Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 28(6): 2105 – 2116 (2024)
www.ejabf.journals.ekb.eg

Production and Economic Evaluation of the Common Carp Spreads

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ARTICLE INFO

Article History:
Received: Oct. 31, 2024
Accepted: Dec. 18, 2024
Online: Dec. 28, 2024

Keywords:
Fish spreads,
Quality criteria,
Economic evaluation

ABSTRACT

In Egypt, the cultivation of carp fish species has proved a remarkable success. However, most consumers do not accept them. Therefore, the aim of this study was to use carp fish meat to produce fish spreads with varying levels of potato (0, 5, 10, 15, and 20%) as a substitute and to evaluate their economic viability. The results showed that adding potatoes led to a decrease in moisture, protein, and ash content, while carbohydrate levels increased with higher potato inclusion compared to the control sample. Additionally, pH, TVN, TMA, and TPC values decreased, while TBA values fluctuated. Fat content remained similar across all samples. The addition of 15% potatoes, followed by 5%, resulted in the most favorable sensory properties compared to the control sample. The total energy content increased in the treatments compared to the control, although total protein content gradually decreased. Economically, the control product had a higher return (71.59%) compared to the other treatments (21.06 - 65.14%), based on shadow prices for minced fish products. This study recommends using carp mince in ready-to-eat products, as they are highly accepted by consumers of all ages. Furthermore, adding potatoes, particularly at the 15% level, improved many quality indices of carp fish spreads.

INTRODUCTION

Carp fish is one of the most widely cultured species due to its fast growth rate, ease of cultivation, and high feed efficiency ratio. However, it has low consumer preference and a limited market because of its intramuscular bones and unpleasant odor. As a result, many studies have focused on alternative products made from carp, such as fish burgers, sausages, balls, chips, and other products **(Shabanpour *et al.*, 2007; El-Sherif & Ibrahim, 2012; Abul-Fadel *et al.*, 2018; Eman *et al.*, 2016, 2022)**. The chemical composition of the raw common carp (*Cyprinus carpio*) meat ranges from 70.47-73.4% moisture, 15.6-16.26% protein, 7.98-12.24% lipid, and 0.68-0.71% ash content **(Elsayed *et al.*, 2016; Mahmoud, 2017)**. In modern times, the convenience, nutritional adequacy, and good taste of ready-to-eat products, such as fish spreads, have become an integral part of contemporary lifestyles. While some fish spreads are limited in availability and expensive, they are suitable for all consumers. Fish spreads, as value-added products, are made from underutilized and unmarketable fish species, as reported by several researchers **(Bhattacharya *et al.*, 2012; Shakerardekani *et al.*, 2013; Rathod *et al*., 2018; Mohanty *et al*., 2019; Kakatkar *et al.*, 2022; Mostafa *et al*., 2023)**. Therefore, this study aimed to evaluate the production of fish spreads using the common carp fish mince, with varying levels of potato replacement (0, 5, 10, 15, and 20%), along with an economic assessment.

MATERIALS AND METHODS

Materials

Carp fish

About 9kg of common carp (*Cyprinus carpio*) samples were obtained from Elserw Fish Farm, National Institute of Oceanography and Fisheries (NIOF), in December 2023. The fish were immediately transferred to the Fish Technology and Processing Lab at NIOF. The average weight and length of the samples were recorded as 2.23 ± 0.78kg and 46.88 ± 1.49cm, respectively.

Food ingredients and plastic tubes

Corn flour, potatoes, butter, sunflower oil, onion, garlic, sodium chloride, sodium polyphosphate, sodium bicarbonate, spices, as well as plastic tubes with screw cover (capacity 125g) were purchased from local market.

Processing of fish spread

The carp fish samples were manually filleted, washed, and soaked in a brine solution containing 10% sodium chloride and 0.02% acetic acid for 10 minutes. They were then rinsed, drained, and minced (3mm) using an electric meat mixer. The fish mince was cooked by autoclaving at 116ºC for 20 minutes. The powdered spices were sautéed in sunflower oil by heating. Potatoes were carefully washed with tap water, peeled, boiled in enough water, drained, and then gently minced. Plastic tubes were sterilized using pre-heated water, drained, and prepared for use.

