

Determination of fat composition in the meats of tilapia and Nile perch fishes collected from Blue Nile and White Nile, Sudan

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Abstract

Fish provides a good source of high quality protein and contains many of fat-soluble vitamins (A, D, E and K), mineral elements and antioxidant. This study determined the fat composition in the meats of two popular fish species that were brought from the fish market of Wad Medani City (Blue Nile samples; BN), and from Kosti fish market (White Nile samples, WN). The preparation of fish meat-fat and fat composition (through GC-MS), were run in the Food Analysis Laboratory, and the Central Laboratory - University of Gezira. The results showed that, Hexadecanoic acid was detected in WN Nile Perch (3.01%) and Tilapia (13.37%), whereas BN samples did not contain this fatty acid. Eicosanoic acid appeared in only BN samples: Tilapia (9.60%) and perch (2.12), Oleic acid (omega 9) appeared only in WN samples (it was 4.01% in NP, and 16.54% in T. Octadecanoic acid (Stearic acid) was appeared in all BN and WN samples (it was 8.45% in BN Perch, 1.6% in BN Tilapia, 1.60% in WN Tilapia and 0.29% in WN Perch). The more abundant fatty acids was Oleic acid (total sum 20.55%), then Hexadecanoic acid (16.38%). From the proposed results, the feasibility of local production of fish oils for human consumption should be done.

Keywords: Fat; Gas Chromatography; Tilapia; Nile Perch; Nile; Sudan

1. Introduction

Fish are an important resource for humans worldwide, especially as food. Commercial and subsistence fishers hunt fish in wild fisheries or farm them in ponds or in cages (in aquaculture) [1].

Fishing in Sudan is largely carried out by the traditional sector, from the country's major reservoirs, Red Sea, and the rivers to catch fish for sale locally and in nearby urban centers. Sudan's total production of fish and fishing products had significant growth, with estimates of a potential catch of 150,000 tonnes per annum from freshwater sources and 10,000 tonnes from the Red Sea. Aquaculture production reached a high of 1,950 tonnes in 2007 [2].

Eating oily fish containing long-chain omega-3 fatty acids may reduce systemic inflammation and lower the risk of cardiovascular disease. Eating about 140 g of oily fish rich in omega-3 fatty acids twice per week is a recommended consumption amount. Increasing intake of omega-3 fatty acids may slightly reduce the risk of a fatal heart attack [3]. According to the US Food and Drug Administration (FDA), the risk from mercury by eating fish and shellfish is not a health concern for most people [4].

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Fish oils serves as valuable medicinal drugs and food supplements globally depending on its quality. Fish provides a good source of high quality protein and contains many of fat-soluble vitamins (A, D, E and K), mineral elements, antioxidant in addition to cholesterol, cholesterone and oleic acid which are vital for the healthy functioning of the body [5][6].

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Various fish species of different origins and prices are found in fish-markets. This variation makes the consumers very confused about what is to be selected. The aim of this study was to determine the fat composition of some popular Nile fish species using GC-MS.

2. Material and methods

2.1 Study samples

Study samples included Nile perch (*Lates niloticus* سمك العجل) and Tilapia (*Oreochromis niloticus* سمك البلطي) from Blue Nile which were brought from Wad Medani fish market, Gezira State, Sudan, and the same fishes species of the White Nile that were brought from Kosti fish market, White Nile State, Sudan.

2.2 Preparation of fish meat-oil

The samples of the whole fishes were first cleaned using tap water, then the meat of the caudal part (between caudal fin and pectoral fins) of each fish species was cut into small pieces. 5 g of each pieces were put in clean beaker and 10 ml of hexane solvent was added. Each beaker-mouth was then wrapped with aluminum foil so as to prevent evaporation of hexane solvent. After 24 hours, the liquid part of each beaker was filtered to obtain the fish meat-oil. Hexane was not evaporated from the mixtures.

2.3 GC-MS analysis of fatty composition of fish-meat samples

The filtered liquids (hexane and meat-oil) were analyzed using GC-MS technique (GCMS-QP2010 Ultra, Shimadzu Europa GmbH, Library: NIST 11s.lib) which was carried out at Central Laboratory, University of Gezira. The chemical constituents revealed from the GC-MS analysis along with their retention time, base peak, molecular weight, molecular formula and compound names were presented in the result sections.

