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Biochemical and Sensory Quality of the African Catfish (*Clarias gariepinus*) Spreads

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ABSTRACT

The African catfish (*Clarias gariepinus*) is known for its resilience in extreme conditions; however, it is not widely accepted by most Egyptian consumers. This study aimed to determine the biochemical and sensory quality of fish spread made from the catfish meat, with varying levels of potato substitution. Five treatments were designed: a control (without potatoes) and four treatments with 5, 10, 15, and 20% potatoes. The results showed that the control spread contained 63.24% moisture, 16.05% crude protein, 16.60% fat, 2.25% ash, and 1.68% carbohydrates. Additionally, the quality indices recorded were pH 6.51, TVN 13.02mg/ 100g, TBA 0.23mg MDA/kg sample, and TPC 43×10^2 cfu/g. These values varied with each treatment, showing significant changes in both protein and carbohydrate content. Regarding sensory quality, the fish spread with 10% potatoes received a high score for color, while the treatment with 15% potatoes achieved high scores in color, spreadability, aftertaste, and overall acceptability. In conclusion, spreads made from the catfish were well accepted by panelists, and the inclusion of potatoes up to 15% improved both the biochemical and sensory quality. This study recommends that underutilized catfish be considered a good source for creating suitable fish spreads for all ages.

INTRODUCTION

Aquaculture is growing rapidly to cover the high protein demand for 9 billion human populations by 2050 **(Gebremichael *et al.*, 2023)**. Factors of increasing in population growth, disposable incomes, working women and relative preferences are encouraging to the demand for ready to-eat fishery products **(Venugopal, 2006; Bochi *et al.*, 2008; Kilinc *et al.*, 2008)**. The demand for fishery products as modern life style has been increased due to convenience, nutritional adequacy and good taste. However, spreads are limited and expensive **(Mohanty *et al.*, 2019; Kakatkar *et al.*, 2022)**.

Although fish are a cherished delicacy that can help overcome socio-economic, age, religious, and educational barriers **(Adebayo-Tayo *et al.*, 2008)**, they are also extremely susceptible to microbial contamination **(Abolagba & Uwagbai, 2011)**.

The catfish has gained a wide acceptability due to its unique sensory properties and being a good source of nutritive value required for human **(Abdullahi *et al.*, 2001)**. Fish spreads have good quality and nutritional value in addition to their convenience and shelf life. Moreover, they are regularly consumed and are made from underutilized fish. However, most fish spreads do not contain functional lipid or micronutrients **(Bhattacharya *et al.*, 2012; Rathod *et al.*, 2018)**. Recently, **Kakatkar *et al.* (2022)** studied the shelf life of fish spread processed from Bombay duck (*Harpadon nehereus*) and preserved using gamma rays (5 kGy). They concluded that the developed fish spread was suitable for all consumers. **Mostafa *et al.* (2023)** reported that the protein content decreased by adding feta cheese and ketchup to produce the Indian mackerel and pangasius spreads while carbohydrates, fat and nutritional value increased.

In Egypt, freshwater African catfish (*Clarias gariepinus*) exhibits successful growth under extreme conditions due to its strong resistance to poor water quality. However, it is not widely accepted by most consumers, despite its nutritional value being comparable to that of other species such as tilapia. Therefore, this study was designed to determine the biochemical and sensory quality of fish spreads made from the African catfish (*Clarias gariepinus*) with varying levels of potato substitution (0, 5, 10, 15, and 20%).

MATERIALS AND METHODS

Materials

About 15kg of live catfish (Clarias gariepinus) samples (Fig. 1A) were purchased from the Elkanater Elkaairia market in December 2023. The average weight and length recorded were 1.177 ± 5.74kg and 51.92 ± 8.40cm, respectively. The fish were immediately transferred to the Fish Technology and Processing Laboratory at the National Institute of Oceanography and Fisheries (NIOF), Egypt.

All spices and other additives (potatoes, corn flour, butter, sunflower oil, onion, garlic) were purchased from the local market (Table 1). Food grade-multilayers tubes with screw cover (capacity 50g) were carefully sterilized using heated water and drained.

