ARCHIVOS LATINOAMERICANOS DE NUTRICION
Organo Oficial de la Sociedad Latinoamericana de Nutrición Vol. 58 Nº 1, 2008

Fatty acid concentration, proximate composition, and mineral composition in fishbone flour of Nile Tilapia

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SUMMARY. Nile tilapia (*Oreochormis niloticus*) fishbone is a fish part with unknown composition. After elaboration of flour fishbone of tilapia it was analysede. The results in100g of flour were: moisture (14.2%), protein (40.8%), total lipids (25.3%), and ash (18.3%), and mineral (in 100g) was 2715.9mg (calcium), 1.3mg (iron), and 1132.7mg (phosphorus). A total of 22 fatty acids were detected in fishbone flour total lipids (TL), being the major ones in (g) of total lipids: 16:0 (208.5mg); 18:1n-9 (344.3mg); and 18:2n-6 (109.6mg). The concentration of linolenic acid - LNA (18:3n-3); eicopentaenoic acid - EPA (20:5n-3), and docosahexaenoic acid - DHA (22:6n-3) were (29.9mg), (3.3mg), and (12.9mg), respectively. The content to saturated (SFA) were (296.2mg), monounsaturated (MUFA) 415.0mg, and polyunsaturated (PUFA) 175.6mg. The ratio PUFA:MUFA:SFA was 1:2.4:1.7, and the ratio omega-6/omega-3 fatty acids were 2.8. The last is within the recommended values. The results show low concentrations of omega-3 fatty acids in flour. The value caloric and calcium, iron, phosphorus, and protein content the fishbone flour of tilapia may results a valuable alternative food in the human diet.

Keywords: Fatty acid, proximate analysis, minerals, fish, flour, Nile tilapia, fishbone.

RESUMEN. Concentración de ácidos grasos, composición centesimal y composición mineral en harina del espinazo de Tilapia del Nilo. El espinazo de tilapia (*Oreochormis niloticus*) es una parte del pescado con composición desconocida. Se obtuvo y analizó la harina de espinazo de tilapia. Los resultados hallados cada 100 gramos de producto fueron: humedad (14,2g), proteina (40,8g), lípidos totales (25,3g), cenizas (18,3g) y calorias (391Kcal). El contenido de minerales en 100g fue calcio (2715,9mg), hierro (1,3mg), y fósforo (1132,7mg). Un total de 22 ácidos grasos fueron encontrados en los lípidos totales de la harina de espinazo, siendo los mayoritarios por g de lípidos totales:16:0 (208,5mg); 18:1n-9 (344,3mg) y 18:2n-6 (109,6mg). La concentración de ácido linolênico - LNA (18:3n-3); ácido eicosapentaenóico - EPA (20:5n-3), y ácido docosahexaenóico - DHA (22:6n-3) fueron (29.9mg), (3.3mg), y (12.9mg), respectivamente. El contenido de los saturados (SFA) fue 296,2mg, monoinsaturados (MUFA) 415,0 mg y polinsaturados (PUFA) 175,6mg. La razón PUFA:MUFA:SFA fue 1:2,4:1,7 y la razón ácidos grasos omega-6/ácidos grasos omega-3 fue 2,8. Esta última está de acuerdo con los valores recomendados. Los resultados mostraron bajas concentraciones de ácidos grasos omega 3 en la harina; sin embargo, por su aporte calórico, y por su contenido de calcio, hierro, fósforo y proteínas la harina del espinazo de tilapia puede resultar una alternativa interesante para la dieta humana.

Palabras claves: Ácidos grasos, composición centesimal, minerales, pescado, harina, tilápia del Nilo, espinazo.

INTRODUCTION

Nile tilapia (*Oreochromis niloticus*), a species of African origin, is one of the most farmed fish in the tropical and subtropical regions all over the world (1,2), and favored by its rusticity, fast growth, adaptation to diverse environments, good consumer acceptance and high quality, low fat content, and absence of intramuscular "y" shaped bones (3). However, many times the processing of the fillet of this species produces parts that are not used, mainly the head, skin, viscera, and bones. Fishbone is constituted by the remaining meat after the removal of the fillet, bones, and cartilages. Many times it is used as a foodstuff in the form of soups, broths, etc.

