



Research Article

Chemical and Sensory Evaluation of a Snack Fortified with Fish Roe Protein Concentrate

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ABSTRACT

Roes are considered as abundant and underutilized fish by-product in Nigeria. The production of roe protein concentrate (RPC) is expected to increase the economic value and potency of their usage. A protein concentrate was produced using herring roes, and the concentrates (HRPC) were used to fortify a rice-based snack (Garabiya) using four different ratios of rice to protein concentrates (90:10; 85:15; 75: 25 and 70:30). The results of the proximate composition shows that the 100% rice garabiya recorded lower moisture (1.30%), protein (4.71%) and ash (0.22%) contents, and significant amounts of carbohydrate (65.82%) while the fortified Garabiya samples had higher proximate composition, and it increases with increase in protein concentrate. The mineral analysis of the samples does not indicate significant differences ($P \geq 0.05$) in most of the minerals. Sodium and Potassium were the most abundant minerals and the highest value was observed in garabiya with 30%HRPC (500.01mg/g and 30.00mg/g). Among the garabiya samples also, the results of amino acid profile indicated leucine (10.80g/100g) and lysine (7.08g/100g) being the most predominant essential amino acids recorded. The results of the sensory evaluation of the garabiya were not significantly different ($P \geq 0.05$) from the 100%rice Garabiya, although the HRPC30% is comparable with the control sample. Roe protein concentrates contained high amounts of protein, fat and ash, as well as minerals and amino acid contents. A highly nutritious garabiya has been produced through fortification with herring roe protein concentrate (HRPC).

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INTRODUCTION

Global fish consumption has risen because of its high nutritional value and numerous health benefits, making it an essential and affordable source of animal protein, as well as a major contributor to the international food trade (Rathod *et al.*, 2021). Marine fish, crustaceans, molluscs, and echinoderms all reproduce by the means of eggs. The eggs are produced and matured in the ovaries that in gastronomic terms are called roe (Bekhit, 2022). Roe is the term used to describe fish eggs (oocytes) gathered in skeins (Mahmoud *et al.*, 2008). The composition of the roe is important for both the nutritional quality as well as the taste when roe is used as a human foodstuff. Traditionally, most coastal communities around the world have included different types of roe in their diet, either by eating the roe together with the raw or prepared dish of, e.g., fish or mussels, or by manufacturing special roe products either using the whole row sac or separated eggs. Examples of such roe products are salted caviar from sturgeon and kaviar of loose eggs from other marine organisms, or salted, dried, fermented, smoked, cooked, fried, etc. of whole roe sacs or parts thereof (Bledsoe and Basco, 2006). The preparation techniques used are obviously related to methods and needs of conservation and may be dependent on the specific food culture in question. A celebrated type of roe is caviar from sturgeon which has a long, dramatic, and complicated history (Saffron, 2002). Other well-known types of roe products derive from common fish species, e.g., salmon, trout, cod, herring, lumpfish, flying fish, and smelt. Less common is roe from echinoderms like sea urchins, sea cucumbers, and starfish, crustaceans like crabs and lobsters, and cephalopods like squid and cuttle fish. *Garabia*, is a sweetened snack that is produced from rice, sugar, groundnut oil and spices (ginger, cloves, and pepper). It is a "Royal snack" that is mainly prepared by the Kanuris and Shuwa Arabs of Yobe and Borno States (Kyari, 2002). The major ingredient used in garabiya production is rice flour. Rice is the seed of the grass species *Oryza sativa* (Asian rice) or *Oryza glaberrima* (African rice). As a cereal grain, it is the most widely consumed staple food for a large part of the world's human population, especially in Asia. It is the Agricultural commodity with the third-highest worldwide production, after sugarcane and

maize (FAOSTAT, 2012). Rice is a good source of staple food in many parts of the world, but it is not regarded as a complete protein, it does not contain all of the essential amino acids in sufficient amounts for good health, and should be combined with other sources of protein, such as nuts, seeds, beans, fish, or meat (Jianguo *et al.*, 2003). Integrating aquatic proteins into food products offers opportunities for creating innovative value-added items, with successful applications already seen in products like mayonnaise, ice cream, spaghetti, pasta, macaroni, wheat flour bread, Indian bread, and biscuits (Phadtare *et al.*, 2021). This study is therefore limited for the production of roe protein concentrate from herring roe and fortifying a rice-based snack (*garabiya*), and evaluating its chemical and sensory properties.