Technological processes

Catfish samples were manually filleted, washed, soaked in the acid-brine (10% sodium chloride and 0.02% acetic acid) for 10min at 22ºC, rinsed, drained and minced (3mm) using electrical meat mixer. Fish mince was cooked by autoclave at 116ºC for 20 minutes. Moreover, powder spices were well mixed and sautéed with sunflower oil by heating. Potatoes were carefully washed, cut into rings shape, put in pot with enough water and boiled for 30 minutes. Additionally, cooked potatoes were drained, gently minced and shells were discarded.

Table 1. The recipe used in this work

Item	**%**	***Spices mix**	**g**	**%**
Cooked fish mince	65.00	White pepper	0.84	42
Boiled potatoes as Replacer	**0, 5, 10, 15, and 20%**	Cumin	0.52	26
Corn flour	2.44	Cardamom	0.04	2
Butter	10.00	Cubeb	0.06	3
Sunflower oil	10.00	Clove	0.04	2
Carrot	5.40	Red pepper	0.22	11
Fresh garlic	1.00	Coriander	0.20	10
Fresh onion	2.00	Ginger	0.04	2
Sod. chloride	1.50	Cinnamon	0.02	1
Polyphosphate	0.40	Turmeric	0.02	1
Sod. carbonate	0.26			
***Spices mix**	2.00			

Treatments

Five treatments were designed: a control (without potatoes) and treatments with 5, 10, 15, and 20% potato levels replacing fish mince, as shown in Table (2).

Preparation of fish spreads

Cooked fish mince was gently homogenized with sautéed spices and potatoes paste and was then filled in tubes (Fig. 1B). All treatments were autoclaved at 110ºC for 10min, tightly closed, cooled and analyzed.

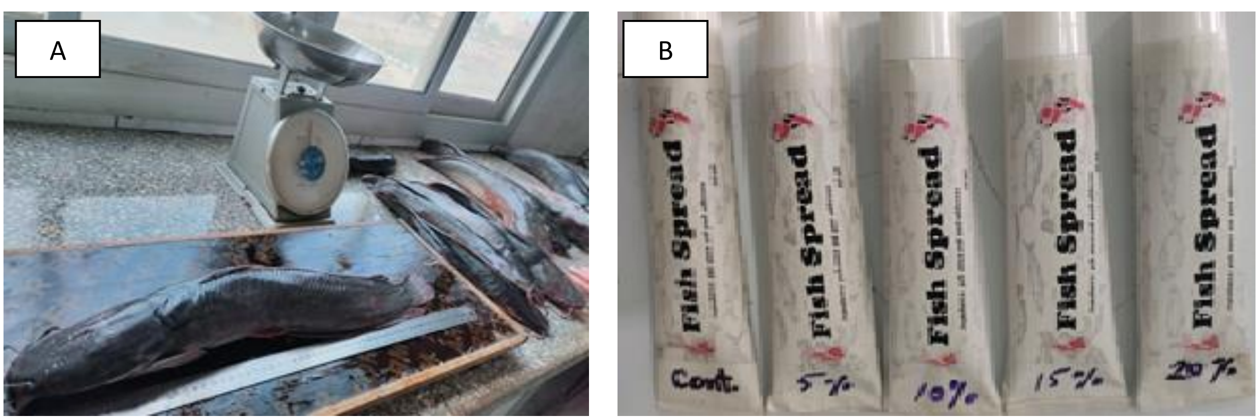

Fig. 1. (A) Raw catfish; **(B)** Its spreads

Table 2. The recipes of fish spreads (kg) used in this study

Item	Treatments				
	Control	**5%**	**10%**	**15%**	**20%**
Cooked fish mince (65%)	650	617.5	585.0	552.5	520.0
Boiled potatoes	-	**32.5**	**65.0**	**97.5**	**130.0**
Additives (35%)					
Butter	100	100	100	100	100
Sunflower oil	100	100	100	100	100
Carrot	54	54	54	54	54
Corn flour	24.4	24.4	24.4	24.4	24.4
Spices mix	20	20	20	20	20
Onion	20	20	20	20	20
Garlic	10	10	10	10	10
Sod. chloride	15	15	15	15	15
Sod. bicarbonate	4	4	4	4	4
Polyphosphate	2.6	2.6	2.6	2.6	2.6