We point out that there are no reports in either the national or international literature on the fatty acid and mineral composition of Nile tilapia fishbone flour, which prompted us to evaluate its nutritional value.

MATERIAL AND METHODS

Sampling

Nile tilapia (*Oreochromis niloticus*) were raised in culturing tank (240m^2) and given commercial feed (Acqua fish 28, Supra®, São Leopoldo - Brasil) ad libitum during 6 months. The head, fillets, skin, viscera, and fishbone of 40 Nile tilapia were removed. The fishbone were washed with deionized water and steam-cooked for 25min. After cooking, fishbones were ground in an endless-screw grinder and dried on a tray

in oven for 4h at 180ºC. Next, the flour was sieved in a 14mesh stainless steel sieve. The product obtained, referred to as Nile tilapia fishbone flour, was packed in polyethylene bags, wrapped in aluminum foil after removal of air, and stored in refrigerator at 4ºC for later analysis.

Analytical methods

Moisture, protein, and ash contents were determined by AOAC (4). Total lipids – TL (fat) were extracted according to Bligh & Dyer (5). The results were expressed in wet-basis.

Energetic values (kcal/g) were calculated by multiplying the protein content by 4 and the total lipids content by 9 and adding up the results. The data were multiplied by 4.184 to convert them to kj/g.

Calcium and iron were determined by Flame Atomic Absorption Spectrometry (FAAS) at 422.7mm and 248.0nm, respectively, using spectral band width of 0.2nm (6). Phosphorus was determined by UV-VIS spectrophotometry (7) at 715nm using the ammonium phosphomolybdate method.

Transesterification of total lipids were prepared by Joseph & Ackman (8). The methyl esters were separated by gas chromatography in Varian model 3380 equipped with flame ionization and cyanopropyl capillary column (100m x 0.25µm i.d., CP-7420 Varian, EUA). Hydrogen (carrier gas) flow was 1.0mL/min with nitrogen flow of 30mL/min and hydrogen and synthetic air flows of 30 and 300mL/min for the flame detector. The injected volume was 1.0µL in split mode 1:80. Injector and detector temperatures were 220 and 240ºC. The column temperature was raised from 165ºC to 235ºC in 18 min at 4ºC/min, and kept at this temperature for 24.5min.

For the identification of fatty acids, fatty acid retention times were compared to those of standard methyl esters (Sigma, St. Louis, MO) and equivalent chain-length values (ECL) were used (9, 10). Retention times and peak area percentages were determined by Star software (Varian). The quantification (in mg fatty acid/g of total lipids) was made against methyl ester of tricosanoic acid from Sigma (USA) as an internal standard (23:0) as described by Joseph & Ackman (8). Theorical FID (flame ionization detector) correction factor (11, 12) values were used to obtain concentration values. Fatty acid content is reported in mg g^{-1} of total lipids by using the following formula:

$$\text{Fatty acid (mg g}^{-1}\text{ TL)} = \frac{(A_X)\,(W_{IS})\,(CF_X)}{(A_{IS})\,(W_X)\,(1.04)} \times 1000$$

Where TL = total lipids, A_X is the peak area (fatty acids), A_{IS} the peak area of internal standard (IS) methyl ester of tricosanoic acid (23:0), W_{IS} is the weight (mg) of IS added to the sample (in mg), W_X is the sample weight (in mg), CF_X is the theoretical correction factor, and 1.04 = conversion factor necessary to express results as mg of fatty acids rather than as methyl esters.

Statistical analysis

The results were submitted with Statistica software version 5.0 (13).

RESULTS

Results of proximate composition and fatty acids in commercial feed used in the present experiment are presented in Table 1. The results reveal a high concentration of linoleic acid- LA (223.4mg g^{-1} TL) and low concentration of linolenic acid - LNA (18.9 mg g^{-1} TL). LNA was the only one in the n-3 PUFA series present in commercial feed.