3. Results and discussion

3.1 Fat composition of Blue Nile fish samples

The fat composition of Nile Perch (NP) and Tilapia (T) meats that brought from the Blue Nile (Wad Medani fish market) through GC-MS technique showed that, about 14 main compounds were detected in the meat-fat of Nile perch meat (Table, 1) and about 15 compounds from the meat-fat of Tilapia (Table, 2). The main compound of NP were: n-Hexadecanoic acid (19.55%); 1s,4R,7R,11R-1,3,4,7-Tetramethyltricyclo- (18.36%); 2-methyltetracosane (12.34%); Octadecanoic acid (8.45%); 7,8-Epoxy lanostan-11-ol,3-acetoxy- (7.03%); Hexadecane (5.37%); Octadecane (4.51%). The profile also involved the Eicosane (2.12%) which found normally in paraffin waxes and used to form candles.

The main compounds in T were: 1s,4R,7R,11R-1,3,4,7-Tetramethyltricyclo- (13.2%), 2-(4,5-dihydro-3-methyl-5-oxo-1-phenyl-4-p (13.06%), Eicosanoic acid (9.60%), 2-Trifluoroacetyldodecane (7.38%), 2-methyltetracosane (6.31%), 9,9-Dimethoxybicyclo[3.3.1]nona-2,4-dione (5.59%), Propane, 2-(ethenyloxy)- (5.04%), Ethanedia, dioxime (4.02%).

Table 1 Main meat-fat composition of Nile Perch brought from the Blue Nile (Wad Medani fish market) through GC-MS technique

Peak	R. time	Area%	Name	Mol. form.	Mol. wt
1	6.742	0.88	5-Aminoisoxazole	C ₃ H ₄ N ₂ O	84
2	10.598	5.37	Hexadecane	C ₁₆ H ₃₄	226
3	11.457	2.86	Phenol,2-methoxy-3-(2-propenyl)-	C ₁₀ H ₁₂ O ₂	164
4	13.710	18.36	1s,4R,7R,11R-1,3,4,7-Tetramethyltricyclo[5.	C ₁₅ H ₂₂ O	218
5	15.780	3.63	Tetradecane	C ₁₄ H ₃₀	198
6	17.258	12.34	2-methyltetracosane	C ₂₅ H ₅₂	352
7	18.121	2.12	Eicosane	C ₂₀ H ₄₂	282
8	18.664	4.51	Octadecane	C ₁₈ H ₃₈	254
9	18.830	1.88	Pentadecanoic acid	C ₁₅ H ₃₀ O ₂	242
10	20.322	3.45	Phthalic acid, butyl undecyl ester	C ₂₃ H ₃₆ O ₄	376
11	20.573	19.55	n-Hexadecanoic acid	C ₁₆ H ₃₂ O ₂	256
12	22.732	2.36	Octadecanal	C ₁₈ H ₃₆ O	268
13	23.029	8.45	Octadecanoic acid	C ₁₈ H ₃₆ O ₂	284
14	27.225	7.03	7,8-Epoxy lanostan-11-ol,3-acetoxy-	C ₃₂ H ₅₄ O ₄	502

Table 2 Main meat-fat composition of Tilapia (*Oreochromis niloticus*, (سمك البلطي)) brought from the Blue Nile (Wad Medani fish market) through GC-MS technique

Peak	R. time	Area%	Name	Mol. form.	Mol. wt
1	3.100	1.32	5-Aminoisoxazole	C ₃ H ₄ N ₂ O	84
2	3.651	5.04	Propane, 2-(ethenyl-oxo)-	C ₅ H ₁₀ O	86
4	4.523	4.02	Ethanedial, dioxime	C ₂ H ₄ N ₂ O ₂	88
5	15.779	13.06	2-(4,5-dihydro-3-methyl-5-oxo-1-phenyl-4-p	C ₁₇ H ₁₃ N ₅ O ₅	367
6	5.947	2.73	2-Amino-4-dimethylaminomethylenepentane	C ₈ H ₁₂ N ₄	164
7	6.366	3.61	Cis-Aconitic anhydride	C ₆ H ₄ O ₅	156
8	7.279	3.06	Acetic acid cyano-	C ₃ H ₃ NO ₂	85
9	13.682	13.20	1s,4R,7R,11R-1,3,4,7-Tetramethyltricyclo [5.	C ₁₅ H ₂₂ O	218
10	20.565	9.60	Eicosanoic acid	C ₂₀ H ₄₀ O ₂	312
11	20.680	1.60	Octadecanoic acid, octadecyl ester	C ₃₆ H ₇₂ O ₂	537
12	22.061	7.38	2-Trifluoroacetyloxydodecane	C ₁₄ H ₂₅ F ₃ O ₂	282
13	22.759	3.32	Dodecanoic acid, 3-hydroxy-	C ₁₂ H ₂₄ O ₃	216
14	23.011	5.59	9,9-Dimethoxybicyclo[3.3.1]nona-2,4-dione	C ₁₁ H ₁₆ O ₄	212
15	23.159	6.31	2-methyltetracosane	C ₂₅ H ₅₂	352

