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RESEARCH ARTICLE

FATTY ACIDS COMPOSITION AND PROFILE IN THE LIVER OIL OF THREE COMMERCIAL NILE FISHES IN SUDAN

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ABSTRACT

The composition of fatty acids in liver oils from the Nile fishes, *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus* was studied by gas liquid chromatography. *Polypterus senegalus* liver oil contains 65.5%, saturated acids (Myristic 5.4, Palmitic 36.9, Stearic 10.8, Tricosanoic 7.7, Heptadecanoic 2.8 % and Pentadecanoic 1.9) and 34.5% unsaturated acids. *Clarias lazera* liver oil contains 57.5% saturated acids (Palmitic 28.1, Stearic 13.5, Tricosanoic 12 and Heptadecanoic 3.9) and 42.5% unsaturated acids. *Lates niloticus* liver oil contains 58.8% saturated acids (Palmitic 35, Stearic 15.7, Tricosanoic 5.9, Heptadecanoic 1.5 and Pentadecanoic 0.7%) and 41.2% unsaturated acids. Oleic acid formed 28.3%, 19.9%, 11.5% in *C. lazera*, *L. niloticus* and *P. senegalus*, respectively. Eicosapentaenoic C20:5n3 was (0.36 ± 0.02 g/100g) in *P. senegalus*, (0.17 ± 0.02 g/100g) in *C. lazera*. Eicosapentaenoic, EPA, and Docosahexaenoic C22:6n3, DHA, together formed 1.9% in *P. senegalus*, 10.9% in *C. lazera*, and 9.8% in *L. niloticus*. Omega-3s formed 1.74% 0.83%, 0.49% and 1.74% of TFA in *L. niloticus, P. senegalus* and *C. lazera*, respectively. Omega-6s formed 1.2% of TFA in *L. niloticus* and 1.13% in *Polypterus*, but not detected in *C. lazera*. The livers of Nile fishes proved to be potential sources of essential fatty acids and valuable for human consumption. More focus on oil extraction from the liver of the Nile fish is needed. It is, certainly, decreases environmental pollution.

Key words: Fatty acids, liver, Nile fish, n-3/n-6 ratio, polyunsaturated fatty acids, EPA, DHA.

INTRODUCTION

The freshwater and marine fish are important source of essential fatty acids and constitute a great food potential for humans (Connor, 2000; Innis, 2004; Given *et al*., 2006; Farhat and Chaudhry, 2011) Fish store the lipids in various organs; particularly in muscles and liver. Recent studies have indicated that some parts of fish such as the head, intestine and liver are eliminated as a waste, but are commonly a rich source of fatty acids and may be used in oil extraction (Ackman, 1994; 2002; Covadonga, 2004; Sovik and Rustad, 2005; Kwetegyeka *et al*., 2008). Analysis of the extracted oil from these parts has shown the prominent presence of the important essential polyunsaturated fatty acids (PUFAs) such as n-3 polyunsaturated fatty acids (Sathivel *et al*., 2002; Mnari *et al*., 2007; Khoddami *et al*., 2009). Unfortunately, discarding these parts means that all their nutritional properties are missed. With growing public awareness of the clinical benefits of EPA and DHA and population growth, there is a need to locate a compatible source of these and other essential fatty acids such as the liver of fish. The Nile fishes constitute a great food potential for Sudanese communities. Previous studies of muscles tissues from some commercial Nile fish indicates that these fish can provide energy and minerals, and contain all essential amino acids (Mohamed *et al.*, 2010) as well as considerable amount of fatty acids (Mohamed and Al-Sabahi, 2011). It is of great importance to know the fatty acid content in different parts of the Nile fish which is economically important and willingly consumed. The livers of Nile fish may provide 'a rich and underexploited' source of polyunsaturated fatty acids, including essential omega-3s and omega-6s. The livers may contribute to the total level of fatty acids, thus increasing the commercial value of the fish and could potentially generate significant revenue for fish processing industry and the environment. Unfortunately, discarding these livers means that all their nutritional properties are missed. So, the present study constitutes a first approach to the knowledge of the fatty acid composition and profile of the fish livers of three commercial Nile fish species in Sudan, in order to determine the nutritional value of this part of the fish which is usually considered as waste and discarded.