The cooked fish mince and other ingredients were manually mixed and divided into five groups, with the fish mince replaced by 0 (control), 5, 10, 15, and 20% potatoes (Table 1). All treatments were then filled into tubes (Fig. 1), autoclaved at 110ºC for 10 minutes, cooled, and subsequently analyzed.

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Fig. 1. Carp fish spreads treatments

Table 1. The recipe and treatments used in this work

Item	%	*Spices mix	g	%
Fish mince	65.00	White pepper	0.84	42
Treatments (potatoes levels)	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
Sod. polyphosphate	0.40	Turmeric	0.02	1
Sod. birbonate	0.26			
*Spices mix	2.00			

Methods

Biometric parameters, including total length, weight, gender of carp samples and yield (meat wt. (kg)/total wt.(kg)×100) were measured. The chemical composition, including moisture, crude protein (TN×6.25), fat and ash content were determined according to the method of **AOAC (2000)**. The total carbohydrates content was calculated by difference, as described by **Maclean *et al*. (2003)** as follows:

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

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

Sensory tests (appearance, texture, odor, spreadability, taste, aftertaste, and total acceptability) of the catfish spreads were evaluated by panelists using a 9-point Hedonic Scale (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, 1 = dislike extremely), as described by **Muzaddadi (2013)**.

The results were statistically analyzed (*P*≤ 0.05) and expressed as mean ± SD using SPSS (version 16).

RESULTS

Raw carp fish

Table (2) shows some biometric parameters of raw common carp samples. The mean length and weight of the common carp samples were 46.88±1.49cm and 2.23 ±0.78kg, respectively. All samples were female, with yield and waste values of 35% and 65%, respectively.

Table 2. Biometric parameters of the raw common carp fish

Item	Value
Total length	46.88±1.49 cm
Total weight	2.23 ±0.78 kg
Gender	Female
Yield	35%
Waste	65%

Carp fish spreads

Nutritional composition

The chemical composition of carp fish spreads (ww) are presented in Table (3). The results showed that the moisture content of fish spreads containing different levels of potatoes ranged from 58.02 to 58.99%, while the control spread recorded 63.24%. The crude protein content ranged from 12.12 to 14.12% in the fish spreads with potatoes, while the control contained 15.71%. The ash content ranged from 3.16 to 3.89%, with the control showing a slight increase at 4.01%. The total energy of the spread treatments studied was influenced by the ingredients used in each treatment.

Table 3. Chemical composition of carp spreads (ww)

Constituent (%)	Control	Fish spread with different replaced potatoes levels			
		5%	10%	15%	20%
Moisture	63.24±0.73	58.02±1.15	58.99±1.83	58.82±1.56	58.42±1.11
Protein	15.71±1.17	14.12±1.15	13.88±0.00	13.10±0.12	12.12±1.09
Fat	15.07±1.14	15.66±1.85	15.16±1.09	15.45±1.17	15.88±1.41
Ash	4.01±0.12	3.89±1.18	3.16±0.32	3.36±1.07	3.86±0.28
Salt content	2.31±0.28	2.63±0.22	2.38±0.18	2.37±0.21	3.22±0.41
*Carbohydrates	1.97	8.31	8.81	9.27	9.72
Total energy (Kcal/100g)	206.35	230.66	227.20	228.53	230.28

Results (n=3) were expressed as mean ± SD. *Carbohydrates percent calculated by difference.

Quality indices

Table (4) shows some quality indices of carp spreads. The pH values were lower in the treatments containing potatoes (6.67–6.70) compared to the control spread (6.84). The acid value (AV) was higher in the spreads with potatoes, ranging from 0.09 to 0.14mg KOH/g sample compared to the control (0.08 mg KOH/g sample). The TBA values decreased to 0.03 and 0.02mg MDA/kg sample in the 5 and 10% potato treatments, respectively, while they increased in the 15 and 20% potato treatments compared to the control (0.06mg MDA/kg). On the other hand, the TVN value decreased in all treatments containing potatoes (25.90mg/ 100g sample) compared to the control spread (28mg/ 100g sample). A similar trend was observed in the TMA values. Finally, the FAN value was lower in the control spread (1.01%) than in the spreads containing potatoes, which ranged from 1.09 to 1.25%.