TABLE 1
Proximate composition (g/100g) and fatty acid (in mg/g of total lipids) of commercial feeds

Composition (mean ± SD)[a]			
Moisture	Protein [b]	Ash	Total lipid
12.7 ± 0.8	42.0 ± 1.3	12.9 ± 0.7	10.2 ± 0.9
Fatty acids	M ± das	Fatty acids	M ± SD[a]
12:0	5.0 ± 0.9	18:2n-6 (LA)	223.4 ± 29.6
14:0	12.3 ± 1.4	18:3n-6	2.4 ± 0.3
14:1n-9	4.5 ± 1.0	18:3n-3 (LNA)	18.9 ± 1.6
15:0	2.6 ± 0.4	20:0	2.6 ± 0.3
16:0	211.6 ± 18.7	20:1n-9	2.1 ± 0.3
16:1n-7	36.8 ± 3.4	22	1.9 ± 0.3
17:0	3.5 ± 0.4	22:1n-11	1.8 ± 0.4
17:1n-9	6.3 ± 0.7	22:1n-9	1.5 ± 0.2
18:0	87.6 ± 89	24:0	1.6 ± 0.4
18:1n-9	289.0 ± 20.5		

[a]Mean and standard deviation of three samples in triplicate.
[b]Based on nitrogen content (N x 6.25).

The average weight of ground fishbone Nile tilapia (40 fishbones) was approximately 4.4 kg, while the weight obtained after cooking, grinding, drying, and sieving was approximately 1.8 kg, 41% of the initial weight.

The proximate composition of Nile tilapia fishbone flour, including moisture, protein, total lipids (fat), ash, energetic values, calcium (Ca), iron (Fe), and phosphorus (P) contents are presented in Table 2.

Moisture was reduced from 65g/100g (*in natura* fishbone) to 14.2g/100g (fishbone flour). Nile tilapia fishbone flour protein (40.8g/100g), total lipids (25.3g/100g), and ash (18.3g/100g) contents were much higher than those values found by Visentainer et al. (14) protein (14.1g/100g), total lipids (8.4g/100g), and ash (4.8g/100g) for Nile tilapia heads.

The calcium and phosphorus contents were 2715.9 and 1132.7mg/100g Nile tilapia fishbone flour as shown in Table 2.

TABLE 2
Proximate composition (g/100g), energy (Kj or Kcal/100 g), and minerals (mg/100g) of Nile tilapia fishbone flour

	Proximate Composition[a]					Minerals[c]		
	Moisture	Protein[b]	Total lipids	Ash	Energy	Ca	Fe	P
Fishbone flour	14.2 ± 0.1	40.8 ± 0.2	25.3±0.2	18.3±0.1	1636/391	2715..9± 0.3	1.3±0.3	1132.7±0.1

[a] Mean and standard deviation of three samples in triplicate.
[b] Based on nitrogen content (N x 6.25).
[c] Minerals: Ca (calcium); Fe (iron), and P (phosphorus).

The fatty acid composition of Nile tilapia fishbone flour is given in Table 3. It was detected 22 fatty acids in the total lipids (TL), being palmitic acid, 16:0 (208.5mg/g of TL); oleic acid, 18:1n-9 (344.3mg/g of TL); and linoleic acid, 18:2n-6 (109.6mg/g of TL) the major ones. They also predominated in the lipid fraction of Nile tilapia heads as reported by Visentainer et al. (14) and in tilapia viscera according by Souza et al. (15). The concentration of LNA, EPA, and DHA were (29.9mg/g of TL), (3.3mg/g of TL), and (12.9mg/g of TL), respectively.