MATERIALS AND METHODS

Sample acquisition and preparation

Atlantic Herring (*Clupea harengus*) were purchased directly from fish dealers from Gamboru Market, rice and other ingredients were purchased from Maiduguri Monday market, Borno State. Protein concentrates and the fortified *Garabiya* were processed at the Food Processing Laboratory, Department of Food Science and Technology, University of Maiduguri. Standard methods were used (AOAC, 2006) in all the chemical analysis (protein, fat, ash, and moisture); and the analyses were carried out in the National Agency for Food and Drug Administration and Control laboratories (NAFDAC), Maiduguri Branch, Borno State.

Experimental Design

The experiment was 1 (fish species) x4(formulations) factorial design making a total of 5 samples along with the control sample. Values are means of triplicate analysis.

Preparation of Herrings Roe Protein Concentrates (HRPC)

Herring Roe was used based on availability in Maiduguri Markets and road side vendors. Protein Concentrate (HRPC) was prepared according to the method used by Narsing *et al.*, (2012) as demonstrated in fig 1 below. Fresh roes were separated manually from skins and blood vessels of the fish. The roe was homogenized using a high-speed mixer, and dried at $45\pm 2^{\circ}\text{C}$ for about 10 hours in a cabinet tray drier. The dried roes were ground and defatted using isopropanol maintaining a solid

to solvent ratio of 1:3 (w/v) at ambient temperature of $28\pm 2^{\circ}\text{C}$ for two hours, with occasional stirring. The solvent was decanted and the extraction was repeated for three times to ensure maximum removal of lipid. The residue was dried in a vacuum drier 60°C for a

period of six (6) hours. The defatted and dried roes were ground to powder using a mixer, and then sieved through a 180μ mesh to obtain roe protein concentrates.

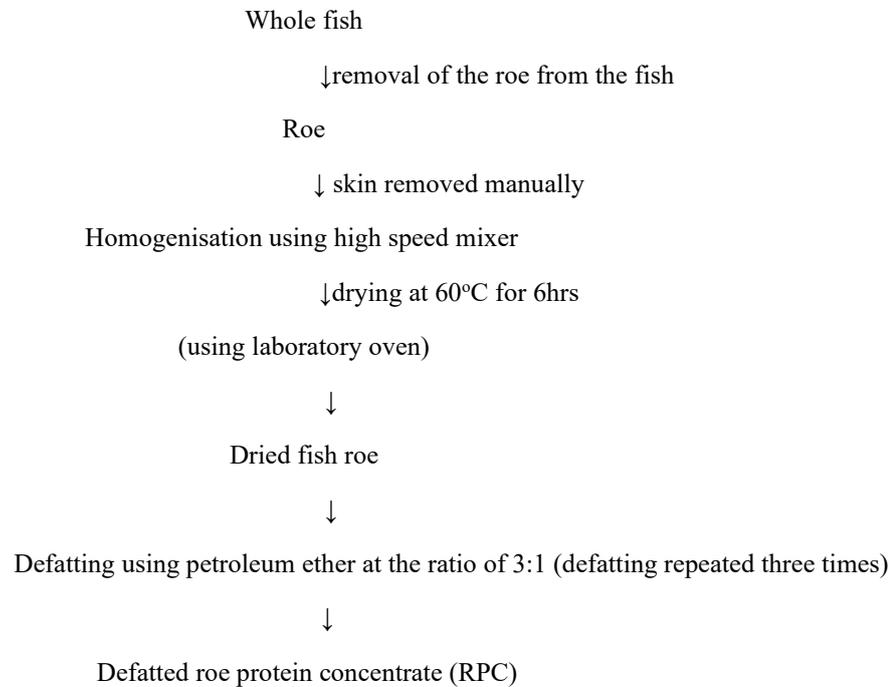
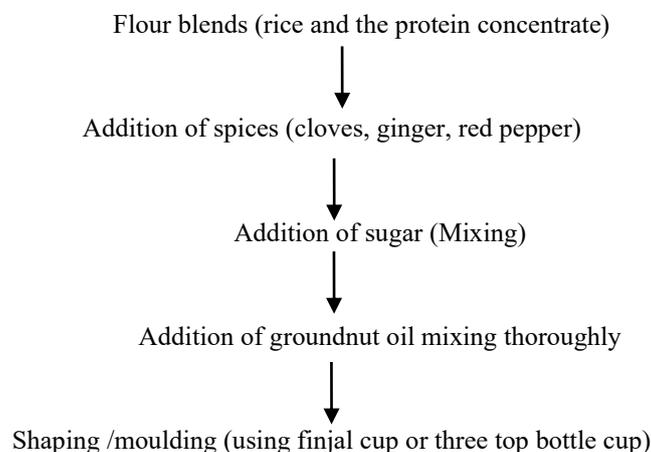


