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Effect of Adding Carp Fish Powder on Some Quality Attributes of Biscuits

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ABSTRACT

This study investigated the effect of different levels of fish powder (FP), in combination with oat substituted for wheat flour, on the quality attributes of biscuits. The results showed that the FP contained 70.83% crude protein, 22.87% lipids, 3.44% ash, and 2.87% carbohydrates, while moisture content was not detected. The values of the measured quality attributes were below recommended limits. The total essential amino acids (EAA) and non-essential amino acids (NEAA) were 166.68 and 319.93mg/ g, respectively. Saturated fatty acids (SFA) and unsaturated fatty acids (USFA) were recorded at 31.31% and 64.86%, respectively. In biscuits supplemented with FP, both protein and ash content increased significantly with higher levels of fortification. However, the quality attributes of all treatments remained below the allowable limits. Sensory evaluation revealed that biscuits fortified with 20% FP received the highest scores from the panelists compared to the control sample. Data also showed that EAA, NEAA, SFA, and USFA (except for C18:2) increased noticeably in biscuits containing 20% FP compared to the control. In conclusion, supplementing biscuits with up to 20% FP improved their nutritional quality and sensory acceptability. This study recommends using carp fish as a primary source of fish powder, especially since this species is generally underutilized and not favored by most Egyptian consumers.

INTRODUCTION

Biscuits are popular ready-to-eat snacks due to their palatability, widespread consumption, relatively long shelf life, and appeal across various age and income groups, particularly the elderly, low-income populations, and children. They are of great economic importance **(Bassiouny *et al*., 1990)**. Wheat flour is commonly used in biscuit production because of its unique rheological properties, which significantly affect baking quality.

To enhance nutritional value, high-protein sources—especially those rich in essential amino acids such as legumes and oilseeds—are often blended with wheat flour

to create composite flours. These blends offer both nutritional and economic benefits **(Adebowale *et al.*, 2012)**. Additionally, oats are considered safe for most individuals with celiac disease and are less likely to trigger immune-mediated responses due to their unique amino acid sequences. Oats can be used as a partial or complete substitute for wheat flour to improve the nutritional profile of gluten-free biscuits. However, although oats have high nutritive value, high substitution levels can negatively affect the sensory acceptability of the final product **(Comino *et al.*, 2015; Duta & Culetu, 2015)**.

Feyera (2020) emphasized that the consumption of nutritious snacks can help reduce energy and protein malnutrition among adults and children. Biscuits, being light, affordable, and convenient, are consumed by a wide range of population groups globally. Moreover, biscuits made from various combinations of grains and legumes have shown high sensory acceptance.

In terms of nutritional value, fish and fish products are excellent sources of highly digestible protein rich in essential amino acids, unsaturated fatty acids such as omega-3, and both major and trace minerals **(Tacon *et al.*, 2020)**. **Urganc and Isik (2021)** investigated the incorporation of pomegranate peel into biscuits and concluded that it should not exceed 12% to avoid bitterness and sourness. **Gao *et al.* (2022)** formulated healthy biscuits using konjac, pumpkin seeds, low-gluten wheat flour, and maltitol, resulting in increased dietary fiber and protein content with reduced sugar levels. **Hoang *et al.* (2022)** used corncob powder with enzymes in biscuit production and found improvements in dietary fiber, antioxidant activity, total phenolic content, and breaking strength, along with reduced hardness and increased overall acceptance compared to the control sample.

Recently, **Nasser and Amin (2025)** demonstrated that fortifying crackers with dried shrimp and oyster meat powder significantly enhanced fat and amino acid content, as well as improved taste, flavor, and texture.

Based on these findings, the current study was designed to investigate the effects of incorporating various levels (5%, 10%, 15%, and 20%) of common carp fish powder, in combination with oat flour substituted for wheat flour, on the quality attributes of biscuits.

