FATTY ACIDS COMPOSITION AND PROFILE IN FAT AND MUSCLE OIL OF THE NILE FISH *POLYPTERUS SENEGALUS* (CUVIER, 1829) FROM SUDAN

Elagba Haj Ali Mohamed*

Natural History Museum, University of Khartoum, P. O. Box 321, Khartoum, Sudan
***Corresponding** author: Email: elagba2000@yahoo.com

ABSTRACT

Fatty acid composition and profile were investigated in the fat and muscle oil of the Nile fish species *Polypterus senegalus* (Nile bichir), obtained from the White Nile in Sudan. Fatty acids were extracted through the Folch extraction method (using chloroform: methanol at the ratio of 2:1). Generally, the fat oil was found to be the richest in fatty acid composition (452.5±0.75mg/g) compared to (128.7 ± 3.6 mg/g) to muscles. In both tissues analyzed, palmitic C 16:0, Stearic C18:0, Tricosanoic C23:0, Palmitoleic C16:1 and Oleic C18:1n9c acids were found to be the most abundant fatty acid. Appreciable quantities of essential polyunsaturated fatty acid such as lenoleic acid (C18:2n6c, 8 and 5.3%), lenolenic (C18:3n3, 4 and 3.8%) and eicosapentaenoic acid (EPA) (20:5n3, 3 and 7.9%) were also found in fat and muscle oil, respectively. The study points out that the fat and muscles of *P. senegalus* contain appreciable levels of Omega-6 (n-6, 8.4 and 5.3%) and Omega-3 (n-3, 6.1 and 11.7%) polyunsaturated fatty acids (PUFA) and are therefore suitable for an unsaturated low-fat diet. This is important especially for poor communities who cannot afford to get a diet rich in some essential fatty acids.

Keywords: FAtty acid composition, Nile fish, Omega -3 and Omega-6, *Polypterus senegalus*, polyunsaturated fatty acids, EPA, DHA.

{**Citation:** Elagba Haj Ali Mohamed. Fatty acids composition and profile in fat and muscle oil of the nile fish *Polypterus senegalus* (Cuvier, 1829) from Sudan. American Journal of Research Communication, 2013, 1(12): 152-166} www.usa-journals.com, ISSN: 2325-4076.

Running title: Fatty acids composition in fat and muscle oil of *Polypterus senegalus*

INTRODUCTION

Polypterus senegalus (Cuvier, 1829) of the family Polypteridae is a common freshwater fish throughout the Nile and the White Nile in Sudan (Sandon, 1950, Bailey 1994)) and live in various areas in Africa. It is strictly carnivorous bottom- feeding fish. This species is classified by fishermen and consumers as low grade fish, low-cost and commonly treated as trash fish and used for poultry feed. But, some Sudanese tribes traditionally dry the fish under the sun and use it for human diet. Its oil is also extracted and used for traditional medication.

Fish in general is known for its high nutritional value (Steffens, 1997; Simopoulos, 2002). Fish tissue is the main source of long chain polyunsaturated fatty acid**s** especially the ω-3 and ω-6, fatty acid**s.** These fatty acid**s** have particular importance in fish, since their consumption contributes in improvement of learning ability (Yonekubo *et al*., 1994; Suzuki *et al*., 1998), in reducing the appearance of cardiovascular diseases (Nordov *et al*., 2001) as well as in preventing neural diseases and protect against cancer (Shahar *et al*., 1994; Von Schacky *et al*., 1999; Connor, 2000. Arts *et al*., 2001; Lauritzen *et al*., 2001; Silvers and Scott, 2002). Since ω-3-PUFAs, such as α-linolenic acid (18:3n3), eicosapentaenoic (20:5n3, EPA) and

docosahexaenoic (22:6n3, DHA), are effectively synthesized only by aquatic organisms, humans can obtain these essential components from marine and freshwater products (Sushchik *et al*., 2007).