Figure 1. Production of HRPCs

Garabiya Production

Garabiya was produced using the method described by Kyari (2002) as described in figure 2 below. The fortified *Garabiya* was also compared with the traditionally manufactured *Garabiya* to determine their organoleptic and chemical properties. The

major ingredients used in *Garabiya* production are rice flour, sugar, groundnut oil, ginger, cloves and pepper. The ingredients were made into flour, mixed in appropriate proportion and the resulting dough is then shaped using *finjal* cups and dry-fried in a local pan known as “*ngaya*” for 10-15 minutes.



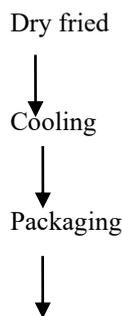


Figure 2: *Garabiya* Processing (Source: Kyari, 2002)

Proximate Analysis

The proximate composition (Moisture Content, Protein, Fat, Fibre, and Carbohydrates) of the fortified *Garabiya* and the locally processed *Garabiya* were determined following the guidelines outlined in AOAC (2006).

Amino Acid Analysis

The Amino Acid profile in the known sample was determined using methods described by Benitez (1989). The known sample was dried to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator and loaded into the Applied Biosystems PTH Amino Acid Analyzer.

Mineral analysis

Mineral content of *Garabiya* was determined using atomic absorption spectrophotometer (AOAC, 2006). The minerals examined were; Potassium, Iron, Sodium, Calcium, and Phosphorus.

Sensory Evaluation

The sensory evaluation test was conducted by a team of 20 panellist that were drawn from staff and students of Department of Food Science and Technology, University of Maiduguri, who have good experience of the quality characteristics of good quality *Garabiya*. The test was conducted while the samples were fresh. The panelists were provided with clean water to rinse their mouth after tasting each *Garabiya*. *Garabiya* were evaluated for their color, texture, flavor, taste, appearance and overall acceptability. The samples were coded with different letters and served to the panellist to guard against any bias. The panelists were asked to rate the given samples for test, colour, texture and overall acceptability based on a nine point hedonic scales with the ratings of: 9=Like extremely, 8=Like very much, 7=Like moderately,

6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much and 1=Dislike extremely (Ihekoronye and Ngoddy, 1985).

Statistical Analysis

Data obtained were subjected to analysis of variance (Ihekoronye and Ngoddy 1985), at 5% levels of significance using the IBM/SPSS version 22 software.

RESULTS AND DISCUSSION

Proximate Composition of the Fortified *Garabiya*

Table 1 shows the proximate composition of the fortified *Garabiya*. There was a significant difference ($P \leq 0.05$) in the proximate composition except the fat and ash contents among the fortified *Garabiya* and the 100% rice *Garabiya*. The protein content varies significantly and increased with increase in the protein concentrates, sample containing 30% protein concentrates had the highest protein content. 100% rice *Garabiya* had lowest moisture, protein and ash. There was no significant difference in the ash content of the *Garabiya* (0.22 to 0.85%) and the least was recorded in 100% rice. The moisture content in the *Garabiya* recorded in this study is similar to that obtained by Badau *et al* (2013) in *Garabiya* fortified with cowpea. The fat content is however higher, but lower in protein and carbohydrate contents. Jeyasanta *et al.*, (2013) reported that maintaining moisture content below 10% ensures microbial safety in fishery products. The findings also revealed that rice–fish roe *Garabiya* serves as a rich energy source, capable of meeting the body's daily energy needs. In general, the low moisture content observed across all *Garabiya* samples suggests product stability, high quality, and nutrient concentration. Protein levels in *Garabiya* increased with higher

incorporation rates, thereby improving its nutritional value. This enhancement is attributed to the high-quality biological proteins in fish, which have a balanced amino acid profile rich in methionine and cystine amino acids that are typically limited in cereal-based proteins. Omotosho *et al.* (2011) emphasized that ash content effectively reflects the mineral composition of fish and fish products. In the present study, the HRPC20% exhibited a significantly ($P \leq 0.05$) higher ash content than the control and other samples, likely because fish provides abundant amino acids and minerals. Similar findings on the ash content of fish protein concentrate (FPC) from eviscerated ribbon fish meat were reported by Akhade *et al.* (2016).