MATERIALS AND METHODS

Materials

Fish samples

Approximately 10kg of common carp (*Cyprinus carpio*) samples (Fig. 1A) were obtained from a local fish market in Benha, Egypt, during July 2024. The samples were transported in an icebox to the Fish Processing and Technology Laboratory at the National Institute of Oceanography and Fisheries (NIOF), Egypt. Upon arrival, all fish samples were thoroughly washed with tap water, drained, and their morphometric

parameters were recorded. The average total length and weight were 44.50 ± 5.00cm and 1.588 ± 0.515kg, respectively.

The fish were then manually filleted, and all non-edible by-products (fins, viscera, skin, bones, etc.) were removed. The edible portion of the fish constituted approximately 43.31% of the total body weight.

Ingredients

Wheat flour, oat, butter, sunflower oil, sugar, sodium bicarbonate ($NaHCO_3$), potassium sorbate (K-sorbate), and vanillin were purchased from a local market.

Technological processes

Preparation of common carp fish powder (FP)

Fish fillets were soaked in a 0.02% acetic acid solution to improve odor, then rinsed thoroughly with tap water and drained. The drained fillets were minced using a meat mixer (Tornado, MG-2000), cooked in an autoclave at 100°C for 15 minutes, and then dried in an electric oven at 80°C for three days. After drying, the samples were ground using an electric mixer, sieved, and packed in polyethylene bags for storage until further use (Fig. 1B).

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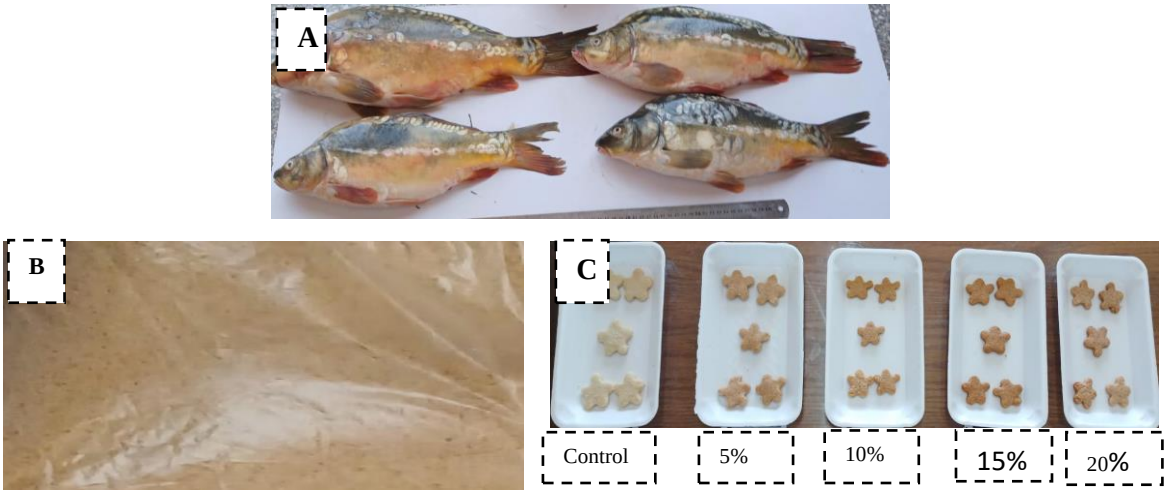

Fig. 1. (A) Common carp (*Cyprinus carpio*); **(B)** Fish powder; **(C)** Biscuits supplemented with fish powder

Treatments

Both butter and sugar were gently mixed and sunflower oil was added to obtain emulsion form. After that, wheat flour, vanillin, $NaHCO_3$ and K-Sorbate were gradually added and homogenized with emulsion form. This dough was divided into five parts; control, 5, 10, 15 and 20% oat flour as replacer of wheat flour. These treatments were supplemented with 5%, 10%, 15% and 20% FP and compared with control sample (without fish flour), as shown in Table (1). All samples were star-shaped using stainless

steel star, backed in pre-heated electrical dry oven at 185°C for 30min, left at room temperature, and finally packed in polyethylene bags (Fig. 1C).