Table 4. Quality indices of carp spreads

Quality indices	Control	Fish spread with different potatoes levels			
		5%	10%	15%	20%
pH value	6.84±0.15	6.70±0.13	6.70±0.16	6.67±0.11	6.76±0.03
Acid value (mg KOH/g)	0.08±0.00	0.09±0.01	0.09±0.02	0.10±0.01	0.14±0.03
[1]TBA (mg MDA/kg)	0.06±0.00	0.03±0.00	0.02±0.00	0.37±0.00	0.41±0.00
[2]TVB–N (mg / 100gm)	28.00±0.16	25.90±0.07	25.90±0.00	25.90±0.07	25.90±0.07
[3]TMA-N (mg / 100gm)	7.81±0.21	6.94±0.13	6.94±0.07	6.08±0.17	6.08±0.27
[4]FAN (%)	1.01±0.07	1.09±0.02	1.21±0.04	1.25±0.02	1.14±0.23
[5]TPC ($\log_{10}$ cfu/g)	5.26±0.54	5.09±0.62	5.03±0.73	4.36±0.83	5.02±0.84

Results (n=3) were expressed as mean ± SD. [1]TBA: thiobarbituric acid; [2]TVB-N: total volatile basic nitrogen; [3]TMA-N: trimethyleamine nitrogen; [4]FAN: free amino nitrogen;and [5] TPC:total plate count.

Regarding microbial load, TPC values were lower in all spreads containing potatoes, especially the 15% treatment (4.36–5.09 log cfu/g), compared to the control (5.26 log cfu/g).

Sensory properties

The sensory properties of carp spreads, as evaluated by trained panelists, are presented in Table (5). The appearance score of the control was lower than the scores for the other treatments containing potato levels, except for the 10% treatment, based on the panelists' evaluations.

Similar scores were noted in colour, flavour and spreadability scores. Treatment containing 15% potatoes has got the best scores of taste, after taste and overall acceptability followed by 5% treatment than the other ones.

Table 5. Sensory properties of fish spreads

Property	Control	Fish spread with different replaced potatoes levels			
		5%	10%	15%	20%
Appearance	6.83±1.15	8.00±1.13	6.83±1.16	7.83±1.21	8.00±1.03
Color	7.50±1.09	8.00±1.31	7.00±1.22	8.00±1.21	8.00±1.13
Flavor	6.83±1.18	8.00±1.09	6.83±1.19	7.50±1.18	7.17±1.17
Spreadability	7.17±1.26	7.50±1.27	7.17±1.15	7.83±1.22	7.50±1.21
Taste	7.50±1.22	7.88±1.24	7.25±1.12	8.00±1.23	6.88±1.10
After taste	7.67±1.17	7.33±1.12	7.67±1.24	8.00±1.02	6.33±1.23
Total acceptability	7.00±1.34	8.00±1.22	7.00±1.23	8.00±1.23	7.00±1.14

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.

Economic evaluation

Table (6) shows the prices of common carp and its by-products used in this study to produce one kg of common carp fish spreads. The price of 8kg of whole common carp was estimated at 400 Egyptian pounds (EP). Therefore, the cost of the 2.925kg of fish mince used was estimated at 415.25 EP. Approximately 1.5kg of fishmeal was obtained from the remaining waste.

Table 6. Total prices of fish, fish mince, and fishmeal

Item	Quantity (kg)	Price (EP)
Common carp fish	8.00 kg	400
Fish mince used	2.925 kg	415.25
Waste	5.075kg	1.50 kg (fishmeal)

The total cost of the different common carp fish spread products is shown in Table (7). The total costs were estimated at 158.50 EP for the control, and 153.90, 146.59, 140.47, and 134.68 EP for spreads containing 5, 10, 15, and 20% potatoes, respectively.

Table 7. Total costs (estimated per one kg fish spread) of different carp fish spread products

Recipe (%)	Treatments				
	Control	5%	10%	15%	20%
Fish mince	92.89	88.24	83.60	78.91	74.31
Potatoes	-	0.29	0.78	1.17	1.56
Butter	4.00	4.00	4.00	4.00	4.00
Sunflower oil	4.00	4.00	4.00	4.00	4.00
Carrot	0.25	0.25	0.25	0.25	0.25
Corn flour	0.55	0.55	0.55	0.55	0.55
Spices mix	3.30	3.30	3.30	3.30	3.30
Onion	0.83	0.83	0.83	0.83	0.83
Garlic	0.41	0.41	0.41	0.41	0.41
Sod. Chloride	0.20	0.20	0.20	0.20	0.20
Sod. Bicarbonate	1.30	1.30	1.30	1.30	1.30
Polyphosphate	3.70	3.70	3.70	3.70	3.70
Plastic tube	2.50	2.50	2.50	2.50	2.50
Cost of processing (40%)	45.57	42.83	41.17	39.45	38.76
Total costs (EP)	159.50	153.90	146.59	140.47	135.67