Fish oil is the main source of ω-3 fatty acids, therefore, the fatty acid**s** composition of fish oil is very important for its functional properties (Von Schacky *et al*., 1999; Maes *et al*., 2000; Nestel, 2000). Many studies have been conducted on the lipid composition of different fish species in different parts of the world including the Nile fish (Dayhuff and Wells, 2005; Eboh *et al*., 2006; Shirai *et al*., 2006; Zmijewski *et al*., 2006; Mnari *et al.*, 2007, Miniadis-Meimaroglou *et al*., 2007; Sushchik *et al*., 2007, Mohamed and Al-Sabahi, 2011, 2013, Elagba, 2013). The nutritional value of *Polypterus* is not well known. Extraction and characterization of *Polypterus* oils would provide information on of its food quality and increase the consumption of commercially available and cheap fish species rich in these fatty acid**s.**

Therefore, the objective of this study was to determine the fatty acid composition and profile in fat and muscle oil of the abundant and low-cost Nile fish *Polypterus senegalus*, to find out an alternative source for unsaturated fatty acids and to inform the consumer about the fatty acid level in the this fish, in order to guarantee an optimal use of the fatty acids, especially n-3 and n-6 fatty acids.

MATERIALS AND METHODS

Fish Samples

Fresh specimens of the Nile fish *Polypterus senegalus* were purchased from local fish market in Khartoum. Fish specimens were transported to the laboratory and each specimen was filleted

and triplicate samples of muscle and fat tissues were taken. Fat was extracted from minced 10g of tissues by chloroform and methanol (2:1 v/v), according to the method described by Sathivel *et al*. (2002).

Fatty acids analysis

Fatty acids were analyzed as their methyl esters (FAME) 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 determination of tissues (mg/g) and weight percentage of the total fatty acids (%TFA).

RESULTS AND DISCUSSION

Sixteen fatty acids were identified in the fat oil and only 8 fatty acids were detected in the muscle oil of *Polypterus senegalus* are shown in Table 1. The most abundant saturated fatty acids (SFA) in fat and muscle oil were palmitic, Stearic and Tricosanoic, respectively, 8% and 26%, 15% and 12%, 11% and 25%. The Palmitoleic acid content in the monounsaturated fatty acid (MUFA) group was, respectively, 13% and 5.7% and oleic acid was 16% and 13.7%. The highest content of total fatty acids was found in the fat oil (452.5±0.75mg/g) compared to (128.7 ± 3.6 mg/g) in muscle oil (Table 2).

Table 1. Fatty acids composition (mg/g) and profile (%) in the fat and muscle oil of the Nile fish *Ploypterus senegalus* from Sudan

FATTY ACIDS	FAT		MUSCLES	
	Mg/g	%	Mg/g	%
Myristic C14:0	35.07 ± 0.4	8	0	0
Pentadecanoic C15:0	12.11 ± 0.05	3	0	0
Palmitic C16:0	38.08 ± 1.09	8	33.7 ± 0.4	26
Heptadecanoic C17:0	18.06 ± 0.43	4	0	0
Stearic C18:0	69.61 ± 1.69	15	16 ± 0.2	12
Tricosanoic C23:0	49.93 ± 1.95	11	32.1 ± 0.9	25
Myristoleic C14:1	7.28 ± 0.09	2	0	0
Pentadecanoic C15:1	5.74 ± 0.09	1	0	0
Palmitoleic C16:1	56.82 ± 1.13	13	7.3 ± 0.2	5.7
Heptadecanoic C17:1	3.83 ± 0.01	1	0	0
Oleic C18:1n9c	74.16 ± 0.08	16	17.7 ± 0.7	13.7
Ecosenoic C20:1	9.18 ± 0.1	2	0	
Erucic C22:1n9	7.09 ± 0.02	2	0	0
Lenoleic C18:2n6c	37.91 ± 0.22	8	6.8 ± 0.2	5.3
Lenolenic C18:3n3	15.60 ± 0.15	4	4.9 ± 0.1	3.8
Eicosapentaenoic C20:5n3(EPA)	12.07 ± 0.69	3	10.1 ± 0.01	7.9