Analytical methods

Moisture, crude protein (calculated as TN × 6.25), fat, and ash content of all treatments were determined according to the methods of **AOAC (2000)**. Salt content, expressed as sodium chloride, was measured following the method of **Mol *et al.* (2010)**. Total carbohydrate content was calculated by difference, as described by **Maclean *et al.* (2003)**. The energetic value (kcal/100 g) of the cooked samples was calculated using the formula:

Energetic value = [(% of carbohydrate × 4) + (% of protein × 4) + (% of fat × 9)]

The pH value of the filtrate was measured using a digital pH meter (Adwa, AD 131) according to the method outlined by **Egbert *et al.* (1992)**. The TBA value was assessed using the method of **Tarladgis *et al.* (1960)**, while the total volatile basic nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N) content were determined following the method of **AMC (1979)**. Additionally, total plate count (TPC) was examined according to **APHA (1992)**.

Sensory tests (including appearance, texture, odor, spreadability, taste, aftertaste, and total acceptability) were evaluated using a 9-point hedonic scale (where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither liked nor disliked, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely) for catfish spreads (Muzaddadi, 2013). The results obtained were statistically analyzed ($P \leq 0.05$) and expressed as mean ± SD using SPSS (Version 16).

RESULTS

Nutritional composition of catfish spreads

The nutritional composition (wet weight) of different catfish spreads is shown in Table (3). The control spread contained moisture at 63.24%; crude protein at 16.05%; fat at 16.60%; ash at 2.25%; and salt at 1.41%, and carbohydrates at 1.68%. With regard to the effect of adding potatoes, the average moisture content ranged from 62.20 to 63.81%; crude protein from 10.88 to 13.66%; fat from 16.11 to 16.49%, ash from 2.12 to 2.34%; salt from 1.52 to 1.76%; and carbohydrates from 5.61 to 7.07% across all treatments containing 5, 10, 15, and 20% potatoes. Additionally, the total energy of the treatments ranged from 219.52 to 222.79kcal/ 100g compared to the control spread at 221.04kcal/ 100g.

Table 3. Nutritional composition of the catfish spreads products

Constituent (%)	Control	Catfish spreads with potatoes			
		5%	10%	15%	20%
Moisture	63.24±0.34	62.20±0.53	63.81±0.02	62.94±0.02	63.27±0.07
Crude protein	16.05±0.93	13.66±0.96	12.41±0.92	12.10±0.14	10.88±0.00
Fat	16.60±3.30	16.19±0.00	16.16±6.31	16.11±1.49	16.49±0.39
Ash	2.25±0.66	2.34±1.50	2.12±0.01	2.12±0.06	2.29±0.08
Salt (sod. chloride)	1.41±0.33	1.76±0.16	1.64±0.33	1.52±0.42	1.76±0.66
Carbohydrates	1.86	5.61	6.11	6.73	7.07
Energetic value (kcal/100g)	221.04	222.79	219.52	220.31	220.21

These results were expressed as mean ± SD.

Quality criteria

Table (4) demonstrates some quality indices of the catfish spread products. The control fish spread had a pH of 6.51, total volatile nitrogen (TVN) of 13.02mg/ 100g, trimethylamine (TMA) of 6.94mg/ 100g, and free amino nitrogen (FAN) of 1.88mg/ 100 g. Additionally, it had an acid value (AV) of 0.38mg/ 100g, a TBA value of 0.23mg MDA/ kg sample, while the total plate count (TPC) was 43 × 10^2 cfu/g sample. These values varied across the other treatments, depending on the different levels of potatoes.

Sensory evaluation

Sensory tests of the catfish spreads products are tabulated in Table (5). The sensory properties were carried out the first day after fish spreads processing by trained panelists. Control fish spread had got slightly scores of appearance, color, flavor, taste, after taste and overall acceptability, while it had got a like moderately of spreadability test. Both treatments containing 5 and 20% potatoes received similar scores for sensory properties. The treatment with 10% potatoes achieved a high score (very much) for color, while the treatment with 15% potatoes scored highly in color, spreadability, aftertaste, and overall acceptability.