Table 1. The recipe of biscuits supplemented with different levels of fish powder (FP)

Ingredient	Biscuits supplemented with FP levels				
	Control	5%	10%	15%	20%
Wheat flour	53.34	50.67	48.04	45.34	42.64
Oat	-	2.67	5.30	8.00	10.70
Fish powder	-	5.00	10.00	15.00	20.00
Butter	14.61	14.61	14.61	14.61	14.61
Sun flower oil	14.62	14.62	14.62	14.62	14.62
Sugar	16.64	16.64	16.64	16.64	16.64
$NaHCO_3$	0.68	0.68	0.68	0.68	0.68
K-Sorbate	0.02	0.02	0.02	0.02	0.02
Vanillin	0.09	0.09	0.09	0.09	0.09

-: Not added.

Analytical methods

The moisture, crude protein, lipid content and ash content **(AOAC, 2012)** were determined. Carbohydrate by difference and total energy (**Maclean *et al.*, 2003)** were calculated. The pH value **(Egbert *et al.*, 1992)** was evaluated by using a digital pH meter (Adwa, AD 131). Total volatile basic nitrogen (TVB-N) (**AMC, 1979**), and free amino nitrogen (FAN) **(AOAC, 2012)** were determined. Thiobarbituric acid reactive substances (TBARS value was determined according to the method described by **Tarladgis *et al.* (1960)**. Amino acids content **(AOAC, 2012)** was determined at the Regional center for food and feed (RCFF), Agriculture Research Center, Giza, Egypt. Fatty acids profile **(IUPAC, 1974)** was determined. Total plate count (TPC) and yeasts and molds **(APHA, 1976)** were examined. Sensory tests (appearance, texture, odor, taste, taste after and overall acceptability) were estimated on a 9- point hedonic scale **(Abd-Allah, 2019; Emam *et al.*, 2022)**. Statistical analysis: the results obtained (n=3) were statistically analyzed using SPSS (Ver. 16) and they were expressed as mean±SD standard deviation.

RESULTS and DISCUSSION

Fish powder

Biochemical analysis

Table (2) shows the chemical composition of common carp fish powder (FP). The constituents of carp fish powder were 70.83% crude protein, 22.87% lipids, 3.44% ash and 2.87% carbohydrates content and moisture content did not find. These results show that the fish powder obtained from common carp fish is the important source of protein and lipids content besides it's a good source of minerals. The microbes are absent due to the absence of water content.

Table 2. Chemical composition (%) of common carp fish powder (FP)

Constituent (%)	Value
Moisture	-
Crude protein	70.83± 0.00
Fat	22.87± 0.08
Ash	3.44 ± 0.06
Carbohydrate	2.87 ± 0.01

-: Undetectable

With respect to previous studies, these results disagree with those of **Abd-Allah (2019)**, who showed that the chemical composition of fish protein concentrate (FPC) extracted from common carp waste constituted protein with 87.5%, fat with 3.6% and ash with 8.9%. Additionally, **Emam *et al.* (2022)** elucidated that the chemical composition of grass carp meat powder is composed of moisture (9.66%), crude protein (77.00%), fat (18.00%) and ash content (4.30%). This variation in these data is due to the original source of raw material, season of catch, gender, spawning period, size, age, temperature and times used throughout drying process, etc. **(Shearer, 1994; Hadjinikolova, 2008; Miroslav *et al.*, 2011)**.

Quality attributes

Some quality attributes of FP are presented in Table (3). The data show that carp meat powder have pH 6.51, TVB 9.78 mg/100 g, FAN 1.82 mg/100 g, and TBARS 0.05 mg MDA/kg sample. In addition, TPC was 47.00×10^2 cfu/g sample while yeasts and molds did not appear.