Table 2. The composition (mg/g) and profile (%) of the major groups of fatty acids in the fat and muscle oil of the Nile fish *Ploypterus senegalus* from Sudan

FATTY ACIDS	FAT		MUSCLES	
GROUPS	Mg/g	%	Mg/g	%
TFA	452.5 ± 0.75	100	128.7 ± 3.6	100
SFA	222.9 ± 0.9	49	81.8 ± 7.3	63.5
UFA	229.7 ± 0.3	51	46.9 ± 2.1	36.5
MUFA	164.1 ± 0.2	36	25.1 ± 4.5	19.5
PUFA	65.6 ± 0.3	15	21.8 ± 1.8	17
N-6	37.9 ± 0.2	8.4	6.8 ± 3.3	5.3
N-3	27.67 ± 0.4	6.1	15 ± 2.4	11.7
N-3/N-6		0.7		2.2

SFA= Saturated fatty acids; UFA= Unsaturated fatty acids; MUFA= Mono unsaturated fatty acids; PUFA= Poly unsaturated fatty acids.

As shown in (Figue 1 and 2), each of the saturated (SFA) and unsaturated fatty acid (UFA) groups has its specific concentration and profile in the fat and muscle oil. Although, the fat oil is rich in SFA (222.9±0.9 mg/g), the percentage was low (49%) as compared to (63.5%) in the muscle oil. The muscle oil was poor in UFA (46.9 ± 2.1mg/g) forming (36.5%) of TFA. The percentage of monounsaturated fatty acid (MUFA) acids was higher in the fat oil (36%) than in muscle oil (19.5%), while the percentage of polyunsaturated fatty acid (PUFA) was almost same in the two tissues. Appreciable quantities of essential polyunsaturated fatty acid (Figure 3) such as lenoleic acid (C18:2n6c, 8 and 5.3%), lenolenic (C18:3n3, 4 and 3.8%) and

eicosapentaenoic acid (EPA) (20:5n3, 3 and 7.9%) were also found in fat and muscle oil, respectively.

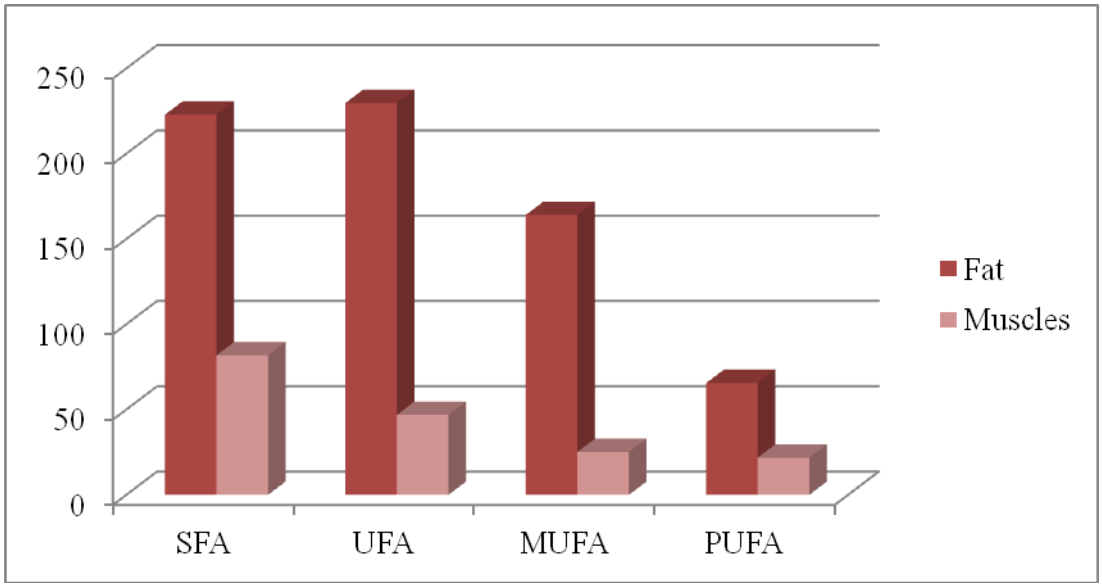

Figure 1: Contents (mg/g) of major groups of fatty acids in fat and muscle oil of *Polypterus senegalus*.