MATERIALS AND METHODS

Fish collection and Sampling

All fresh fish were purchased from the fish market in Khartoum. Triplicate samples were taken from the liver of each specimen. Lipids were extracted from 10g samples using the procedure of Folch *et al*. (1957), by homogenizing them in a mechanical blender with a mixture of chloroform and

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methanol (2:1 v/v). Methyl esters of fatty acids were prepared for subsequent use in gas-liquid chromatography.

Fatty acids analysis

Fatty acids were analyzed as their methyl esters with a gas chromatography mass spectrometry (GC-MS; Hewlett-Packard 5890 GC), according to the procedure of Ahlgren *et al*. (1994). Fatty acids were identified by comparison with the retention time of standards (Supelco, PUFA-3), and the concentration of individual fatty acid was calculated using heneicosanoic acid (C21:0) as internal standard. The results are presented as the (means ± standard deviation, SD) of triplicate determinations of liver tissues (g/100 g) and weight percentage of the total fatty acids (%TFA).

RESULTS AND DISCUSSION

The compositions (g/100g) and profiles (%) of total fatty acids and major fatty acids groups of oil extracted from the livers of *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus* are shown in Table (1) and (2) and Figure (1). *Polypterus senegalus* was found to be the richest in total fatty acids, TFA, (19.27 ± 0.02 g/100g) followed by *L. niloticus* (14.95 ± 0.04 g/100g) and then came *C. lazera* (4.45 ± 0.06g/100g). Saturated fatty acids (SFA) ranged between 57.5% and 65.5%, forming (65.5%) in *Polypterus*, (57.5%) in *Clarias*, and (58.8%) in *Lates*. Monounsaturated fatty acids (MUFA) made up 24.3%, 31.6% and 21.6% of total fatty acids, while polyunsaturated fatty acids (PUFA) accounted for 10.2%, 10.9% and 19.6% of TFA, in *Polypterus*, *Clarias* and *Lates*, respectively. Palmitic acid and Stearic acid were the highest among saturated fatty acids (SFA), forming, respectively, (36.9% and 10.8%) of TFA in *Polypterus*, (35% and 15.7%) in *Lates*, and (28.1% and 13.5%) in *Clarias*. The most abundant monounsaturated fatty acid (MUFA) was Oleic acid, forming 11.5%, 28.3% and 19.9% of TFA in *Polypterus Clarias* and *Lates*, respectively. As shown in Figure (2), the liver oil of each of the three species contained all the essential fatty acids (Docosahexaenoic C22:6n3, Lenoleic C18:2n6, Lenolenic C18:3n3 and Eicosapentaenoic C20:5n3) acids, although in low quantities and vary in composition. Lenoleic acid C18:2n6 was the most abundant PUFA forming (8%) of TFA in *Lates* and (5.9%) *Polypterus*, but was not detected in *Clarias*. Very low quantities of Eicosapentaenoic C20:5n3, EPA, were detected in *Polypterus* (1.9%) and *Lates* (1.1%), while Docosahexaenoic acid C22:6n3, DHA, made up the greatest proportion of PUFAs in *Clarius* (10.9%) and *Lates* (8.7%) of TFA, but was not detected in *Polypterus*. Eicosapentaenoic C20:5n3, EPA and Docosahexaenoic acid C22:6n3, DHA, together formed 1.9% in *Polypterus*, 10.9% in *Clarias*, and 9.8% in *Lates*. Omega-3s formed 0.83%, 0.49% and 1.74% of TFA in *Polypterus*, *Clarias* and *Lates*, respectively, and omega-6s formed 1.13% of TFA in *Polypterus* and 1.2% in *Lates*, but not detected in *Clarias* (Fig. 3). It can be inferred from Table (1) that the profile of each individual fatty acid varies according to the species and may be due to the environmental effect on tropical fish species (Agren *et al*., 1987; Suriah *et al*., 1995). This composition was similarly found in other fish such as rainbow trout and salmon (Haliloglu *et al*., 2004;