Table 3. Some quality indices of raw common carp powder (FP)

Item	Value
pH value	6.51±0.00
TVB-N(mg/100 g sample)	9.78 ± 1.53
FAN (mg/100 g sample)	1.82 ± 0.06
TBARS (mg MDA/kg sample)	0.05± 0.00
TPC (count × 10^2cfu/g)	47.00±4.24
Yeasts and Molds (count × 10^2cfu/g)	-

-: undetectable

Our data are lower than those recorded in the study of **Abd-Allah (2019)**, who found that the values of TVB-N and TBARs of FPC were 10.10mg/ 100g and 0.14mg MDA/ kg, respectively. Moreover, except pH value, **Emam *et al.* (2022)** demonstrated that the values of TVB-N, TBARS, and pH of common carp meat powder were 29mg/ 100g, 0.22mg MDA/kg and 6.00, respectively, and the TPC value was 1.0×10^2 cfu/g sample. These variations refer to the original source of raw fish, species, as well as the drying conditions **(Shearer, 1994; Hadjinikolova, 2008; Miroslav *et al.*, 2011)**. In addition, the yeast and molds did not appear in fish powder, which agrees with the results of **Immuclate *et al.* (2013)**.

Amino acid composition

The amino acids composition of common carp meat powder (FP) is presented in Table (4). The results showed that the fish powder contained 9 essential amino acids (EAAs). Value of lysine was the highest (50.64 mg/g sample), followed by leucine (39.37 mg/g sample), arginine (31.71 mg/g sample) while the lowest value was found in methionine (1.34 mg/g sample). Additionally, it contained 7 non EAAs, proline recorded the highest value (78.70 mg/g sample), followed by cystine (66.30 mg/g sample), glycine (62.65 mg/g sample) while aspartic was recorded with the lowest value (16.84 mg/g sample). The highest and lowest values of lysine and methionine as EAAs were 50.64 and 1.34 mg/g, and the corresponding values of proline and aspartic as NEAAs were 78.70 and 16.84 mg/g, respectively. Additionally, total EAAs and NEAAs were 166.68 and 319.93mg/ g sample, respectively. Our results of EAAs and NEAAs disagree with their values (12.77 and 56.06g/ 100g sample, respectively) of fish protein concentrate extracted from tilapia by-products (**Ibrahim, 2009)**.

Table 4. Amino acid composition (mg/g sample) of common carp meat powder (FP)

*EAAs	Value	*NEAAs	Value
Histidine	2.73	Aspartic	16.84
Threonine	6.68	Glutamic	48.51
Arginine	31.71	Serine	21.69
Valine	10.41	Glycine	62.65
Methionine	1.34	Alanine	25.24
Phenylalanine	12.74	Cystine	66.30
Isoleucine	11.06	Proline	78.70
Leucine	39.37		
Lysine	50.64	**Total**	**319.93**
Total	**166.68**		

*EAAs: Essential amino acids, **NEAAs: Nonessential amino acids.

Additionally, **Abd-Allah (2019)** studied the amino acid composition of FPC and found that the highest EAA was lysine (24.36 g/16g N) and the lowest was isoleucine (2.05 g/16g N). **Mohamed (2022)** found that the EAAs of dried spider conch (*L. lambis*) meat protein are composed of leucine (5.27%), lysine (4.26%), histidine (0.73%) and cysteine (0.65%), while the values of glutamic and Aspartic as the highest NEAAs were 11.14 and 6.54%, respectively, and the lowest percentages were those for serine (2.73%) and proline (2.14%). Furthermore, **Emam *et al.* (2022)** found that the highest and lowest values of EAAs of carp meat powder were those recorded for lysine (10.31 g/16g N) and methionine (1.91 g/16g N) while glutamine (10.55 g/16 gN) and proline (1.89 g/16g N) recorded the highest and lowest values for the NEAAs, respectively.