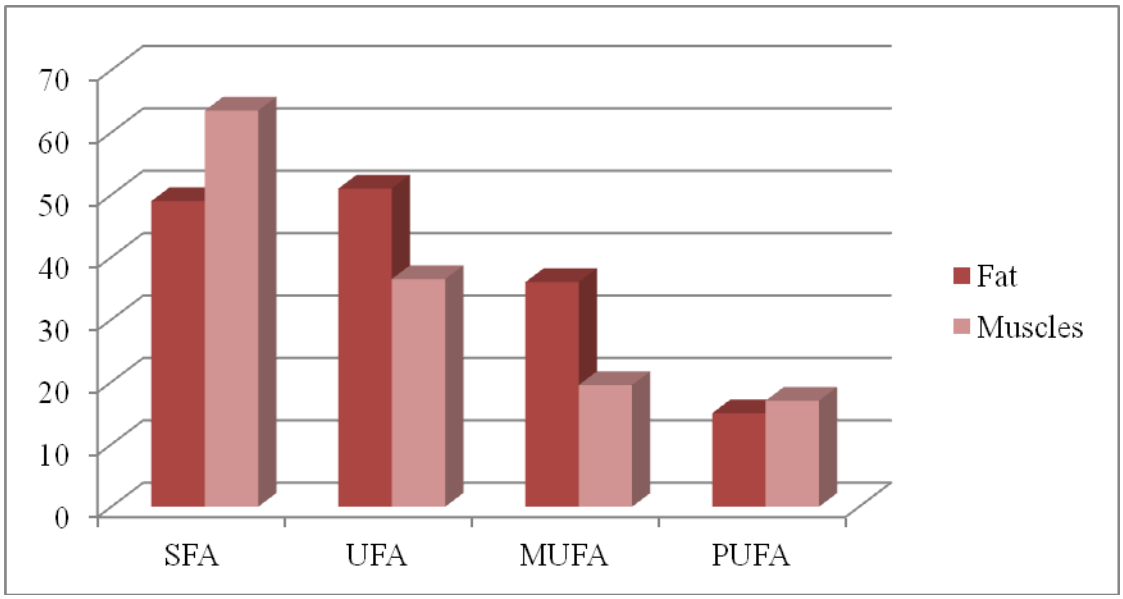

Figure 2: Profiles (%) of major groups of fatty acids in fat and muscle oil of *Polypterus senegalus*.

