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Full Length Research Paper

Fatty acids content and profile of common commercial Nile fishes in Sudan

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The muscle tissues of the Nilefishes: *Lates niloticus, Bagrus bayad, Oreochromis niloticus, Synodontis schall* and *Tetraodon lineatus* were analyzed for fatty acids compositions and profiles by gas liquid chromatography. Of the thirty-three fatty acids of different saturation levels detected, the predominant fatty acids were palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1ω9), docosahexaenoic acid (DHA, C22:6n3), eladic acid (C18:In9t), arachidic acid (C23:0) and palmitoleic acid (C16:1). Docosahexaenoic acid alone amounted to 37 to 77% of unsaturated fatty acids (UFAs). Eicosapentaenoic (EPA, C20:5n3), arachidonic (C20:4n6) and eicosadienoic (C20:2) acids were not detected in any of the fish studied. The range of saturated fatty acids was 31 to 65%, polyunsaturated fatty acids (PUFAs) were 4 to 53% and monounsaturated fatty acids (MUFAs) were 16 to 33%. *Tetraodon lineatus* contained 53% of the PUFAs and *L. niloticus* contained 33% of the MUFAs. The omega 3 and 6 (ω3/ω6) ratio was 0.9 to 3.6 and *S. schall* showed the highest ratio. The results showed that all the studied species of the Nile fish were comparable to other freshwater fish and were good sources of PUFAs, while *S. schall* was the best source of ω3 essential fatty acid (35% of UFAs) compared to the other four species. It was recommended that, other species of the Nile fish, especially the unused ones should be assessed for different sexes, seasons, sizes and geographical localities, because it could influence post-harvest processing and storage.

Key words: Arachidonic, decosahexaenoic, eicosapentaenoic, fatty acid profile, Nile fish, omega-3/omega-6 ratio, polyunsaturated.

INTRODUCTION

Fishes are an important source of animal proteins and other essential nutrients required in the human diets (Neil, 1996; Zenebe et al., 1998a; Steffens, 2006; Fawole et al., 2007). There has been a higher interest in the lipid and fatty acid composition of fish because; various fats from both seawater and freshwater fish have high concentration of monounsaturated and polyunsaturated fatty acids (Ackman and Takeuchi, 1986; Rahman et al., 1995; Nestel, 2000; Su et al., 2004). Fish meat and oils are good sources of unsaturated omega-3 fatty acids, eicosapentacenoic acid (EPA, 20:5n-3) and docasahexaenoic acid (DHA, 22:6n-3), as well as its precursor, alpha linolenic acid (Bays and Lansing, 1994; Isik et al., 1999; Saba, 2000; Sharma et al., 2009; Ugoala et al. 2009). Omega-3 and omega-6 polyunsaturated fatty acids have received particular interest. Both have beneficial effects on the human health (Nestel, 1990; Bays and Lansing 1994; Ackman, 2002), and play a role in reducing the cholesterol level (Potter and Kiss, 1995), stabilizing the electrical activity of the heart cells (Dallongeville, 1991), and atherosclerotic plaque (Calder, 2004). They also minimize the risk of heart disease (Kortanje et al., 1991; Albert et al., 1998; Senderson et al., 2002; Harris, 2004; Given et al., 2006) and improve the learning ability (Lim and Suzuki, 2002). Therefore, fish meat containing high n-3/n-6 ratios of PUFAs are the most beneficial in terms of human health and regular fish consumption reduces the risk of atherosclerosis (Kromhout et al., 1995; Neil, 1996; Mozaffarian et al., 2003). The fatty acids were

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Abbreviations: PUFAs, Polyunsaturated fatty acids; **MUFA,** monounsaturated fatty acids; **UFAs,** unsaturated fatty acids; **SFAs,** unsaturated fatty acids.

compared in different species of freshwater and marine fish (Zenebe et al., 1998a; Ackman et al., 2002; Alasalvar et al., 2002; Shirai et al., 2006; Zuraini et al., 2006; Mnari et al., 2007). Their composition and profile vary with the season, region (Zenebe et al., 1998b; Shirai et al., 2002; Nadezhda et al., 2007) and different diet (Isik et al., 1999; Shirai et al., 2002; Khan et al., 2003; De Silva et al., 2004; Misra and Samantaray, 2004; Sharma et al., 2009).