Fatty acids composition

The data of fatty acids composition of common carp fish powder (FP) are shown in Table (5). Fish powder contained 6 saturated FAs; the highest and lowest values were 24.810 and 0.04 for palmitic acid (C16:0) and behenic acid (C22:0), respectively. Total

SFAs was 31.31%. On the other side, the corresponding values of unsaturated FAs were 35.65 and 0.26% considering oleic acid (C18:1) and homo-γ-linolenic acid (C18:3).

Table 5. Fatty acid composition of common carp fish powder (FP)

*SFAs	%	**USFAs	%
Butyric acid (C4:0)	-	Myristoleic acid (C14:1)	0.29
Caprylic acid (C8:0)	-	Palmitoleic acid(C16:1)	9.59
Capric acid (C10:0)	-	Oleic acid(C18:1)	35.65
Lauric acid (C12:0)	0.07	Linoleic acid(C18:2)	12.17
Myristic acid (C14:0)	2.34	Linolenic acid(C18:3)	2.95
Palmitic acid (C16:0)	24.8	Homo-γ-linolenic acid(C18:3)	0.26
Stearic acid (C18:0)	3.86	Arachidonic acid(C20:4)	1.05
Arachidic acid (C20:0)	0.20	Eicosapentaenoic acid(C20:5)	2.06
Behenic acid (C22:0)	0.04	Docosahexaenoic acid(C22:6)	0.52
		Erucic acid(C22:1)	0.32
Total	**31.31**	**Total**	**64.86**

*SFAs: saturated fatty acids, **USFAs: Unsaturated fatty acids.
- : Undetectable.

The highest values were registered in the following order: C18:1 (35.65%) > C18:2 (12.17%) > C16:1 (9.59%) whereas the lowest values were found in homo-γ-linolenic acid, C18:3 (0.26%) andC14:1(0.29%). However, values of C20:5 and C20:6 were 2.06 and 0.52%, respectively. Total USFAs was 64.86%. Our data in this study disagree with those reported by **Abou Zeed (2016)**; the highest percentage of saturated fatty acids was recorded for palmitic acid (39.74%) and the lowest was for lauric acid (0.23%), while the corresponding values of oleic and myristoleic were 25.13 and 0.12% of squilla lipids, respectively. In this context, **Mohamed (2022)** found that the highest and lowest values of SFAs were 25.32 and 7.38% of palmitic and myristic acids, respectively, while the corresponding values of oleic and eicosapentaenoic acids as USFAs were 11.34 and 0.47% of dried spider conch meat, respectively. Based on these results, it could be said that fish powder in this study is considered a good source for USFAs (Omeg-3).

Biscuits supplemented with fish powder (FP)

Biochemical composition

The biochemical composition of biscuits supplemented with fish powder is illustrated in Table (6). Data showed that the moisture content wasn't found in all treatments, due to water wasn't added throughout preparation of the ingredients used.

Table 6. Biochemical composition of biscuits supplemented with fish powder (FP).

Constituent (%)	Control	Biscuits supplemented with FP			
		5%	10%	15%	20%
Moisture	-	-	-	-	-
Crude protein	4.40± 0.00	8.80± 0.00	13.13± 0.00	13.13±0.00	17.50±0.00
Fat	30.70± 1.63	29.30± 0.99	28.20±0.64	27.50± 0.28	27.10±0.85
Ash	0.75± 0.071	2.10±0.21	1.19± 0.87	1.43± 0.67	1.40±0.14
Carbohydrates	64.22±1.70	59.93±1.24	57.80± 0.64	57.95±0.92	54.00±0.71
Total energy(Kcal/100g)	550.25±7.85	538.40±3.96	537.27±8.27	531.82±1.13	529.90±4.81