Table 4. Some quality indices of raw catfish spreads

Index	Control	Catfish spreads with potatoes levels			
		5%	10%	15%	20%
pH value	6.51±0.03	6.24±0.07	6.39±0.01	6.65±0.01	6.45±0.01
[1]TVBN (mg/100g)	13.02±0.00	10.42±0.00	7.81±0.00	10.42±0.00	7.81±0.00
[2]TMA (mg/100g)	6.94±0.00	7.81±0.00	6.08±0.00	5.21±0.00	6.94±0.00
[3]FAN (mg/100g)	1.88±0.00	2.23±0.06	2.18±0.28	2.15±0.02	2.52±0.00
[4]AV (mg/100g)	0.38±0.04	0.46±0.01	0.41±0.07	0.31±0.01	0.48±0.08
[5]TBARS (mg MDA/ kg)	0.23±0.02	0.70±0.08	0.25±0.08	0.38±0.02	0.34±0.06
[6]TPC (cfu/g)	43± 4.24×10^2	61±9.90×10^2	25±1.41×10^2	56±2.82×10^2	52±1.06×10^2

These results were expressed as mean ± SD. [1]TVN: total volatile basic nitrogen; [2]TMA: trimethylamine nitrogen; [3]FAN: free amino nitrogen; [4]AV: acid value; [5]TBARS: thiobarbituric acid reactive substances; [6]TPC: total plate count.

Table 5. Sensory evaluation of the catfish spreads

Test	Control	Catfish spreads with potatoes levels			
		5%	10%	15%	20%
Appearance	6.94±1.27	7.81±1.00	7.94±0.77	7.94±0.56	7.81±0.96
Color	6.81±1.31	7.56±1.29	8.00±1.10	8.25±0.76	7.69±0.88
Flavor	6.31±1.33	7.63±0.69	7.50±1.20	7.69±1.10	7.50±0.71
Spreadability	7.06±1.32	7.50±0.89	7.81±0.84	8.31±0.53	7.44±0.90
Taste	6.44±1.35	7.19±1.13	7.75±1.16	7.63±1.30	7.75±0.46
After taste	6.75±0.89	7.38±1.19	7.56±1.45	8.00±0.96	7.75±0.46
Overall acceptability	6.75±1.49	7.63±1.30	7.94±0.86	8.13±0.88	7.81±0.65

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.

DISCUSSION

In this work, the results align with other studies that indicate the nutritional requirements of ready-to-eat fish products, which are due to their content of moisture, proteins, lipids, minerals, and vitamins. These characteristics have contributed to the increasing demand among consumers **(Pagarkar *et al.*, 2011; VKM, 2014; Nikmaram *et al.*, 2018; Emam *et al.*, 2016, 2022)**.

The moisture content of catfish spreads (Table 3) is consistent with the findings of **Freitas *et al.* (2012)**, who reported 62.17% for tilapia spread, as well as final spread products from **Khater and Farag (2016)** and mackerel and pangasius spreads ranging from 54.10 to 63.50% **(Mostafa *et al.*, 2023)**. This moisture content is higher than the 56.12 to 58.12% found in tilapia spreads **(Minozzo *et al.*, 2008)**.

Regarding protein content, all samples except the control (Table 3) were comparable to the 12.75% reported for fish spread by **Kakatkar *et al*. (2022)**. This protein level is higher than the 8.77% to 9.69% found in tilapia spreads **(Minozzo *et al.*,**

2004), 8.53% **(Minozzo *et al.*, 2008)**, 9.75% **(Freitas *et al*., 2012)**, and 9.75% **(Khater & Farag, 2016)**, but lower than the 19.8% to 21.50% reported by **Mostafa *et al.* (2023)**.

The results of fat content (Table 3) are lower than 27.41% **(Minozzo *et al.*, 2004)**, 26.12-28.15% (**Minozzo *et al.*, 2008)**, 18.81% (**Freitas *et al.*, 2012; Khater & Farag, 2016)**, and higher than 3.53% **(Kakatkar *et al.*, 2022)** and 4.10-13.30% (**Mostafa *et al.*, 2023)**. The ash content in this study aligns with the finding of **Minozzo *et al*. (2004)**, who reported a value of 2.20%, and corroborates with the value of 2.11%, recorded in the studies of **Freitas *et al.* (2012)** and **Khater and Farag (2016)**. While, the current result is higher than 1.51%, noted by **Kakatkar *et al.* (2022)**. However, it is lower than the range of 3.01 to 3.26% reported by **Minozzo *et al*. (2008)** and that (4.00 to 4.30%) detected by **Mostafa *et al*. (2023)**. Additionally, both carbohydrate content and total energy varied depending on the recipes used.

