FATTY ACID COMPOSITION OF NILE TILAPIA *OREOCHROMIS NILOTICUS MUSCLES*: A COMPARATIVE STUDY WITH COMMERCIALLY IMPORTANT TROPICAL FRESHWATER FISH IN PHILIPPINES

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Abstract

Six tropical freshwater species were collected from Philippines in order to study the characteristic of polyunsaturated fatty acids distributions. 16:0 and 18: l n-9 were the predominant saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) in both neutral lipids (NL) and polar lipids (PL). There was an absence or very low values of n3 highly unsaturated fatty acid (HUFA) in NL of all species. However these fatty acids found in PL of all species studied with higher levels. The high proportions of docosahexaenoic acid (DHA) in PL were found with catfish Arius (20.71%), ayungin (17.64%), and snakehead (17.09%) whereas anabas (4.21%) gave lower DHA content. In PL, arachidonic acids (ARA) was found in high proportions, and also is superior to eicosapentaenoic acid (EPA) (ranged from 3.35 to 10.67% and from 0.42 to 4.74%, respectively). Tilapia lipid appears to be intermediate in nutritional quality between all species studied; the proportions of DHA, EPA and ARA in PL were 16.27%, 4.52% and 9.36%, respectively. According to the n-3/n-6 ratio in both fractions, only ayungin is in the range typical of freshwater fish. Our results indicate that the wild tropical freshwater fish studied here are not good sources of n-3 HUFA fatty acids. Therefore, aquatic nutritionists and farmers should combine their efforts in order to manipulate the nutritional quality of these species to enhance their n-3 HUFAs concentrations especially when these species are reared in captivity system. The wash-out strategy may provide an adequate description of the changes in the fillet lipid fatty acid profiles of fatty fish.

Keywords: Tropical freshwater fish; Polar lipids; Neutral lipids; docosahexaenoic acid; eicosapentaeoic acid; Arachidonic acid

INTRODUCTION

Most developing countries are located in tropical or sub-tropical areas, and fish is a vital component of food security for these countries. Rivers and lakes in these

countries were more accessible and kinder sources of fish, and also carry over 40% of the world's known fish species (Zenebe, Ahlgren, Gustafsson, and Boberg, 1998). Moreover, the production and consumption of freshwater fish, has increased during recent years. Therefore effort is needed to improve the output performances and quality of the most important tropical freshwater fish.

Lipids are an important component in fish and human diets, both as energy and fatty acids (FA) sources (Sargent *et al.*, 1989). Among the FA, particular emphasis has been placed on the n-3 and n-6 polyunsaturated fatty acids (PUFA). Polyunsaturated omega-3 (n-3) fatty acids, eicosapentaenoic acid (EPA, C-20:5) and docosahexaenoic acid (DHA, C-22:6), are of interest because they reduce the risk of cardiovascular diseases (Leaf and Weber, 1988; Kang and Leaf, 1996). In addition, fatty acid composition data are needed by food scientists and nutritionists to aid them in dietary formulation, processing and product development (Ackman, 1989). Since these fatty acids composition may vary among fish species, it is necessary to determine both the lipid content and the PUFA distribution. Lipids can be divided into two main classes, i.e. neutral lipids (NL) and polar lipids (PL). PL are important constituents of membranes and they function as precursors in eicosanoid metabolism (structural fat), whereas the NL serve mainly as a depot of lipids used as an energy source (depot fat) (Henderson and Tocher, 1987). Therefore, for comparison between some species, fatty acid composition in both NL and polar lipids PL must be investigated.

The aim of this study is to investigate the characteristic of polyunsaturated fatty acids distributions in some of the wild tropical freshwater fish. In the authors' opinion, this may help recommend the dietary fatty acids manipulation for improving these wild fish for human nutrition when these species reared in captivity system.

MATERIALS AND METHODS

Thirty samples belonging to six species of commercial importance tropical freshwater fish were obtained from Binangonan (having a long coast line facing the Laguna de Bay) in the province of Rizal, Philippines. These are Nile tilapia (*Oreochromis niloticus*), snakehead (*Channa striatus*), climbing Perch (*Anabas testudineus*), ayungin, (*Leiopotherapon plumbeus*), African catfish (*Clarias gariepinus*) and longsnouted catfish (*Arius argyropleuron*). Samples of these species were introduced into crushed ice and transported into the laboratory. The fish fillets were obtained by carefully cutting the fish to gain the maximum amount of flesh. The samples were freeze-dried and stored at -80 ^{o}C until lipid extraction.