-:Undetectable

Control sample had 4.40% protein, 30.70% fat, 0.75% ash and 64.22% carbohydrates content. These results changed based on the level of fish powder added, so the corresponding ranges were 13.13 - 17.50% protein, 27.10 - 29.30% fat, 1.19 - 2.10% ash and 54.00 -59.93% carbohydrates content. Therefore, it could be found that the protein content increased with increasing the fish powder level, as shown in treatment containing 20% FP. However, the protein content in both treatments containing 10% and 15% followed the same trend (13.13%). In contrast, the fat content was found. Ash levels increased slightly compared to the control sample; this increase fluctuated between different treatments. The results in this work do not match those of **Ibrahim (2009)**; the fish protein concentrate extracted from tilapia by-products is composed of 17.31% moisture, 12.50% crude protein, 22.655 % fat, 7.28 % ash and 40.26% carbohydrates. Additinally, **Abd-Allah (2019)** found that the chemical composition of FPC contained 3.17% moisture, 88.96% protein, 3.26% fat, and 4.61% ash content. **Emam *et al.* (2022)** showed that the chemical composition of snacks containing 10% FP with moisture at 2.68%, crude protein at 18.23%, fat at 2.74 %, ash at 3.50 % and carbohydrates at 72.85%, and the total energy was 388.98 Kcal/100g. This difference is due to pre-mentioned factors beside the recipe used.

Quality attributes

Data in Table (7) exhibit some quality indices of biscuits supplemented with common carp fish powder. The pH value in a particular treatment containing 5% fish powder decreased sharply (6.58) while in other treatments, it was taken the same similar value of control sample (6.83). With regard to the effect of fish powder on the TVN content, it was found that TVN value increased to 8.70mg/100g sample compared to control sample (6.95mg/100gmg/100g sample). The values of FAN were similar (0.30mg/100g sample) in both treatments containing 5% and 10% FP and also in other treatments (0.40 mg/100g sample). Concerning the addition of fish powder into fat quality, TBA value increased with increasing fish powder level compared to control sample (0.58 mg MDA/kg sample) however, its value decreased in treatment containing 5% fish powder (0.55 mg MDA/kg sample). The growth of yeasts and molds did not appear in all samples, with the exception of the control and treatment containing 10% FP. This growth may be due to cross- contamination which occurred during preparation of samples.

Table 7. Some quality indices of biscuits supplemented with fish powder (FP)

Item	Control	Biscuits supplemented with FP			
		5%	10%	15%	20%
pH	6.83±0.00	6.58±0.00	6.82±0.00	6.81±0.00	6.73±0.00
TVB (mg/100g)	6.95± 0.00	8.70± 0.00	8.70± 0.00	8.70± 0.00	8.68± 2.44
FAN (mg/100g)	0.40± 0.07	0.30± 0.00	0.30± 0.07	0.40±0.07	0.40± 0.00
TBARS (mg MDA/kg)	0.58± 0.26	0.55± 0.06	0.97±0.51	0.90± 0.00	1.32 ± 0.40
TPC (count × 10^2 cfu/g)	0.50± 0.71	12.50± 13.44	61.00± 22.60	55.00±4.24	37.50± 6.36
Yeast and Molds count (count × 10^2 cfu/g)	0.50±0.71	-	0.50±0.71	-	-

-: Undetectable.

Our results are lower than those reported by **Abd-Allah (2019)**; the values of TVB-N and TBARS of fish crackers recorded 14.61mg/ 100g and 0.82mg MDA/kg sample, respectively. Additionally, **Emam *et al.* (2022)** reported that values of TVB-N, TBARs and pH of snacks containing 10% FP were 12.60%, 1.64% and 5.81, respectively. Generally, our results of microbial load did not exceed the permissible limit (10^6 cfu/g) and agree with the results of **Immuclate *et al.* (2013)**, who reported that the improper handling, unhygienic conditions could cause a high microbial load on dried fish products.