The pH values reported in this study are slightly higher than those found in mackerel (6.15) and pangasius (6.21) spreads **(Mostafa *et al.*, 2023)**. Moreover, it is greater than the values for the salmon (6.09), herring (5.78), and anchovy pastes (5.64) **(Khater & Farag, 2016)**. On the other hand, the total volatile nitrogen (TVN) content for the control treatment is consistent with **Khater and Farag (2016)**, who reported TVN values of 13.80, 13.92, and 14.36mg/ 100g for herring, salmon, and anchovy pastes, respectively.

For the other treatments, while TVN values concur with previous studies, trimethylamine (TMA) content varied; **Kakatkar *et al.* (2022)** found TMA values of 3.51mg/ 100g. In contrast, our results showed a notable decrease in TVN compared to the higher values of 32.08 and 21.67mg/ 100g for the mackerel and pangasius spreads, respectively **(Mostafa *et al*., 2023)**. Overall, the TVN and TMA values in this study remain within the acceptable limits established by **Connell (1990)**, which are 35 and 15mg/ 100g, respectively.

The thiobarbituric acid (TBA) values (Table 4) are lower than those reported for anchovy, salmon, and herring pastes (1.73, 2.26, and 1.30mg MDA/kg, respectively) **(Khater & Farag, 2016)**; whereas, they are lower than the 1.67mg MDA/kg found by **Kakatkar *et al.* (2022)** and the values for mackerel (2.03mg MDA/kg) and pangasius spreads (2.67mg MDA/kg) **(Mostafa *et al.*, 2023)**.

The total plate count (TPC) in this study (Table 4) is lower than the values reported for salmon, herring, and anchovy pastes (5.34, 5.35, and 5.53 log cfu/g, respectively) **(Khater & Farag, 2016)** and 2.42 log cfu/g from **Kakatkar *et al.* (2022)**. However, it is higher than the TPC values for mackerel and pangasius spreads, which ranged from 1.8×102 to 3.1×102 and 8.1×103 to 9.7×103 cfu/g, respectively **(Mostafa *et al.*, 2023)**. This indicates a relatively good microbial quality for the catfish spreads developed in this study.

Regarding sensory properties, the catfish spreads (Table 5) did not exhibit any fishy odor, though a strong fishy taste was detected during sensory analysis. Despite this, all fish spread products were accepted, aligning with the findings of **Aquerreta *et al.* (2002)**. The absence of fishy odor in our study can be attributed to the pre-soaking of fish fillets in acid-brine, the addition of spices, and the deodorization achieved through autoclaving during cooking. This is consistent with the outcomes of **Bhattacharya *et al.* (2012)**, who noted that autoclaving effectively minimized strong fishy odors. Additionally, **Freitas *et al.* (2012)** found that spreads seasoned with salt were preferred by the largest number of panelists.

Our results agree with those of **Mostafa *et al.* (2023)**, who reported that sensory scores for mackerel and pangasius spreads ranged from very good to good. Moreover, **Kakatkar *et al.* (2022)** observed a correlation between sensory scores and microbiological quality, reinforcing the importance of these factors in consumer acceptance.

Overall, the variations between our results (Table 3) and those of previous studies can be attributed to differences in fish species, types and quantities of ingredients used, as well as processing conditions. These factors play a significant role in determining the sensory qualities of fish products.

CONCLUSION

The catfish is often considered unappealing to many consumers in Egypt, likely due to its appearance, feeding behavior, and associated sounds. This study aimed to develop fish spreads that leverage the nutritional benefits of the catfish while addressing these disadvantages. The findings revealed that both the raw catfish and its spreads possess high nutritional value and quality indices. Furthermore, the incorporation of potatoes significantly enhanced the biochemical, safety, and sensory qualities of the catfish spreads.

In conclusion, this work recommends utilizing the catfish to create delicious products viz. spreads that can appeal to consumers of all ages. By promoting these spreads, it may be possible to improve the acceptance of the catfish in the market and expand its culinary applications.

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