Total lipid was extracted with chloroform/methanol (2:1 v/v) containing 0.01% of Butylated hydroxytoluene (BHT) as antioxidant (Folch, Lees, and Stanley, 1957). The organic solvent was evaporated under a stream of nitrogen and the lipid

content was determined gravimetrically. Polar (PL) and neutral lipid (NL) were separated by a silica cartridge (Sep-pak plus, Waters, Milford, MA, USA) as procedure described by Juaneda and Rocquelin (1985). Fatty acid methyl esters (FAME) were prepared by transesterification with borontrifluoride in methanol according to the procedure of Miyashita, Inukai, Ota, Sasaki, and Ota (1999). The resultant fatty acids methyl esters were purified by thin-layer chromatography (Silicagel 70 Plate, Wako, Osaka, Japan; solvent system: petroleum ether/diethyl ether/ acetic acid = 90:10:1, v/v). The FAME was separated and quantified analyzed using GC-17A gas liquid chromatography (GC- 17A; Shimadzu, Kyoto, Japan) equipped with a hydrogen flame ionization detector (FID) and an Omegawax 320 fused silica capillary column (30 m_0.32 mm i.d.; Supelco, Bellefonte, PA, USA). Helium was used as carrier gas with pressure 80 kPa. The oven initial column temperature was 160 ^{o}C for 5 min, followed by an increase at a rate of 4 ^{o}C min^{-1} to a final temperature of 210 ^{o}C. Individual FAME were identified by a reference to authentic standards (Funakoshi, Tokyo, Japan) and to a will characterized known fish oil FAME, and were quantified with an integrator (C-R7A plus; Shimadzu).

RESULTS AND DISCUSSION

Lipids and fatty acid groups

The total, neutral and polar lipids content of muscles are presented in Table (1). Fish are often classified on the basis of their fat content according to Bennion, 1980. Based on this classification, lean fish have lower than 5% fat by weight. This includes tilapia (2.54%), snakehead (2.98%) and African catfish (4.77%). The lipid content recorded for tilapia muscles; correspond with previously given content by Justi, Hayashi, Visentainer, de Souza, and Matsushita (2003), Al-Shagrawi et al. (1998) and Luzia *et al.* (2003). Whereas the fatty fish have more than 10% fat by weight. The fatty fish studied were longsnouted catfish (10.29%), ayungin (12.55%) and climbing Perch (19.51%). Lipid-rich tissues are typically known to contain triacylglycerols as principal lipids, while tissues low in lipid may be dominated by phospholipids (Sargent, Bell, McEvoy, Tocher, & Estevez, 1999). NL account for 94.28% in ayungin, while PL makes up 75.50% in tilapia.

Data of fatty acids profiles of lipid fractions in freshwater fish muscles are illustrated in Tables (2 and 3). In general the fatty acid profile of NL showed higher variation than that in PL. The Composition of fatty acid groups of NL in the muscles of freshwater fish were found to be 37.47-62.96% saturated (SFA), 26.61-58.42% monounsaturated (MUFA) and 0.57–8.70% PUFA, whereas the Composition of fatty acid groups of PL consisted of 32.86–41.16% SFA, 12.00–34.24% MUFA and 18.47–44.76% PUFA. Our data agree with Ackman (1980) who reported that PL fraction contained lower SFA values, and much lower MUFA values than the NL. PL in most

freshwater fish contain higher PUFA levels and lower MUFA and SFA, compared with NL (Ackman and Takeuchi, 1986). On the basis of the above results, it may be concluded that the fatty acid composition depends on the lipid class. Fatty fish species accumulate depot lipids composed mainly of saturated and monoene fatty acids, while in lean fish phospholipids represent a larger proportion of total lipids which mean higher PUFA level in these fishes.