Sensory evaluation

The scores of sensory properties of biscuits supplemented with fish powder are shown in Table (8). It was found that adding fish powder to biscuits could improve the appearance, color, flavor, texture and total acceptability properties of treatments compared to control sample. However, the scores of taste were similar in all treatments. In this respect, **Ibrahim (2009)** found that salt biscuits containing 5% FPC was the best trial although ash was high content. He concluded that FPC extracted from tilapia by-products can be incorporated in different formula such as salt biscuits. While, **Abd-Allah (2019)** showed no significant differences between the sensory properties of crackers containing 5% and 10% FPC. **Emam *et al.* (2022)**, in their study, reported that the recipe containing fish powder improved properties of dough of snacks, especially that containing 10% fish powder. Furthermore, oat levels used as a replacer of wheat flour up to 20% enhanced the sensory properties of biscuits (**Comino *et al.*, 2015; Duta & Culetu, 2015)**.

Table 8. Sensory attributes of biscuits supplemented with common carp fish powder (FP)

*Property	Control	Biscuits supplemented with FP			
		5%	10%	15%	20%
Appearance	6.50± 2.17	6.70± 1.83	7.10± 1.20	7.30± 1.06	7.45± 0.83
Color	6.50± 2.27	7.10± 1.29	7.45± 1.17	7.35± 1.06	7.60± 0.97
Flavor	7.40± 2.22	7.50± 2.07	7.60± 0.97	7.45± 1.64	8.00± 0.82
Texture	6.60± 2.12	6.60 ± 1.96	7.65± 1.25	7.20± 1.40	7.60± 1.08
Taste	7.30± 1.89	7.40± 1.78	7.30± 1.06	7.30± 0.95	7.30± 1.06
After taste	7.50± 2.22	7.40± 1.71	6.80± 1.32	7.40± 1.27	7.30± 0.82
Overall acceptability	7.00± 2.06	6.80± 1.62	7.40± 0.97	7.20± 1.23	7.10± 1.45

*9- like extremely, 8-like very much, 7-like moderately, 6-like slightly, 5-neither liked nor dislike, 4-dislike slightly, 3-dislike moderately, 2-dislike very much, 1-dislike extremely.

In general, biscuits are being a light, cheap meal and they can be eaten at any time. Fish powder has a high nutritional source of essential amino acids, unsaturated fatty acids and minerals as well as improved the taste, flavor and texture of snacks (**Tacon *et al.*, 2020; Nasser & Amin, 2025)**.

Based on the results obtained for sensory tests, the best treatment was that containing 20% FP compared to the other ones. Therefore, biscuit supplemented with 20% FP was nutritionally evaluated (AAs and FAs) compared with the control sample.

Amino acid composition of control and biscuit containing 20% FP

The results in Table (9) show the amino acid composition of control and biscuit containing 20% FP. The total EAAs were 22.29 and 91.99 mg/g sample of control and biscuit containing 20% FP. Moreover, all EAAs of biscuit supplemented with 20% FP increased markedly compared to the control. The values of leucine (21.22mg/g), followed by lysine (20.59 mg/g sample), and arginine (14.87 mg/g sample) of 20% FP were more than their corresponding values recorded for the control. On the other side, the total non-essential amino acids were 68.52 and 143.90mg/ g sample of control and treatment fish powder containing 20%. In addition, all NEAAs of biscuit supplemented with 20% FP increased compared with the control. The values of glutamic (43.76 mg/g), followed by proline (28.99 mg/g sample), and glycine (16.83 mg/g sample) of 20% FP were more than their corresponding values of control. Furthermore, cystine was found in biscuit containing 20% FP while it wasn't detected in the control sample. Moreover, levels of oat as replacement of flour increased the amino acids too, due to different amino acid sequences that may trigger the immune mediated response **(Comino *et al.*, 2015; Duta & Culetu, 2015)**.