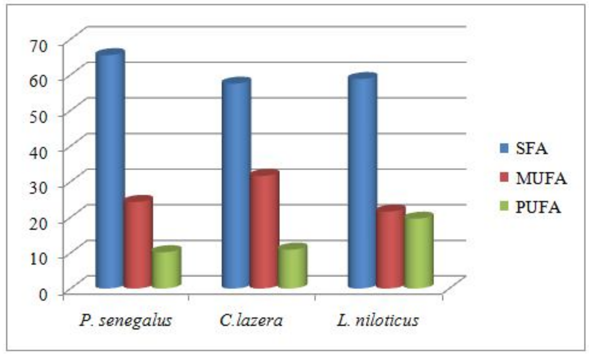

Figure 1: Major groups of fatty acids (%/TFA) in liver oil of the Nile fish *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus*.

Table 1. Fatty acids composition (mean ± standard deviation, g/100g) and profile (%) in liver oil of *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus.*

Fatty acids	*P. senegalus*	%	*C. lazera*	%	*L. niloticus*	%
Myristic C14:0	1.05 ± 0.01	5.4	0	0	0	0
Pentadecanoic C15:0	0.36 ± 0.01	1.9	0	0	0.11 ± 0.01	0.7
Palmitic C16:0	7.11 ± 0.03	36.9	1.25 ± 0.07	28.1	5.24 ± 0.06	35
Heptadecanoic C17:0	0.54 ± 0.01	2.8	0.17 ± 0.01	3.9	0.22 ± 0.03	1.5
Stearic C18:0	2.08 ± 0.05	10.8	0.6 ± 0.16	13.5	2.35 ± 0.09	15.7
Tricosanoic C23:0	1.49 ± 0.06	7.7	0.54 ± 0.09	12	0.88 ± 0.03	5.9
Myristoleic C14:1	0.22 ± 0.01	1.1	0	0	0	0
Pentadecanoic C15:1	0.17 ± 0.01	0.9	0	0	0	0
Palmitoleic C16:1	1.7 ± 0.03	8.8	0.15 ± 0.07	3.3	0.08 ± 0.01	0.6
Heptadecanoic 17:1	0.15 ± 0.01	0.6	0	0	0	0
Oleic C18:1n9c	2.21 ± 0.01	11.5	1.26 ± 0.01	28.3	2.97 ± 0.09	19.9
Ecosenoic C20:1	0.27 ± 0.01	1.4	0	0	0	0
Nervonic C24:1	0	0	0	0	0.17 ± 0.04	1.1
Lenoleic C18:2n6c	1.13 ± 0.01	5.9	0	0	1.2 ± 0.01	8
Lenolenic C18:3n3	0.47 ± 0.01	2.4	0	0	0.26 ± 0.01	1.8
Eicosapentaenoic C20:5n3 (EPA)	0.36 ± 0.02	1.9	0	0	0.17 ± 0.02	1.1
Docosahexaenoic C22:6n3 (DHA)	0	0	0.49 ± 0.01	10.9	1.3 ± 0.06	8.7

Table 2. The major groups of fatty acids in liver oil of *Polypterus senegalus, Clarias lazera* and *Lates niloticus*

Fatty acid groups	*P. senegalus*	*C. lazera*	*L. niloticus*
TFA	19.27 ± 0.02	4.45 ± 0.06	14.95 ± 0.04
SFA	12.62 ± 0.03	2.56 ± 0.08	8.8 ± 0.04
MUFA	4.69 ± 0.01	1.4 ± 0.05	3.2 ± 0.04
PUFA	1.96 ± 0.01	0.49 ± 0.01	2.93 ± 0.02
SFA (%TFA)	65.5	57.5	58.8
MUFA (%TFA)	24.3	31.6	21.6
PUFA (%TFA)	10.2	10.9	19.6