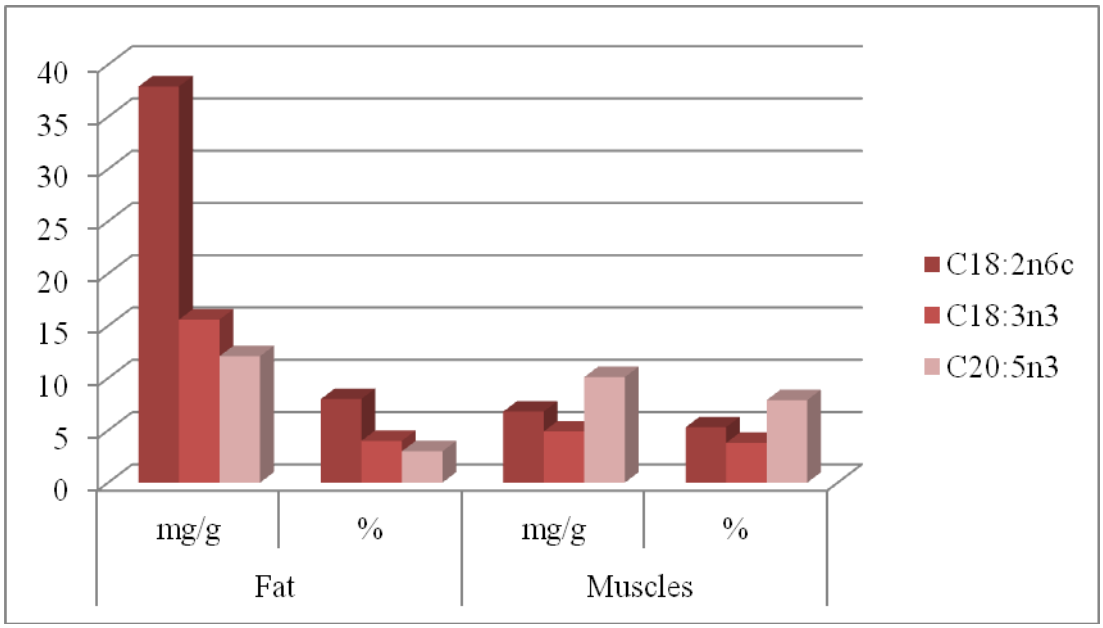

Figure 3: Essential fatty acids (mg/g) and profile (%) in fat and muscle oil of *Polypterus senegalus*.

Figure (4) shows that the muscle oil is high in n-3 PUFA, forming (11.5%) of the TFA compared to (6.1%) in fat oil. The n-6 PUFA vary between the fat and muscles, making up, respectively, (8.4% and 5.3%) of the TFA. The n-3/n-6 ratio was 0.7 in the fat oil and 2.2 in the muscle oil.

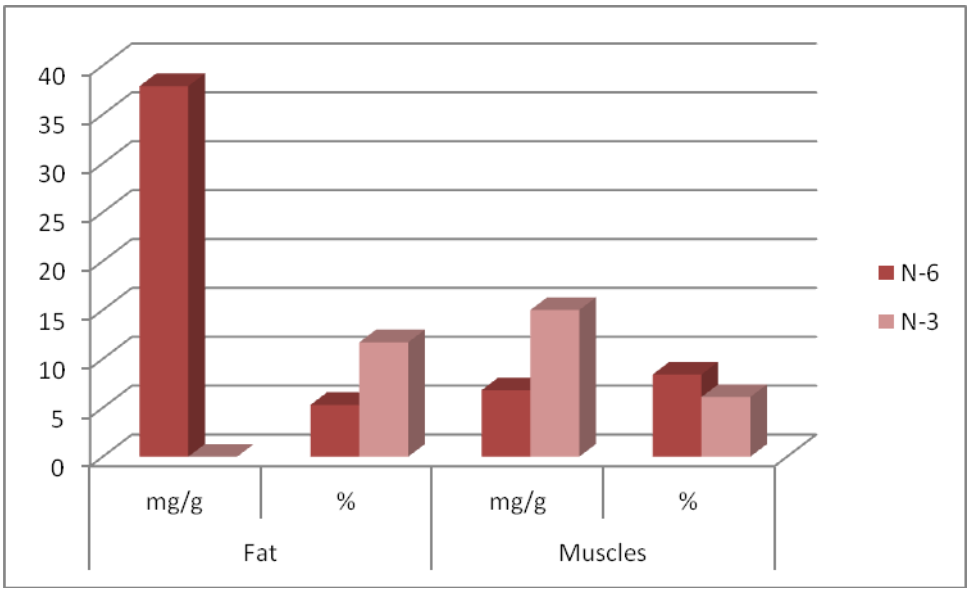

Figure 4: Contents (mg/g) and profile (%) of n-6 and n-3 fatty acids in fat and muscle oil of *Polypterus senegalus*.