Table 9. Amino acid composition (mg/g) of control and biscuit containing 20% FP

EAAs			NEAAs		
AA	Control	20%	AA	Control	20%
Histidine	1.00	3.30	Aspartic	2.39	11.03
Threonine	0.88	4.00	Glutamic	22.33	43.76
Arginine	4.12	14.87	Serine	3.83	12.87
Valine	2.53	7.88	Glycine	11.19	16.83
Methionine	0.61	3.15	Alanine	4.61	13.06
Phenylalanine	3.02	9.25	Cystine	0.00	10.92
Isoleucine	2.05	7.73	Proline	22.44	28.99
Leucine	5.56	21.22	Tyrosine	1.73	6.44
Lysine	2.52	20.59	**Total**	**68.52**	**143.9**
Total	**22.29**	**91.99**			

*EAAs: Essential amino acids, **NEAAs: Nonessential amino acids.

Similar trend was observed in other studies, **Ibrahim (2009)** reported that biscuits containing 5% FPC had higher values of methionine, tyrosine, histidine, and cystine as non-essential AAs and also aspartic and glutamic acids than control sample. **Abd-Allah (2019)** found that leucine and valine as well as glutamine and glycine were higher in the 5%-fortified crackers than control. In this context, **Emam *et al.* (2022)** found that snacks supplemented with 15% grass carp powder had high values of leucine, valine and lysine as well as glutamine.

Fatty acid composition of control and biscuit containing 20% FP

Table (10) exhibits the fatty acids composition of control and treatment containing 20% fish powder. Adding fish powder led to an increase in all FAs for treatment containing 20%, except C18:2 (27.18%) relative to the control sample (30.64%).

Table 10. Fatty acid composition of control and treatment containing 20% fish powder (FP)

*SFAs	Control	20%	**USFAs	Control	20%
Butyric acid (C4:0)	0.07	0.13	Myristoleic acid (C14:1)	0.32	0.35
Caprylic acid (C8:0)	0.07	0.12	Palmitoleic acid(C16:1)	1.17	1.99
Capric acid (C10:0)	0.22	0.34	Oleic acid(C18:1)	31.97	32.31
Lauric acid (C12:0)	0.51	0.67	Linoleic acid(C18:2)	30.64	27.18
Myristic acid (C14:0)	4.27	4.73	Linolenic acid(C18:3)	0.61	0.84
Palmitic acid (C16:0)	19.17	20.07	Homo-γ-linolenic acid(C18:3)	0.02	0.05
Stearic acid (C18:0)	7.7	7.28	Arachidonic acid(C20:4)	0.05	0.17
Arachidic acid (C20:0)	0.35	0.33	Eicosapentaenoic acid(C20:5)	0.03	0.26
Behenic acid (C22:0)	0.34	0.32	Docosahexaenoic acid(C22:6)	0.01	0.1
Total	**32.7**	**33.99**	**Total**	64.82	63.25

*SFAs: saturated fatty acids, **USFAs: Unsaturated fatty acids.

Based on these results, it could be said that fish powder in this study is considered a good source for unsaturated FAs, in particular omeg-3 FAs. Our results showed that biscuit containing 20% FP had the highest values of palmitic (20.07%) and linoleic (27.18%) compared with 19.17% and 30.64% in the control sample. These data are similar to those reported by **Pasqualone *et al.* (2013)**, who found that palmitic and oleic acids were recorded with the highest values in biscuits enriched with natural anthocyanins. **Caleja *et al.* (2017)**, aligned with this perspective, upon addressing the effect of natural and synthetic antioxidants on the quality of biscuits, found that palmitic and α-linolenic acid recorded the highest values.

CONCLUSION

Carp fish species, although successfully cultured in Egypt, are often underutilized due to the presence of small intramuscular bones and the characteristic of the muddy taste. However, supplementing biscuits with fish powder derived from carp, at levels up to 20%, improved their nutritional quality, particularly when combined with varying levels of oat substituted for wheat flour. Therefore, this study recommends the use of carp fish as a valuable source of fish powder, especially given that these species are generally not favored by most Egyptian consumers.

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