Fatty acids profiles and Guidelines for consumers

The highest proportions of fatty acids in the NL fraction of freshwater fish species were myristic acid (C14:0, 1.56–4.67%), palmitic acid (C16:0, 24.35–43.13%), palmitoleic acid (16:1n-7, 4.24–11.96%), stearic acid (C18:0, 8.51–12.74%), oleic acid (C18:1n9, 9.50– 48.76%) and Vaccenic acid (18:1n-7, 4.68– 6.62%). However, major fatty acids in the PL were palmitic acid (C16:0, 19.33– 29.26%), stearic acid (C18:0, 8.53– 16.83%), oleic acid (C18:1n9, 6.16–25.02%), Vaccenic acid (18:1n-7, 3.33–6.80%), linoleic acid (C18:2n6, 0.86–6.52%), ARA (3.35– 10.67%), EPA (0.42–4.74%), and DHA (4.21–20.71%). The most dominant SFA in both fractions of lipids was palmitic acid. This fatty acid is the most SFA in the eggs and other tissues of most fish species (Harrell and Woods, 1995; Czesny and Dabrowski, 1998). Oleic acid was the most abundant MUFA in both lipid fractions. Generally, PUFA have longer chains in PL than in NL (Ackman and Takeuchi, 1986).

From a human consumer point of view, all fish are considered to be of similar nutritional value, and selection is chiefly based on availability, freshness, flavour and similar factors (Hearn and Sgoutas 1987). On the other hand, results of clinical and epidemiological research suggest that fat composition is very important because of their beneficial effects on human health (Simopoulos, 2002). Therefore, when fish are suggested as a means of improving health, fat quality must be considered (Roche, 1999). The quality of fat has been described using different fatty acids groups such as PUFA/SFA, n-3/n-6 and n-3 HUFAS distribution (Ahlgren, Blomqvist, Boberg, and Gustafsson, 1994; Muller-Navarra, Brett, Liston, and Goldman, 2000).

The ratio n-3/n-6 is better than PUFA/SAFA ratio in comparing the fat quality for different species, because it considers FA families of the n-3 and n-6 type separately (Piggott and Tucker 1990; Sargent, Bell, Bell, Henderson, and Tocher, 1995). Henderson and Tocher (1987) discriminate between the 'freshwater' and 'marine' types of lipids using the n-3/n-6 ratio in NL: in freshwater fish, 1.08–3.3; in marine fish, 8.3–11.4. within the NL fraction. It is only in ayungin within the limits of the above values, while the rest of species the ratio ranged from 0.0 to 1.01, which is lower than the limits for freshwater fish. The absences content of the n-3 fatty acids led to zero value for n-3/n-6 ratio in Snakehead and Anabas. Within the PL fraction, the n-3 fatty acids generally prevail over the n-6 fatty acid in all species studied, except for anabas muscles, for which the n-6 fatty acid was two times higher than n-3. According to Henderson and Tocher, (1987) the n-3/n-6 ratio is 1.6–2.0 for PL of

freshwater fish and 7.8–18.5 for marine fish. In PL, the highest ratio of n6/n3 was obtained from ayungin (2.35) and catfish Arius (2.23). Anabas and snakehead gave the lowest values (0.52 and 1.08, respectively). Ayungin and catfish Arius are within the range typical of freshwater fish. In the rest of the species, the n-3/n-6 ratio ranged from 0.52 to 1.53, which is lower than the limits for freshwater fish. According to the n-3/n-6 ratio in both PL and NL, only ayungin is in the range typical of freshwater fish.