Palmitic and Tricosanoic acids were the primary (SFA) of the muscle oil, contributing 41.2% and 39.3% in the total SFA and up to 26% of TFA in muscle oil. In fat oil these acids formed 17.1% and 22.4%, but Stearic acid contributed 31.3% of SFA in fat oil and 19.6% in muscle oil. Palmitic acid was found to be the most abundant SFA in the most abundant SFA in muscle tissues of some Nile fish species accounting for up to 57% (Mohamed and Al- Sabahi, 2011). In the Nile fish *C. lazera* and *L. niloticus*, this acid formed 29 and 30.4% of TFA of muscle and 59.3 and 72.8% of fat tissues, while Myristic (C14:0), heptadecanoic (C17:0), stearic (C18:0), tricosanoic (C23:0) acids were the second major SFA in both tissues of the two fish species. Eboh *et al*. (2006) reported that palmitic acid was the most prevalent in all fish species with mean values of 8.5% to 37.5%.

Generally, the fat oil contained more TFA (452.5±0.8 mg/g) and SFA (222.9±0.9 mg/g), compared to muscle oil (128.7 ± 3.6 mg/g) and (81.8 ± 7.3 mg/g), respectively. Same trend was reported in fat and muscle tissues of *C. lazera* and *L. niloticus* (Elagba 2013). Nettleton and Exler (1992) reported that fish in general are relatively low in SFA (<30%), except for certain species. The increase in SFA content (51%) in fat oil and (63.5%) in muscles in this study is probably due to the rising of water temperature in Sudan. Nijinkoue *et al*., (2002); Miniadis-Meimaroglou *et al*. (2007); Kwetegyeka (2008) and Tawfik (2009) also found high percentage of SFA in some fish living in water with high temperature and stated that is was probably due to the fact that the SFA tend to increase in fish living in warm water (Ackman, 1989).

Oleic acid was the primary (MUFA) in the fat and muscle oil of *P. senegalus* followed by Palmitoleic acid. Among n-6 (PUFA) the fat and muscle oils contained appreciable amount of Lenoleic C18:2n6c acid, but the level was higher in fat than muscle oil. Among n-3 series the oil of both tissues was a good source of eicosapentaenoic acid (EPA). These fatty acids which a

FAO report declares are essential for human dietary needs (Dumay, 2006). The n-3 fatty acid, docosahexaenoic acid (DHA) was absent in fat and muscle oil. The total percentage of n-3 (PUFA) was higher than n-6 in the muscle oil while fat oil contained more n-6 than n-3 fatty acids. The n-3/ n-6 ratio was higher in muscle oil (2.2) than in fat oil (0.7). The n-3/n-6 ratio in dietary recommendations is 0.2 (Ben Smida, *et al*., 2009).

The result of this study revealed that both fat and muscle oil of *P. senegalus* had different compositions and levels of fatty acids and contained appreciable quantities of essential fatty acids, such as the nutritionally important eicosapentaenoic acid, EPA. This could be related to the type of fish diet, size or age, reproductive status, geographic location and season (Ackman, 1989; Nettleton, 1985; Satio *et al*., 1999, Ben Smida *et al*., 2009).

CONCLUSION

The aims of this paper was to investigate the component fatty acids in fat and muscle oil of the Nile fish *P. senegalus* and to compare the nutritional quality of the fat oil with muscle oil by comparing the levels of essential fatty acids present in each tissue. The results indicated that *P. senegalus* muscles and fat are good sources of omega-3 EFA and of omega-6 EFA. The high percent of SFA in *P. senegalus* fish muscle gives it an advantage in curing processing. The fish fat may also be a useful food source for maintaining human health and effective for the improvement of learning ability and plasma lipid content. However, further studies in both human and animal models are needed for determining the effect of fish oil on brain function and plasma lipid levels.

REFERENCES

Ackman, R.G. (1989). Nutritional composition of fats in sea food. Progress Food Nutr. Sci., 13: 161-289.

Ahlgren, G., Blomqvist, P., Boberg, M. and Gustafsson, I.P. (1994). Fatty acid content of the dorsal muscle – an indicator of fat quality in freshwater idodi fish. J. Fish. Biol., 45: 31 - 157.