The economic return of the produced carp spread products is shown in Table (8). Eight hard plastic tubes were used for each kilogram of product. According to data in Table (8), the control recorded the highest net gain at 65%, followed by 56, 47, 42, and 18% for spreads containing 5, 10, 15, and 20% potatoes, respectively.

Table 8. Economic return of different carp spread products (estimated per one kg fish spread)

Treatment	Price of like products	No. packs	Actual cost	Gain	Net gain	% Net gain
Control	32	8	158.50	256	97.50	65
Treatment 5%	30	8	153.90	240	86.10	56
Treatment 10%	27	8	146.59	216	69/41	47
Treatment15%	25	8	140.47	200	59.55	42
Treatment 20%	20	8	134.68	160	25.32	18

DISCUSSION

It is well known that carp fish species have been successfully cultured in Egypt; however, their meat contains small spines and an unpleasant odor. Therefore, the present study aimed to explore the possibility of utilizing carp as an underutilized fish to obtain a modern, safe, and high-quality product. Fish spread products are ready-to-eat, convenient options that cater to modern lifestyles, all age groups, and meet consumers' nutritional needs (Table 1 & Fig. 1). Adding different levels of potatoes serves several purposes: providing a carbohydrate source, enhancing spreadability, and reducing costs. **Bhattacharya *et al.* (2012)** demonstrated that fish spreads are commonly consumed and prepared from low-economic fish species, which typically lack sufficient macronutrients and micronutrients. Furthermore, modernizing these products led to the development of healthy, wholesome, and nutritious options that contain low salt, low sugar, and high protein and fiber content **(Qian & Ichikawa, 2013; Tahergorabi *et al.*, 2015)**.

Our data (Table 3) aligns with those in previous studies that highlight the nutritional benefits of ready-to-eat fish products. These muscle food products (such as fish patties, balls, burgers, cutlets, sausages, and spreads) contain water, high-quality proteins, ω-3 fatty acids, selenium, iodine, and vitamin D, making them popular among both rich and poor consumers **(Pagarkar *et al*., 2011; VKM, 2014; Tahergorabi *et al*., 2015; Emam *et al*., 2016, 2022; Abul-Fadel *et al*., 2018; Nikmaram *et al*., 2018)**. However, our data (Table 3) differ from those of **Khater and Farag (2016)**, who reported that the moisture, protein, lipid, and ash contents of salmon, herring, and anchovy pastes ranged from 29.1-31.35%, 47.99-52.59%, 3.76-4.34%, and 2.9-3.05%, respectively. The protein content in this study (Table 3), excluding the fat content, varied and is in agreement with that of **Kakatkar *et al.* (2022)**, who found that fish spreads made from the Bombay duck (*Harpadon nehereus*) had a high protein content (12-14%), low fat content (3-5%), and no sugar. They added that fish spreads could provide desired health benefits without the need for additional dietary supplements. Additionally, **Mostafa *et al.* (2023)** reported that the proximal composition of spread products made from the Indian mackerel and *Pangasius* consisted of 63.5% and 54.1% moisture, 21.5% and 19.8% protein, 4.1% and 13.3% fat, 4.0% and 4.3% ash, 10.2% and 8.5% carbohydrates, and 163.7 and 232.9 kcal/100g of nutritional value, respectively.

In general, adding potato levels instead of fish meat led to a significant reduction in water, protein, and ash content. However, fat content remained similar across all treatments. Overall, the addition of potatoes in fish spreads resulted in a decrease in moisture, protein, and ash, while carbohydrates increased with the level of potatoes used. Furthermore, total energy increased in the treatments compared to the control sample, despite a gradual decrease in total protein.