Fishes are very important animal protein source in food security and poverty alleviation in both rural and urban areas of Sudan and they serve as feed for livestock, poultry and carnivorous fish. However, the fatty acids composition and profile of the Nilefish was still unknown compared to other freshwater fishes (Rahman et al., 1995; Zenebe et al., 1998a Fawole et al., 2007). The main objective of this study was to determine the fatty acids composition and profile (percentages) of five Nilefish species: *Lates niloticus,* (L. 1964), *Bagrus bayad*, (F. 1975), *Oreochromis niloticus*, (T. 1982), *Synodontis schall* (Bl- Sch. 1801), and *Tetraodon lineatus*, (L. 1964). These are the most preferred and popular marketed species among consumers in Sudan. The selected species belong economically to different traditional grades, according to the consumer and fishermen preference in the Sudan. Therefore, detailed information about their fatty acids composition was important from nutritional point of view and was needed because it influenced the quality in frozen storage of some fish species.

MATERIALS AND METHODS

Collection of samples

Fresh specimens of each species were obtained from the fishermen at the fish market in Khartoum. The species were *L. niloticus* (L. 1964), *B. bayad* (F. 1975), *O. niloticus* (T. 1982), *S. schall* (Bl- Sch. 1801), and *T. lineatus* (L. 1964). The flesh were carefully removed from their backbones, weighed, minced and freeze dried by freezing to -40°C and the surrounding pressure was reduced to 110, using (MODULYOD). Freeze Dryer model 230. Total lipid was extracted from the dried samples with chloroform-ethanol mixture (2:1) according to the extraction method of Folch et al. (1957).

Fatty acids analyses

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) and was identified by comparing their retention time with those of several commercial standard mixtures (Supelco, USA). The concentration of individual fatty acid was calculated using heneicosanoic acid (C21:0) as internal standard and the result was expressed in mg/g dry weight (DW).

The results (means ± standard deviation, SD) were calculated as both the weight percentage (fatty acid profile) and the concentration (mg/g dry tissues).

RESULTS

Tables 1 and 2 represent the fatty acid composition and profile of the analyzed fish. Thirty-three fatty acids with various chain lengths and saturation levels have been identified; the three major fatty acids were palmitic acid, C16:0; palmitoleic acid, C16:1 and oleic acid, C18:1. The most abundant saturated fatty acids were palmitic acid, 16:0 (9 to 57%/SFA), stearic acid, 18:0 (13 to 47%/SFA) and behenic acid, 22:0 (4 to 23%/SFA); and the most abundant polyunsaturated fatty acids were docosahexaenoic acid, DHA, 22:6n3 (28 to 76%/PUFA) and lenoleic acid, 18:2n6 (11 to 61%/PUFA); while the most abundant monounsaturated fatty acids was palmitoleic, 16:1 (7 to 59%). Eladic acid, 18:1n9t has high concentration in *L. niloticus* and *T. lineatus* (46 and 76% of PUFA), respectively. Some important fatty acids such as eicosapentaenoic (EPA, C20:5n3) and arachidonic acid (C20:4n6) were not detected in any species of the fish studied (Table 1, Figure 1) and other fatty acids were found in some. Among the total fatty acids (Table 3), the content of saturated fatty acids (SFA) was 31 to 65%, polyunsaturated fatty acids (PUFA) were 4 to 53% and monounsaturated fatty acids (MUFA) were 16 to 33%. *T. lineatus* and *S. schall* contained the highest percentages of unsaturated fatty acids (69 and 47%), respectively, and Docosahexaenoic, C22:6n3 DHA alone amounted to 59 to 35% of USFA in these species, respectively. The range of omega-3/omega-6 ($\omega3/\omega6$) was 0.9 to 3.6% and *S. schall* showed the highest ratio.

DISCUSSION

The results of this study showed that in all fish species analyzed, the dominant polyunsaturated fatty acid (PUFA) was that of omega-3 series found in C22:6n-3. The principle saturated fatty acids (SFAs) identified in the studied fish were C16:0 and C18:0 and in term of monounsaturated fatty acid (MUFA), these were C18:1n-9 and C16:1n-9. These results were similar to those reported by Ahlgren et al. (1994), Zenebe et al. (1998b), Bieniarz et al. (2000), Saba et al. (2000), Ackman et al. (2002), Sharma et al. (2009) and Ugoala et al. (2009) in freshwater fish. Three of the analyzed fish have significantly high percentage of n-3/UFA, which agreed with Sharma et al. (2009) in tropical freshwater. Omega-3 PUFA were not detected in *L. niloticus* but this fish has a good proportion of n-6 PUFA that may be due to a conservation of n-6 PUFA in preference to n-3 PUFA (De Silva et al., 2004). The high level of linoleic acid (C18:2n-6), a precursor of n-6 fatty acid in *S. schall* may explain the high levels of n-6 fatty acids in this fish. The absence of eicosapentaenoic (EPA, C20:5n-3) in any of the fish species studied was also reported for some fish species (Nadezhda et al., 2007); may be due to the fact that, these fishes were capable of converting dietary eicosapentaenoic (EPA) into docosahexaenoic (DHA). Evidence was obtained that, the studied fish species *T. Arcticus*, the main food fish species in Siberian Rivers may be capable of converting dietary EPA into DHA. It

Table 1. The fatty acids compositions for five commercial species of the Nile fish.