Arts, M.T., Ackman, R.G. and Holub, B.J. (2001). Essential fatty acids in aquatic ecosystems: A crucial link between diet and human health and evolution. Can. J. Fish. Aquat. Sci., 58: 122-137.

Bailey, R.G. (1994). Guide to the fishes of the River Nile in the Republic of the Sudan. J. Nat. His., 28: 947-948.

Ben Smida, M.A., Marzouk B. and El Cafsi M. (2009). The composition of fatty acids in the tissues of Tunisian swordfish (*Xiphias gladius*). Food Chem., 115: 522 - 28.

Connor, W.E., (2000). Importance of n-3 fatty acids in health and disease. Am. J. Clin. Nutr.. 71: 171S-1755.

Dayhuff, L. and Wells, M. (2005). Identification of fatty acids in fishes collected from the Ohio River using gas chromatography-mass spectrometry in chemical ionization and electron impact modes. J. Chromatogr. A., 1098: 144-149.

Dumay, J. (2006). Extraction de lipides en voie aqueuse par bio-réacteur enzymatique combiné à l'ultracentrifugation: Application à la valorisation de co-produits de poisson (Sardina pilchardus) (p. 325). Thèse de Doctorat, Discipline: Génie des procédés, Spécialité: Bioprocédés et biotechnologies marines. Ecole Polytechnique de l'Université de Nantes.

Eboh, L., Mepba, H.D. and Ekpo, M.B. (2006). Heavy metals contaminants and processing effects on the composition, storage stability and fatty acid profiles of five common commercially available fish species in Oron Local Government, Nigeria. Food Chem., 97: 490-497.

Elagba, H.A.M. (2013). Fatty acids composition in muscle and fat tissues of the Nile fish *Clarias lazera* and *Labeo niloticus* from Sudan. A. J. Sci. Technol., 4(10): 109-113.

Kwetegyeka, J., Mpango, G. and Grahl-Nielsen, O. (2008). Variation in fatty acid composition in muscle and heart tissues among species and populations of tropical fish in Lakes Victoria and Kyoga. Lipids., DOI: 10.1007/s11745 - 008-3200-7.

Lauritzen, L., Hansen, H.S., Jorgensen, M.H. and Michaelsen, K.F. (2001). The essentiality of long chain n-3 fatty acids in relation to development and function of the brain and retina. Prog. Lipid Res., 40: 1-94.

Maes, M., Christophe, A., Bosmans, E., Lin, A. and Neels, H. (2000). In humans, serum polyunsaturated fatty acid levels predict the response of pro-inflammatory cytokines to psychological stress. Biol. Psychiat., 47: 910-920.

Miniadis-Meimaroglou, S., Dimizas, C., Loukas, V., Moukas, A. and Vlachos, A. et al. (2007). Proximate composition, fatty acids, cholesterol, minerals in frozen red porgy. Chem. Phys. Lipids., 146: 104-110.

Mnari, A., Bouhlel, I., Chraief, I., Hammami, M., Romdhane, M.S., El Cafsi, M., et al. (2007). Fatty acids in muscles and liver of Tunisian wild and farmed gilthead sea bream, *Sparus aurata*. Food Chem., 100: 1393 - 1397.

Mohamed, E.H.A., Al-Sabahi, J.N. (2011). Fatty acids content and profile of common commercial Nile fishes in Sudan. Int. J. Fisheries Aqua., 3(6): 98 - 103. Available online at http://www.academicjournals.org/IJFA ISSN 2006-9839 ©2011 Academic Journals.

Mohamed, E.H.A. and Al-Sabahi, J.N. (2013). Fatty acids composition and profile in the liver oil of three commercial Nile fishes in Sudan. As J. Sci. Technol., 4(04): 008 - 011.Available Online at http://www.journalajst.com.