TABLE 3
Fatty acids concentration (mg/g of total lipids) of Nile tilapia fishbone flour

Fatty acid	M ± SD[a]	Fatty acids	M ± SD[a]
12:0	3.5 ± 0.9	21:0	1.5 ± 0.2
14:0	23.8 ± 3.5	20:2n-6	7.2 ± 0.8
14:1n-9	1.5 ± 0.7	20:3n-6	6.0 ± 0.5
15:0	1.8 ± 0.6	22:1n-9	13.5 ± 1.2
16:0	208.5 ±19.2	20:4n-6	0.5 ± 0.1
16:1n-9	46.7 ± 4.1	20:5n-3	3.3 ± 0.3
17:0	2.7 ± 0.4	24:1n-9	6.6 ± 0.7
17:1n-9	2.4 ± 0.2	22:6n-3	12.9 ± 1.3
18:0	54.4 ± 0.6	Saturated (SFA)	296.2 ± 19.5
18:1n-9	344.3 ± 25.4	Monounsaturated (MUFA)	415.0 ± 24.9
18:2n-6	109.6 ± 11.6	Polyunsaturated (PUFA)	175.6 ± 10.5
18:3n-6	6.26 ± 0.9	n-6 (omega-6)	129.6 ± 7.8
18:3n-3	29.9 ± 2.8	n-3 (omega-3)	46.1 ± 2.6
20:1n-9	21.7 ± 2.5	n-6/n-3	2.8 ± 0.2

[a]Mean and standard deviation of three samples in triplicate

As shown in Table 3, Nile tilapia fishbone flour was high in MUFA (415.0mg/g of TL) and SFA (296.2mg/g of TL) and low PUFA (175.6mg/g of TL) content.

DISCUSSION

The alpha-linolenic acid (LNA) was the only one in the n-3 PUFA series present in commercial feed (Table 1).

The high proximate composition protein, total lipids and ash) values of this experiment were due mainly to the water loss; the nutrients were concentrated during flour production. The energetic value of Nile tilapia fishbone flour (1636kJ/100g or 391kcal/100g) shows that its addition to soups, broths, and other dishes will raise their energetic value significantly (Table 2).

Calcium and phosphorus values were higher than those found in residues of tilapia silage of 1580.0mg and 120.0mg/100g contents, respectively (16), and much higher than flour of shrimp head with contents of 449.0mg and 40mg/100 respectively (17). The calcium and phosphorus content were expressive em relation of others foods. The iron content of 1.3 mg of Nile tilapia fishbone flour was higher than that found in Nile tilapia heads (0.42mg/100g) by Adeyeye et al. (18). However, it was lower than values found for beef (4.0mg/100g) (16). This is probably due to the fact that iron is an hemoglobin component.

The n-3 PUFA are considered nutritionally important, although they did not present high contents in Nile tilapia fishbone flour, the values obtained were close to those found in fillets of many fresh water fish (19,20). The low concentrations of n-3 PUFA in flour were due to the low concentration of LNA (a omega-3 series precursor) and of n-3 PUFA in commercial feed.

Recently, nutritionists have strengthened the advantages of a diet rich in MUFA and PUFA, such as the Mediterranean diet, in the prevention of atherosclerosis. Thus, as a way of reducing the risk of cardiovascular disease, it has been recommended to follow a diet with a PUFA, MUFA, and SFA ratio of 1:1.5:1 (21). The ratio for Nile tilapia fishbone flour is 1:2.4:1.7, which differs from the recommended value. The ratio n-6/n-3 (2.8) is close to those of many farmed fresh water fish (19) and within the recommended values range from 2:1 to 3:1 (22).

CONCLUSIONS

The present results indicate that Nile tilapia fishbone flour is a caloric food and that it presents iron and high contents of protein, calcium and phosphorus. The low concentration of omega-3 fatty acids in the commercial feed given to tilapias resulted in low n-3 PUFA concentrations of total lipids in fishbone flour. Nevertheless, Nile tilapia fishbone flour is an interesting alternative food in human diet.

ACKNOWLEDGEMENTS

The authors are grateful to CNPq And Fundação Araucária for the financial support.

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Recibido: 19-10-2007
Aceptado: 04-12-2007