3.2 Fat composition of Blue Nile fish samples

GC-MS analysis for Nile perch meat-fat (Table, 3) brought from White Nile, revealed the detection of 8 compounds. The main compounds detected were: Trichromomethane (91.12%), Oleic acid (4.01%), and n-Hexadecanoic acid (2.11%).

GC-MS analysis for Tilapia meat-fat brought from Kosti fish market (Table, 4) revealed the detection of 11 main compounds of which: Pentadecane (16.85), Oleic acid (16.54), n-Hexadecanoic acid (13.37%), Limonene-6-ol, pivalate (7.34%), Heptadecane (5.19%), Octadecanamide (5.03%) and Octadecanoic acid (stearic acid; 1.6%).

Table 3 Main meat-fat composition of Nile Perch brought from the White Nile (Kosti fish market) through GC-MS technique

Peak	R. time	Area%	Name	Mol. form.	Mol. wt
1	4.721	90.77	Trichromomethane	CHCl ₃	118
	10.391	0.13			
	10.860	0.15			
	11.571	0.07			
2	18.024	0.07	Tetradecanoic acid	C ₁₄ H ₂₈ O ₂	228
3	20.195	0.51	Hexadecanoic acid, methyl ester	C ₁₇ H ₃₄ O ₂	270
4	20.918	2.11	n-Hexadecanoic acid	C ₁₆ H ₃₂ O ₂	256
5	22.675	0.15	Triacotanoic acid, methyl ester	C ₃₁ H ₆₂ O ₂	466
6	23.120	4.01	Oleic acid	C ₁₈ H ₃₄ O ₂	282
7	23.328	0.16	Octadecanoic acid	C ₁₈ H ₃₆ O ₂	284
	23.146	0.13			
8	26.759	0.39	Hexadecanoic acid,2-hydroxy-1(hydroxymet	C ₁₉ H ₃₈ O ₄	330

Table 4 Main meat-fat composition of Tilapia (*Oreochromis niloticus* سمك البلطي) brought from the White Nile (Kosti fish market) through GC-MS technique

Peak	R. time	Area%	Name	Mol. form.	Mol. Wt
1	6.900	3.33	Trichloromethane	CHCl ₃	118
2	13.016	7.34	Limonene-6-ol, pivalate	C ₁₅ H ₂₄ O ₂	236
3	15.821	16.85	Pentadecane	C ₁₅ H ₃₂	212
4	17.301	2.15	Heptadecane	C ₁₇ H ₃₆	240
	18.710	3.04			
5	17.562	3.73	Sulfurus acid, hexyl pentadecyl ester	C ₂₁ H ₄₄ O ₃ S	376
6	20.191	2.70	Hexadecanoic acid, methyl ester	C ₁₇ H ₃₄ O ₂	270
7	20.839	13.37	n-Hexadecanoic acid	C ₁₆ H ₃₂ O ₂	256
8	23.008	16.54	Oleic acid	C ₁₈ H ₃₄ O ₂	282
9	20.680	1.60	Octadecanoic acid (stearic acid)	C ₁₈ H ₃₆ O ₂	284
10	25.491	5.03	Octadecanamide	C ₁₇ H ₃₁ F ₃ O ₂	324
11	26.294	1.45	N,N-Dimethyldodecanamide	C ₇ H ₁₄ O	144

Concerning the detected fatty acids among Blue Nile (BN) and White Nile (WN) fish samples, it was cleared that: Hexadecanoic acid was detected in WN Nile Perch (3.01%) and Tilapia (13.37%), whereas BN samples did not contain this fatty acid.

Eicosanoic acid appeared in only BN samples: Tilapia (9.60%) and perch (2.12), Oleic acid (omega 9) appeared only in WN samples (it was 4.01% in NP, and 16.54% in T).