Nijinkoue, J.M., Barnathan, G., Miralles, J., Gaydou E.M. and Samp, A. (2002). Lipids and fatty acids in muscle, liver and skin of three edible fish from Senegalese coast: *Sardinella maderensis*, *Sardinella aurita* and *Cephalopholis taeniops*. Comp. Biochem. Physiol., Part B, 131: 395-402.

Nestel, P.J. (2000). Fish oil and cardiovascular disease: Lipids and arterial function. Am. J. Clin. Nutr., 71: 228S-231S.

Nettleton, J.A. and Exler, J. (1992). Nutrient in wild and farmed fish and shelffish. J. Food Sci., 57: 257-260.

Nordov, A., Marchioli, R., Arnesen, H. and Videbaek, J. (2001). N-3 polyunsaturated fatty acids and cardiovascular diseases. Lipids., 36: 127-129.

Sandon, H. (1950) An illustrated guide to the freshwater fishes of the Sudan. Sudan Not. Rec., Special Publication: 33-34.

Sathivel, S., Prinyawiwatkul, W., Grimm, C.C., King, J.M. and Lloyd, S. (2002). FA composition of crude oil recovered from catfish viscera. J. A. O. C. S., 79: 989-992.

Satio, H., Yamashiro, R. Alasalvar, C. and Konno, T. (1999). Influence of diet on fatty acids of three subtropical fish, subfamily caesioninae (*Caesio digrumna* and *C. tile*) and family siganidae (*Siganus canaliculatus*). Lipids., 34: 1073-1082.

Shahar, E., Folsom, A.R. Melnick, S.L. Tockman, M.S. and Comstock, G.W. *et al*. (1994). Dietary n-3 polyunsaturated fatty acids and smoking-related chronic obstructive pulmonary disease. N. Engl. J. Med., 331: 228-233.

Shirai, N., Higuchi, T. and Suzuki, H. (2006). Analysis of lipid classes and fatty acid composition of the salted fish roe food products. Food Chem., 94: 61-67.

Silvers, K.M. and Scott, K.M. (2002). Fish consumption and self reported physical and mental health status. Public Health Nutr., 5: 427-431.

Simopoulos, A.P. (2002). The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed. Pharmacother., 56: 365-379.

Steffens, W. (1997). Effects of variation feeds on nutritive in essential fatty acids in fish value of freshwater fish for humans. Aquaculture., 151: 97-119.

Sushchik, N.N., Gladyshev, M.I. and Kalachova, G.S. (2007). Seasonal dynamics of fatty acid content of a common food fish from the Yenisei River, Siberian Grayling, *Thymallus arcticus*. Food Chem., 104: 1353-1358.

Suzuki, H., Park, S.J., Tamura, M. and Ando, S. (1998). Effect of the long-term feeding of dietary lipids on the learning ability, fatty acid composition of brain stem phospholipids and synaptic membrane fluidity in adult mice: A comparison of sardine oil diet with palm oil diet. Mech. Ageing Dev., 101: 119-128.

Tawfik, M.S. (2009). Proximate composition and fatty acids profiles in most common available fish species in Saudi market. A. J. Clinic. Nutrition., 1: 50-57.

Von Schacky, C., Angerer, P., Kothny, W., Theisen, K. and Mudra, H. (1999). Effect of dietary omega-3 fatty acids on coronary atherosclerosis: A randomized double-blind placebo-controlled trial. Ann. Int. Med., 130: 554-562.

Yonekubo, A., Honda, S., Okano, M., Takahashi, K. and Yamamoto, Y. (1994). Effects of dietary fish oil during the fetal and postnatal periods on the learning ability of postnatal rats. Biosci. Biotechnol. Biochem., 58: 799-801.

Zmijewski, T., Kujawa, R., Jankowska, B., Kwiatkowska, A. and Mamcarz, A. (2006). Slaughter yield, proximate and fatty acid composition and sensory properties of rapfen (*Aspius aspius* L.) with tissue of bream (*Abramis brama* L.) and pike (*Esox lucius* L.). J. Food Comp. Anal., 19: 176-181.