Data in Table (4) show that the pH values (6.67–6.84) of the carp spread products were slightly higher than the 6.09, 5.78, and 5.64 pH values of salmon, herring, and anchovy pastes, respectively **(Khater & Farag, 2016)**, and also higher than the 6.15 and 6.21 pH values of mackerel and pangasius spreads, respectively **(Mostafa *et al.*, 2023)**. The TVN and TMA values were lower than the prescribed limits of 35mg/ 100g and 15 mg N/100g, respectively, indicating a fresh original sample **(Khater & Farag, 2016)**. The TBA value in good quality material should be ≤3 and ≥5 in extremely good material **(Sinnhuber, 1958; Connell, 1990; Varlik *et al*., 1993)**. TVN and TBA values in our study differed from those of **Khater and Farag (2016)**, who reported TVB-N values of 13.80, 13.92, and 14.36mg/ 100g in herring, salmon, and anchovy pastes, respectively. The TBA values were 1.73, 2.26, and 1.30 mg MDA/kg, respectively. Recently, **Kakatkar *et al*. (2022)** found that TVN, TMA, and TBA values in the Bombay duck fish spreads were 8.4, 3.51, and 1.67mg MDA/kg, respectively. **Mostafa *et al.* (2023)** found TVN values of 32.08 and 21.67mg/ 100g, and TBA values of 2.03 and 2.67mg MDA/kg, respectively, for mackerel and pangasius spreads. The variation in these results is likely due to differences in fish species, food additives, and processing methods.

Microbial load is a quality marker for determining the shelf life of food products and the potential for harmful microorganism growth **(Arvanitoyannis *et al.*, 2005)**. The TPC in this study ranged from 4.36 to 5.26 log cfu/g for carp spread products (Table 4), which was higher than the acceptable limit of 30-300 cfu/g for fish spreads **(Bhattacharya *et al.*, 2012)** and also higher than the 3.86-3.92 and 3.91-3.99 log cfu/g in Indian mackerel and pangasius spreads, respectively **(Mostafa *et al.*, 2023)**. However, our results were lower than those reported by **Khater & Farag (2016)**, who found total aerobic counts of 5.34, 5.35, and 5.53 log cfu/g in salmon, herring, and anchovy pastes, respectively, and lower than **Kakatkar *et al*. (2022)**, who reported an initial bacterial load of 2.42 log cfu/g in fish spread. In general, adding potatoes led to a decrease in pH, TVN, TMA, and TPC; however, it caused a slight increase in AV, while TBA values fluctuated.

In this study, adding potatoes up to a 15% level improved most sensory properties of the carp spreads, although all spreads were accepted by panelists (Table 5). These results align with those reported by **Aquerreta *et al.* (2002)**, who found that although a strong fishy taste was detected in fish spreads made from tuna liver and mackerel meat, all these products were considered acceptable. **Minozzo (2005)** confirmed that a creamy spread made from tilapia fillets met legal specifications and was well-marketed. Furthermore, the flavor test (Table 5) agrees with that of **Bhattacharya *et al.* (2012)**, who observed that the odor of spreads could be minimized by extending deodorization during autoclaving. **Freitas *et al.* (2012)** showed that the overall impression, appearance, and flavor of tilapia spread produced with common salt were considerably poorer than those prepared with seasoned salt, although both products were well accepted. The sensory scores of the Indian mackerel and pangasius spreads were rated as very good and good, respectively **(Mostafa *et al.*, 2023)**. In general, sensory scores were closely linked to other quality indices investigated in this work, as observed by **Kakatkar *et al.* (2022)**, who found a correlation between sensory scores and microbiological quality. Based on these results, adding potatoes up to 15%, followed by 5%, improved most sensory properties of the fish spreads compared to the control.

Economically, the control product (without added potatoes) had a higher return (71.59%) than the other treatments, which ranged from 21.06% to 65.14% according to shadow prices. These spreads are suitable for all consumers, both in terms of nutritional value and affordability (Tables 6, 7, and 8). It was observed that the price of spreads decreased with an increase in the percentage of potatoes. However, adding potatoes improved the spreadability of the product compared to the control spread.

CONCLUSION

In conclusion, the data obtained in this study indicate the potential for utilizing common carp fish to produce fish spreads as ready-to-eat products that align with modern lifestyles. Additionally, the inclusion of various levels of potatoes improved the physical, chemical, and microbial quality indices of the spreads, despite a decrease in protein content as the potato levels increased. From an economic perspective, the different fish spread products are suitable for families of varying income levels, while also meeting their nutritional requirements.

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