Mineral Composition of the processed Garabiya

Table 2 presents the mineral composition of the *Garabiya*. No significant variation occurred in the calcium content which ranged from 1.10 to 4.40mg between the 0%, 10% and 15%HRPC. Variation occurs with the increase in the HRPC. Sodium, the most abundant (174.00 ± 1.18 to 500.01 ± 13.46) mineral in all the *garabiya* samples, varied significantly and the least was recorded in the 100% rice *Garabiya* (174.00mg). Variation of phosphorus level was observed. Iron level ranged from 1.22 to 2.30mg/g and varied significantly at $p \leq 0.05$. Potassium was the second most abundant mineral and the highest was recorded in HRPC30% (30.00mg). Badau *et al.*, (2013) observed that rice *Garabiya* fortified with cowpea contained 0.235 to 1.031mg Iron, 6.293 to 7.800mg Potassium and 0.891 to 1.432mg Zinc, respectively. Their findings are in agreement with those recorded in this study. Galla (2014) analyzed higher amount of calcium and phosphorus in *Cyprinus carpio* and *Epinephelus tauvina* roe protein concentrates than in this study.

Amino Acid Profile (Essential/Non Essential)of the processed Garabiya

The amino acid profile (essential) of the *Garabiya* were analyzed and presented in table 3. The results obtained showed that leucine and lysine were the most abundant (8.07 and 6.28g/100g) essential amino acids recorded in HRPC30%. Highest isoleucine was recorded in HRPC30% (5.80g/100g sample) and the lowest in the 100% rice *Garabiya* (2.54g/100g sample). Phenylalanine showed significant variation with the highest value in HRPC25%

(4.46g/100g) and the lowest in Control sample 30% (2.80g/100g sample). Tryptophan level ranged from 1.05 to 1.38g/100g recorded in HRPC30% and C100% rice *Garabiya*. Least valine content was observed in the 100% rice *Garabiya*. There was no significant difference in the methionine. There was a significant difference in the histidine among the *Garabiya* and the control sample had the highest value. Shirai *et al.*, (2006) reported that composition of fish roe depends on the type of roe and the method of processing. They are regarded as high-quality foods since they include important amounts of protein and amino acids. The lipid from fish roe products has presented as a useful food source for maintaining human health (Shirai *et al.*, 2006). The non-essential amino acid of the fortified *Garabiya* was presented in table 4. Glutamic acid was the most abundant non-essential amino acid followed by aspartine, arginine, proline, tyrosine, glycine, alanine and cystine. Higher alanine content was observed in HRPC 30% (4.09g/100g) and the lowest was in control (3.15g/100g). The highest value of serine was observed in HRPC15% and the lowest in control. Glutamic acid content ranged from 4.54 to 12.72g/100g and the highest was observed in HRPC30%, and the least in 100% rice *garabiya*. From the obtained findings, it could be noticed that fortified *Garabiya* composed of all amino acids which were higher than the control sample. The findings here shows that addition of HRPC to *Garabiya* increases the nutritional composition of supplemented *Garabiya*. This could be due to fish contains higher amount of amino acids compared to cereal products. Moreover, Proteins derived from fish are nutritionally superior than those in plant sources. Generally, in this study amino acids composition of supplemented *Garabiya* were increased, as the level of fortification increases. The results of the present study are in accordance with Cereal *et al.*, (2015), reported that inclusion of fish protein into wheat flour bread improved nutritional quality of bread due to an excellent source of highly digestible amino acids. The result of this is in harmony with those obtained by Ibrahim (2009), and Mohamed *et al.* (2014) highlighted that fish protein concentrate has a good nutritional protein quality. Sen (2005) emphases that fortification cereal food products with fish protein concentrate is

beneficial to increase nutritional value of the agricultural products.

Sensory evaluation of the *Garabiya*

Table 5 presents the results of the sensory analysis of the *Garabiya* produced. There was no significant difference ($P \geq 0.05$) between the fortified *Garabiya* samples and the control based on their appearance. There was also no significant difference in the texture of the *Garabiya*, except HRPC15% and HRPC20% differs slightly. The texture shows some significant differences between the fortified

samples and the control. Increase in the protein concentrate decreases the score in terms of color, as the panelists scored the 100% rice *Garabiya* higher than the fortified samples. Color is an important aspect of dried products, as it indicates quality and consumer acceptance (Selani *et al.*, 2016). Abraha *et al.*, (2018) mentioned that substitution of cereal products with fish protein concentrate, which is rich in protein can increase their nutritional value and sensory attributes.