Octadecanoic acid (Stearic acid) was appeared in all BN and WN samples (it was 8.45% in BN Perch, 1.6% in BN Tilapia, 1.60% in WN Tilapia and 0.29% in WN Perch).

The more abundant fatty acids was Oleic acid (total sum of 20.55%, then Hexadecanoic acid (16.38%), octadecanoic acid (11.94%) and Eicosanoic acid (11.72%, Table, 5).

It was also noticed that, these samples did not contained omega 3 fatty acids, but some of its direct derivatives, were detected in the samples of this study.

There were a considerable positive correlation between the presence of Oleic fatty acid and Hexadecanoic acid (0.99), whereas negative correlation were also observed between Oleic fatty acid and Eicosanoic acid (-0.56) and Eicosanoic acid and Hexadecanoic acid (-0.55)

Table 5 The concentration (%) of some detected fatty acids within the tested samples

Site of sample	Type (species)	Hexadecanoic acid	Eicosanoic acid	Oleic acid (omega 9)	Octadecanoic acid
Blue Nile	Nile Perch	-	2.12	-	8.45
	Tilapia	-	9.60	-	1.60
White Nile	Nile Perch	3.01	-	4.01	0.29
	Tilapia	13.37	-	16.54	1.60
Total sum		16.38	11.72	20.55	11.94
Mean		4.10	2.93	5.14	2.99
SE		3.17	2.28	3.92	1.85

Correlation analysis

	Hexadecanoic acid	Eicosanoic acid	Oleic acid
Eicosanoic acid	-0.55		
Oleic acid	0.99	-0.56	
Octadecanoic acid	-0.38	-0.03	-0.39

Fatty acids especially n-3 and n-6 polyunsaturated fatty acids (PUFAs) play important role in human health. Total saturates n-3 PUFAs, n-6 PUFAs in all the tissues were not significantly affected by the different levels of *I. aquatica*. Tilapia fish fed 10% diet recorded the highest level of muscle docosahexaenoic acid. The tissue composition of docosahexaenoic acid was higher than eicosapentaenoic acid. There was an increase in PUFAs with increased levels of *I. aquatica*. The study suggests that 20% dietary inclusion of *I. aquatica* resulted into high DHA in all tissues [7]. Monounsaturated fatty acids in Nile Tilapia (*Oreochromis niloticus*) constituted the largest proportion of total unsaturated fatty acids in both sexes. Oleic acid was relatively higher in female than male. Conversely, the polyunsaturated fatty acids were higher in male as compared to female [8].

Fatty material from Nile perch belly flaps was assessed for variation in fat content, fatty acid composition, vitamin A content, and level of contaminants in relation to capture site and season. Nile perch from Lake Victoria had higher material yield and omega-3 fatty acids (FAs) but lower content of vitamin A than those from Lake Albert. Levels of omega-3 FAs (4.36–20.20%) and vitamin A (2.83–7.88 mg/100 g of oil) were generally high. Material weight and

vitamin A contents were higher, whereas FAs were lower in fish captured during the dry season than those in the wet season [9]. Oil was extracted from Nile perch (*Lates niloticus*) head collected from the Victoria Lake (Uganda). The crude Nile perch oil contained a substantial amount of oleic acid (15.2 mol %) and an appreciable level of combined n-3 polyunsaturated fatty acids. Comparing with the commercial production of fish oils, oil from Nile perch heads might stimulate its future use for human consumption and easily could be prepared [10]. Fatty material from Nile perch belly flaps had higher material yield and omega-3 FAs (4.36–20.20%) and vitamin A (2.83–7.88 mg/100 g of oil).

Omega 3 can be detected as α -Linolenic acid or through one of its main metabolic derivatives, such as: stearidonic acid, eicosatetraenoic acid, eicosapentaenoic acid, docosapentaenoic acid, tetra-cosapentaenoic acid, tetracosahexaenoic acid and docosahexaenoic acid [11].

4. Conclusion

From the obtained results, it was clear that, different quantities of different compounds were distributed among the tested fish species brought from different ecosystem. The chemical composition of each fish meat-fat is correlated mainly to the type of feed of which it consumed and water component through which it breathe and drink.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors (Tahany Abdel Gader; Mutaman Ali; Yasir Mohamed; Ayda Ali and Zahir Abbas) declare no conflicts of interest regarding the publication of this paper.

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