Fatty acid	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Caproic C6:0	-	*	-	*	-
Caprylic C8:0	-	*	-	*	-
Capric C10:0	-	*	-	*	-
Undecanoic C11:0	-	-	-	*	-
Lauric C12:0	*	*	*	*	-
Tridecanoic C13:0	-	*		*	-
Myristic C14:0	*	*	*	*	*
Pentadecanoic C15:0	*	*	*	*	*
Pentadecanoic C15:0	*	*	*	*	*
Palmitic C16:0	*	*	*	*	*
Heptadecanoic C17:0	*	*	*	*	*
Stearic C18:0	*	*	*	*	*
Arachidic C20:0	*	*	*	*	*
Behenic C22:0	*	*	*	*	*
Tricosanoic C23:0	*	*	*	*	*
Lignoceric C24:0	*	*	-	*	*
Myristoleic C14:1	-	*	-	*	-
cis-10-pentadecanoic 15:1	*	*	*	*	*
Palmitoleic C16:1	*	*	*	*	*
cis-10-Heptadecanoic 17:1		*	*	*	-
Elaidic C18:1n9t	*	*	*	-	*
Oleic C18:1n9c	*	*	*	*	*
cis-Ecosenoic C20:1	*	*	*	*	*
Erucic C22:1n9	-	*	*	*	*
Nervonic C24:1	*	*	*	*	*
Linolelaidic C18:2n6t		*	*	*	*
Lenoleic C18:2n6c	*	*	*	*	*
L γ -Linolenic C18:3n6		*	*	*	*
Lenolenic C18:3n3	-	*	-	-	*
Eicosadienoic C20:2	-	-	*	-	-
Eicosatrienoic C20:3n6	*	*	*	*	*
Eicosatrienoic C20:3n3	-	*	*	*	-
Arachidonic C20:4n6	-	-	-	-	-
Eicosapentaenoic 20:5n3	-	-	-	-	-
Docosadienoic C22:2	-	*	-	*	-
Docosahexaenoic 22:6n3	*	*	*	*	*

*Indicates fatty acid

could also be due to the absence of arachidonic acid, C20:4n6, which is important n-6 PUFA for production of eicosannoids (Moussa et al., 1996). Blonk et al. (1990), Zenebe et al. (1998b), Isik et al. (1999) and Ugoala et al. (2009) have observed such variation in other freshwater fish.

The observed high levels of SFA in *L. niloticus*, *B. bayad*, and O. *niloticus* indicated that, these fishes have a tendency to conserve highly saturated fatty acids that might be essential for their metabolic activity. This was opposite in *T. lineatus* that contained more unsaturated fatty acid (UFA) (69%) than SFA where 53% was PUFA, and *S. schall* has more of MUFA (25%) but (22%) of PUFA.

The overall significance of this study, based on the fatty acid composition in the investigated fishes, revealed that the Nile fish were good source of SFA (31 to 65%) as well as UFA (35 to 69%) but *S. schall* was the best source of omega-3 essential fatty acid (35% of UFA) compared to the other four species. The results also showed that the Nilefish as other tropical freshwater fish are good source of PUFA and can prevent cardiovascular diseases, increase learning ability and slow the progress of cancers. Regional and seasonal variation in fatty acid

Table 2. The content of fatty acids (mg FA/g, DW) in five commercial species of the Nile fish.