Table 1. Proximate Composition of the processed *Garabiya*

CONCENTRATES*	MOISTURE (%)	PROTEIN (%)	FAT (%)	ASH (%)	FIBRE (%)	CARBOHYDRATE (%)	ENERGY (KJ)
HRPC10%	1.64±0.06 ^b	8.18±0.16 ^b	24.82±0.30 ^a	0.57±0.01 ^{ab}	1.47±0.12 ^{ab}	62.34±0.29 ^c	500.42±2.16 ^{ab}
HRPC15%	1.11±0.11 ^b	8.63±0.08 ^b	24.93±0.11 ^{ab}	0.60±0.01 ^{ab}	3.27±0.40 ^c	61.47±0.08 ^a	500.73±1.64 ^{ab}
HRPC25%	1.66±0.10 ^{ab}	9.33±0.21 ^c	25.96±0.08 ^b	0.85±0.03 ^{bc}	2.67±0.30 ^{cd}	59.53±0.55 ^a	509.08±2.12 ^{bc}
HRPC30%	1.78±0.04 ^{ab}	13.29±0.42 ^d	24.39±0.23 ^{ab}	0.83±0.03 ^b	1.34±0.32 ^a	58.39±0.06 ^a	506.19±0.11 ^b
CONTROL	1.30±0.02 ^a	4.71±0.28 ^a	25.28±0.40 ^b	0.22±0.11 ^a	2.69±0.27 ^{cd}	65.82±0.26 ^d	509.58±1.45 ^{bc}

Samples with the same superscripts in a column are not significantly different $p \geq 0.05$, HRPC-Herrings Roe Protein Concentrates

CONCENTRATES*	CALCIUM	SODIUM	PHOSPHORUS	IRON	POTASSIUM
HRPC10%	1.80±0.01 ^{ab}	316.60±16.38 ^b	1.80±0.01 ^a	1.55±0.00 ^a	15.00±0.28 ^b
HRPC15%	1.97±0.06 ^{ab}	311.50±12.82 ^b	1.90±0.01 ^a	1.60±0.00 ^{ab}	16.00±3.96 ^b
HRPC25%	2.50±0.04 ^b	495.81±13.15 ^c	2.07±0.02 ^a	2.05±0.01 ^b	21.50±0.35 ^c
HRPC30%	4.40±0.06 ^c	500.01±13.46 ^c	2.30±0.01 ^a	2.30±0.01 ^b	30.00±0.28 ^d
CONTROL	1.10±0.01 ^a	174.00±1.18 ^a	1.50±0.01 ^a	1.22±0.01 ^a	13.40±0.37 ^a

Table 2. Mineral Composition of the fortified *Garabiya* (mg/g)

Samples with the same superscripts in a column are not significantly different $p \geq 0.05$, HRPC-Herrings Roe Protein Concentrates

Table 3: Amino Acid Profile (Essential) of the fortified *Garabiya* (g/100g)

CONCENTRATES	LEUCINE	LYSINE	ISOLEUCINE	PHENYLALANINE	TRYPTOPHAN	VALINE	METHIONINE	HISTIDINE	THREONINE	TEAA
HRPC 10%	9.00±0.01 ^b	4.96±0.02 ^{ab}	3.87±0.01 ^{ab}	3.18±0.01 ^{ab}	1.04±0.05 ^a	4.02±0.02 ^{ab}	2.20±0.01 ^d	2.01±0.01 ^a	2.85±0.01 ^{ab}	33.04
HRPC 15%	9.27±0.01 ^b	5.80±0.02 ^d	4.01±0.01 ^b	3.58±0.02 ^{ab}	1.10±0.01 ^a	4.51±0.01 ^{ab}	2.00±0.04 ^b	2.25±0.04 ^b	2.99±0.01 ^b	35.51
HRPC 25%	9.99±0.30 ^{bc}	6.42±0.10 ^c	4.52±0.01 ^b	4.00±0.01 ^b	1.14±0.02 ^a	4.71±0.05 ^b	1.87±0.01 ^d	2.27±0.05 ^b	3.41±0.08 ^c	38.33
HRPC 30%	10.80±0.01 ^c	7.08±0.05 ^c	5.80±0.01 ^b	4.46±0.00 ^{bc}	1.05±0.07 ^a	4.28±0.01 ^d	1.53±0.01 ^a	2.30±0.01 ^{bc}	3.68±0.01 ^c	40.98
CONTROL	7.75±0.10 ^a	3.75±0.28 ^a	2.54±0.31 ^a	2.80±0.26 ^a	1.38±0.23 ^a	3.96±0.06 ^a	2.87±0.17 ^a	2.91±0.05 ^c	2.37±0.21 ^a	30.33