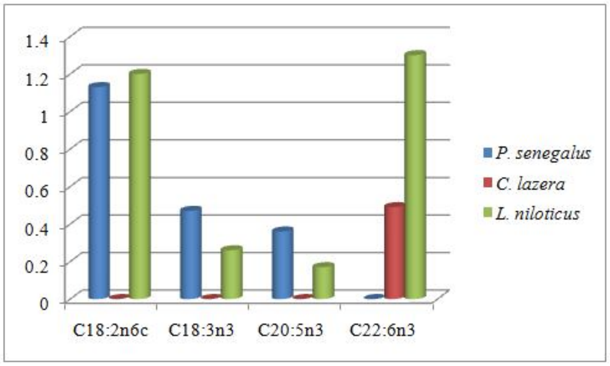

Figure 2: Essential fatty acids in liver oil of the Nile fish *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus*.

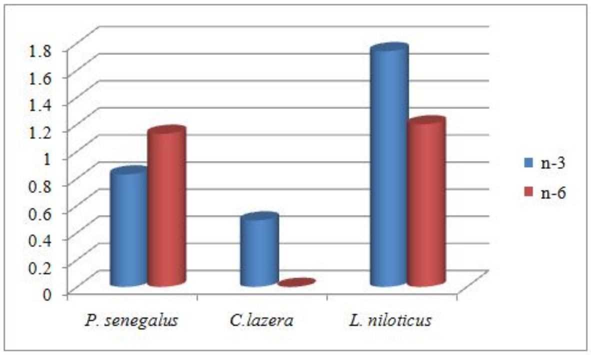

Figure 3: Contents of n-3 and n-6 fatty acids (g/100g) in liver oil of *Polypterus senegalus*, *Clarias lazera* and *Lates niloticus*.

Gladyshev *et al*., 2006). The different proportion of SFAs, PUFAs and MUFAs may also be attributed to species difference and the different diets, seasons and environments. The predominant SFAs in all liver samples were Palmitic and Stearic acid. Palmitic acid was found in high quantity in the liver of *C. lazera* and *L. niloticus*, but more Stearic acid was found in the liver of *Polypterus*. It was reported that Palmitic acid was the predominant saturated fatty acid in freshwater channel catfish, *Ictalurus punctatus*, (Sathivel *et al*., 2002); in rainbow trout, *Oncorhynchus mykiss*, (Haliloglu *et al*., 2004), and in the catfish *Pangasius hypophthalmus* (Ho and Paul, 2009). On the other hand, the liver oil of the present studied Nile fish contained MUFAs characterized by Oleic acid. This agreed with the findings of Ben Smida *et al*. (2009) in Tunisian swordfish, and Khoddam *et al*. (2009) in Sardine liver. Lenoleic and Lenolenic acids, which are essential in human nutrition, since they cannot be synthesized by the body, formed considerable proportion of total fatty acids in liver of the studied Nile fishes.

Both acids prevent skin diseases in the same way as Eicosapentaenoic acid. Eicosapentaenoic acid has attracted great attention because it was found in diet of Eskimos virtually free from atherosclerosis (Dyerberg, 1986). Other investigations have documented that Eicosapentaenoic acid in the blood is an extremely potent antithrombotic factor (Nelson *et al*., 1991; Harris, 2004). The n-3/ n-6 ratio of fish liver in the present study was in good proportion than some other fish species (Suriah *et al*., 1995; Simopoulos *et al*., 1999; Osman *et al*., 2001; Khoddami *et al*., 2009). The n-3/ n-6 ratio is a very useful index for comparing the nutritional value of fish lipid due to their human health effects on coronary heart disease, cancer and autoimmune diseases (Connor, 2000; Ugoala *et al*., 2008; Wu and Bechtel, 2008).

Conclusion

Regarding the nutritional aspect, the present study showed that the liver of the Nile fish species investigated contains appreciable levels of essential fatty acids. The liver of the Nile fish could be used as a promising substitute source to extract fish oil. A better utilization of the Nile fish resources can maximize the returns of oils from the fish for sustainable development. Therefore, more focus on oil extraction from livers of the Nile fish is needed. This would also reduce the environmental pollution caused by throwing by-products into the water.

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