Fatty acid	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
Caproic C6:0	-	5.5	-	11.6	-
Caprylic C8:0	-	12.5	-	13.3	-
Capric C10:0	-	18.1	-	11.7	-
Undecanoic C11:0	-	-	-	3.6	-
Lauric C12:0	5.9	34	6.9	30.4	-
Tridecanoic C13:0	-	2.6	-	9.1	-
Myristic C14:0	13.4	215.4	52.3	110.8	8
Myristoleic C14:1	-	6.1	-	3.4	-
Pentadecanoic C15:0	3.9	113.3	9.5	93.1	21.8
cis-10-pentadecanoic C15:1	12.3	62.2	13.9	43.9	7.3
Palmitic C16:0	123.8	4533	381.2	2481.4	60.1
Palmitoleic C16:1	31.4	1274.3	198.7	625.8	25.8
Heptadecanoic C17:0	10.8	327.5	33.5	214.3	4.3
cis-10-Heptadecanoic 17:1	-	152	3.2	113	-
Stearic C18:0	41.6	1497.7	353.7	1440.1	327.3
Elaidic C18:1n9t	77.8	29.8	60.5	-	270.5
Oleic C18:1n9c	13.9	1646.8	5.6	1824.1	8
Linolelaidic C18:2n6t	-	7	19.6	30.3	9.8
Lenoleic C18:2n6c	10.6	252.8	24	512.4	223
Arachidic C20:0	24.9	336.5	104.2	277.3	111.1
L γ –Linolenic C18:3n6	-	13.9	13.7	38	8.3
cis-Ecosenoic C20:1	2.7	307.3	2.7	117.1	15.6
Lenolenic C18:3n3	-	3.3	-	-	5.3
Eicosadienoic C20:2	-	9.5	2.5	-	-
Behenic C22:0	38.6	572.3	44	1556.4	88.2
Eicosatrienoic C20:3n6	6.7	66	16.5	2.6	37.7
Erucic C22:1n9	-	8.5	11.6	2.2	6.5
Eicosatrienoic C20:3n3	-	5.9	87.6	9.5	-
Arachidonic C20:4n6	-	-	-	-	-
Tricosanoic C23:0	37.4	271	25.2	408.4	64.5
Docosadienoic C22:2	-	9.5	-	69.8	-
Lignoceric C24:0	24.3	76.4	-	21.3	6.7
Eicosapentaenoic C20:5n3	-	-	-	-	-
Nervonic C24:1	32.2	233.9	40.2	453.5	20.6
Docosahexaenoic C22:6n3	-	286.3	62.3	2072.1	898.7
Total fatty acids	512.2	12390.9	1573.1	12600.5	2229.1

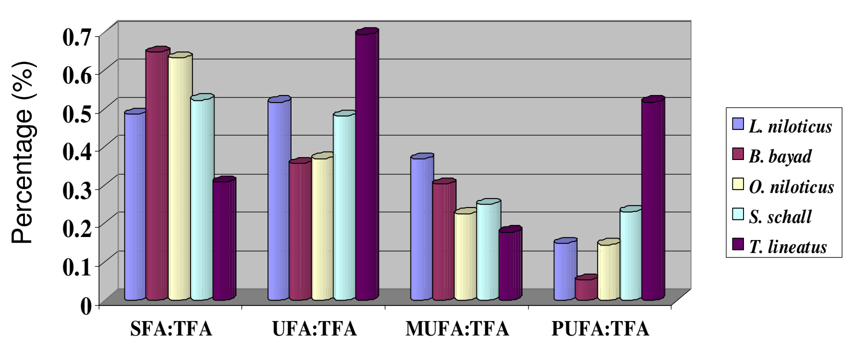

Figure 1. The ratios (%) of different classes of fatty acids to total fatty acids in five commercial Nile fish

Table 3. The contents (mg FAs/g, DW) and profiles (percentages) of different classes of fatty acids in five commercial species of the Nile fish.

Fatty acid	*L. niloticus*	*B. bayad*	*O. niloticus*	*S. schall*	*T. lineatus*
TFA	512.2	12390.9	1573.1	12600.5	2229.1
SFA	324.6	8015.8	1010.5	6682.8	692
USFA	187.6	4375.1	562.6	5917.7	1537.1
MUSFA	170.3	3720.9	336.4	3183	354.3
PUSFA	17.3	654.2	226.2	2734.7	1182.8
Omega - 6	17.3	339.7	73.8	583.3	278.8
Omega - 3	-	295.5	149.9	2081.6	409
SFA / TFA (%)	63	65	64	53	31
USFA / TFA (%)	37	35	36	47	69
MUSFA / TFA (%)	33	30	21	25	16
PUSFA / TFA	4	5	15	22	53
n- 6 / USFA (%)	9	8	13	10	18
n- 3 / USFA (%)	-	7	26	35	27
n-3/n-6	-	0.9	2	3.6	1.5

composition of different body parts need to be analyzed for better understanding of the nutritional fatty acid profile of these species. In addition, the fatty acid profile and content of the other species of the Nilefish should be determined.

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