol. Aliment., Campinas, **31**: 973-979.

Netto, P. C., Paulo, R.C., Judite, L. G. & Maria, M. V. **2014**. Physicochemical and sensory characteristics of snack made with minced Nile tilapia. Food Science and Technology, Campinas, **34**: 591-596.

Nurul, H., Leng, L. A., Yee, C. X. & Herpandi. **2010**. Chemical composition, colour and linear expansion properties of Malaysian commercial fish cracker (keropok). Asian Journal of Food and AgroIndustry, **3**: 473-482.

Rahayu, W. P., Utari, I. W., Nurwitri, C. C. & Nurjanah, S. **2018**. Determination of critical control points in fish-based snacks preparation as foods for school children. International Food Research Journal **25**: 2285-2291.

Ranhotra, G.S., Gelroth, J. A., Glaser, B. K., Loranz, K. J. & Johnson, D.L. **1993**. Composition and nutritional quality of quinoa protein. Cereal Chemistry, **70**: 303-305.

Sarcinelli, M.F., Venturini, K.S. & Silva,L.C. **2007**. Características sold in Aba Metropolis, Abia state, Nigeria. International Journal of Scientific Engineering and Applied Science, **1**: 2395-3470.

Shaltout, O. E. **1993**. Chip-like cod based crackers: acceptability and chemical composition. Food Science and Technology, **26**: 17-21.

Shaviklo,G. R., Olafsdottir, A., Sveinsdottir, K., Gudjon Thorkelsson, G. & Rafipour, F. **2011**. Quality characteristics and consumer acceptance of a high fish protein puffed corn-fish snack. Journal of Food Science and Technology, **48**:668–676.

Shaviklo, G. R., Thorkelsson, G., Rafipour, F. & Sigurgisladottir, S. **2011a**. Quality and storage stability of extruded puffed corn-fish snacks during 6-month storage at ambient temperature. Journal of the Science of Food and Agriculture, **91**:886-893.

Steel, R. G. & Torrie, J. H. **1980**. Principle and procedures of statistics 2nd Ed. McGraw Hill, New York, USA.

Stone, H. & Sidel, J. L. **1993**. Sensory Evaluation Practices, 2 Ed. San Diego, Academic Press.

Tarladgis, B. G., Watts, B.M. & Yonathan, M. **1960**. A distillation method for the quantitative determination of malonaldehyde in rancid food. Journal of the American Oil Chemistry Society, **3**:44- 48.

Ünlüsayın, M., Bilgin, Ş., İzci, L. & Gülyavuz, H. **2002**. The preparation of fish ball from pike perch (*Sander luciopercaL.* Kottelat, 1997) and Tench (*Tinca tinca* L.1758) filet cracks and determination of shelf life. Journal of Science Institute, **6**: 25-34.

Yanar,Y. & Fenercioğlu, H., **1999**. The utilization of carp (*Cyprinus carpio*) flesh as fish ball. Turkish Journal of Veterinary and Animal Sciences, **23**:361-366.

الملخص العربى

تحضير وتقييم وجبات مغذية خفيفة وجديدة من أسماك البساريا (*Atherina boyeri*)

هدى حسين عمارة[١]، عاطف سعد عشبة[٢]، رحاب عبد السلام مصطفى[٣]

(١) قسم بحوث تكنولوجيا اللحوم والأسماك، معهد بحوث تكنولوجيا الأغذية، مركز البحوث الزراعية،الصبحية،الأسكندرية، مصر.

(٢) قسم بحوث تكنولوجيا اللحوم والأسماك، معهد بحوث تكنولوجيا الأغذية، مركز البحوث الزراعية،الجيزة، مصر.

(٣) معهد بحوث تكنولوجيا الأغذية، مركز البحوث الزراعية، الجيزة، مصر.

سلط هذا البحث الضوء على وجبات غذائية خفيفة تم تحضيرها باستخدام أسماك البساريا (*Atherina boyeri*) في منتجات وجبات غذائية خفيفة سمكية مخبوزة ومخبوزة مسبقة الطهي .أظهرت النتائج عن وجود كميات أعلى من محتوى كل المعادن في العينات المخبوزة مقارنة بالعينات المخبوزة مسبقة الطهي. قيم حمض الثيوبربيتيوريك والقواعد النيتروجينية المتطايرة الكلية. وجد أن هذه قيم حمض الثيوبربيتيوريك والقواعد النيتروجينية الطيارة قد زادت بإطالة زمن التخزين والنسبة المئوية للأسماك المفرومة المضافة. أظهر العدد الكلي للبكتيريا والخميرة والفطريات في العينات نشاطًا محدودًا وزاد بزيادة فترة التخزين. أشار التقييم البيولوجي إلى أن الغذاء المتناول والبروتين المستهلك والهضم الحقيقي وصافي البروتين المستخدم كانت الأعلى في الوجبات الأغذائية الخفيفة المخبوزة مسبقة الطهي المحتواة٣٠٪ لحم سمك .(S30) وكانت نسبة كفاءة البروتين ونسبة كفاءة البروتين المصححة هي الأعلى في حمية الكازين ثم الوجبات الغذائية الخفيفة المخبوزة والمخبوزة مسبقةً الطهي الكنترول SC وBC ثم الوجبات الغذائية الخفيفة المخبوزة التي تحتوي على ٢٠٪ لحم البساريا على التوالي. وكانت القيم البيولوجية ٩٧,٠٩٪ و ٩٣,٦٦٪ و ٩٢,٨٩٪ في المجاميع S30 و B30 والكازين على التوالي. بينما تراوحت هذه القيم من ٧٥,٩٩٪ إلى ٨٨,٠٥٪ في باقي العينات.