Samples with the same superscripts in a column are not significantly different $p \geq 0.05$, HRPC-Herrings Roe Protein Concentrates

Table 4: Amino Acid Profile (non-Essential) of the *Garabiya* produced

CONCENTRATES	CYSTINE	ALANINE	GLUTAMINE	GLYCINE	SERINE	ASPARTIC ACID	PROLINE	ARGININE	TYROSINE	TNEAA
HRPC 10%	1.21±0.02 ^{ab}	3.50±0.01 ^a	10.99±0.02 ^b	3.90±0.00 ^a	3.69±0.01 ^b	7.54±0.03 ^b	3.88±0.03 ^b	5.37±0.02 ^a	3.43±0.02 ^a	43.51
HRPC 15%	1.29±0.03 ^{ab}	3.54±0.04 ^a	11.51±0.01 ^c	3.99±0.04 ^a	3.99±0.00 ^b	7.85±0.01 ^b	3.97±0.01 ^b	5.50±0.00 ^a	3.44±0.04 ^{ab}	45.08
HRPC 25%	1.31±0.00 ^{ab}	4.10±0.01 ^b	11.98±0.02 ^c	4.10±0.01 ^b	3.65±0.01 ^b	8.88±0.01 ^c	4.40±0.04 ^c	6.01±0.01 ^{ab}	3.96±0.01 ^{ab}	48.39
HRPC 30%	1.39±0.01 ^b	4.09±0.01 ^{ab}	12.72±0.08 ^d	4.09±0.01 ^b	3.73±0.08 ^b	8.99±0.01 ^c	4.45±0.03 ^c	6.85±0.01 ^b	4.47±0.04 ^b	50.78
CONTROL	1.05±0.10 ^a	3.15±0.28 ^a	4.54±0.31 ^a	3.80±0.26 ^a	1.38±0.23 ^a	3.96±0.06 ^a	2.87±0.17 ^a	5.31±0.05 ^a	3.37±0.21 ^a	29.43

Samples with the same superscripts in a column are not significantly different $p \geq 0.05$, HRPC-Herrings Roe Protein Concentrates

Table 5: Sensory Evaluation of the fortified *Garabiya*

GARABIYA	APPEARANCE	TASTE	TEXTURE	COLOR	Overall Acceptability
HRPC 10%	6.00±2.08 ^a	6.10±2.17 ^{ab}	5.90±1.52 ^a	5.70±1.78 ^{ab}	6.45±2.11 ^{ab}
HRPC 15%	6.35±1.84 ^{ab}	5.35±2.30 ^a	5.90±1.55 ^a	6.25±1.89 ^b	6.30±2.20 ^a
HRPC 25%	6.10±1.80 ^{ab}	5.60±2.14 ^{ab}	5.75±2.20 ^a	5.45±2.16 ^a	6.15±1.79 ^a
HRPC 30%	6.25±2.29 ^{ab}	6.20±1.79 ^b	5.85±2.23 ^a	5.75±1.86 ^a	6.50±2.01 ^{ab}
CONTROL	6.65±2.35 ^b	6.20±2.21 ^b	6.75±1.55 ^b	6.55±2.14 ^b	7.25±1.68 ^b

Samples with the same superscripts in a column are not significantly different $p \geq 0.05$, HRPC-Herrings Roe Protein Concentrates

CONCLUSION

This study concludes that protein concentrates could be prepared from herring roe, and that the protein concentrates could be used at different proportions to prepare rice snacks of higher nutritional qualities based on the results of the protein, mineral and amino acid compositions. HRPC produced were a rich source of protein, fat and ash. Sodium, Iron and potassium were the most abundant mineral recorded. In conclusion, protein concentrates made from herrings roe had higher nutritional value and can be used as an ingredient that can

be incorporated in different formulas such as *Garabiya* and other snacks.

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