There is increasing evidence that n-3 HUFAs are beneficial for human health. They may reduce or inhibit risk factors involved in various diseases like cardiovascular diseases (Kang and Leaf, 1996). In the authors' opinion, n-3 HUFAs levels is a superior index in comparing relative nutritional value of different species. There was an absence or very low values of n-3 and n-6 HUFA in NL fraction: EPA (not detected in snakehead and anabas samples, 1.01% Ayungin, 0.36% African catfish, 0.29% catfish Arius and 0.28% Tilapia), DHA (not detected in snakehead and anabas samples, 2.47% ayungin, 0.79% African catfish, 0.20% catfish Arius and 0.80% tilapia) and ARA (not detected in snakehead and anabas samples, 0.93% ayungin, 0.66% African catfish, 0.25% catfish Arius and 0.62% tilapia). However these fatty acids were found in PL fraction of all species studied with higher levels. The high proportion of DHA was found with catfish Arius (20.71%), ayungin (17.64%), and snakehead (17.09%) whereas anabas (4.21%) gave lower DHA content. In PL of all species studied ARA was found in high proportions, and also is Superior to EPA (ranged from 3.35 to 10.67 % and from 0.42 to 4.74 %, respectively). A maximum value of ARA was obtained from Snakehead and African catfish (10.67 and 10.32%, respectively), whereas anabas gave the lowest proportion (4.21%). African catfish and catfish Arius gave the highest EPA (4.7%), followed by tilapia (4.52%). The n-3 HUFA levels in PL the species studied here may seem high, but not when compared to marine or freshwater temperate species. Freshwater fish are generally characterized by high levels of n6 PUFA, especially ARA, and also they found that the ratio of total n3 to n6 fatty acids is much higher for marine fish than freshwater fish (Wang, Miller, Perren, and Addis, 1990; Rahman, Huah, Hassan, and Daud, 1995). Moreover, within freshwater fish, tropical freshwater fish include considerable amounts n-6 PUFA and less EPA and DHA than temperate freshwater fish (Henderson & Tocher, 1987; Ahlgren *et al*., 1994; Zenebe *et al*., 1998). The high content of n6 PUFA in tropical freshwater fish led to a lower n-3 to n-6 ratio in the both lipid fractions when compared to marine or freshwater temperate species (Henderson and Tocher, 1987). Our results indicate that the tropical freshwater fish studied here are not good sources of n-3 HUFAs. This disagrees with the results of Zenebe *et al.* (1998) and Ozogul, Ozogul, and Alagoz (2007) which showed that that tropical freshwater wild fish are comparable to temperate freshwater and marine fish as sources of PUFA.

Tilapia lipid appears to be intermediate in nutritional quality between all species studied; the proportions of DHA, EPA and ARA in PL were 16.27%, 4.52% and 9.36%, respectively.The lowest nutritional value was observed for anabs, which is very unusual in several respects and in which high levels of 18:1n-9 in neutral and polar lipids at 48.76 and 25.02%, respectively and lower proportions of Σn-3 and n-3 HUFA in PL (6.28 and 5.88%, respectively) were found. British National Foundation recommends females and males have an daily intake of DHA/EPA of 1.1 and 1.4 g, respectively. Appreciably more tilapia and other lean fish would be required to meet the recommended daily intake of DHA/EPA.

In PL, ARA was the most abundant n-6 PUFA followed by LA. The high proportions of ARA, typical of tropical water fish, was also reported by Henderson and Tocher (1987) and Steffens (1997). From a human health point of view, ARA is the principal n-6 fatty acid in the brain, and together with DHA, is important in the brain development of infants (DeUequiza 2000). In addition ARA plays a potential role as a modulator of the heat shock response (Jurivich, Sistonen, Kroes, & Morimoto, 1992). Fish is an important source of EPA and AA, precursors for biosynthesis of eicosanoids (prostaglandins, thromboxanes and leukotrienes) which exercise important functions in the human body (Schacky, 2000). Moreover, the resulting ArA-derived eicosanoids have a considerably higher biological activity than the eicosanoids derived from EPA. EPA competes for the prostaglandin synthesis enzymebinding site with AA and can reduce the production and efficacy of AA derivatives, and thus exerts a modulating influence over the quantity and efficacy of arachidonic acidderived eicosanoids (Weber, 1990). Therefore, it is necessary to take into consideration not only the individual levels of these fatty acids in fish tissues but also the correct ratio among them ARA/EPA. All wild species studied are characterized by high ARA/EPA ratio in PL ranged from 1.69 to 8.82. When these species are reared in captivity system, the ARA/EPA ratio may be controlled by the linoleic acid/linolenic acid ratio in the feeds. Clinical studies need to be conducted to determine the minimum and maximum value of ARA/EPA ratio in fish tissues recommended for human consumption.

Guidelines for farmers

Owing to the low percentages of the n-3 HUFAS that were noted in the muscles lipids of the species studied here, it is necessary to manipulate the nutritional quality of these species to enhance their n-3 HUFAs concentrations especially when these species are reared in captivity system. In some developing countries, this is particularly important because these species represent a major source of nutrition and there is also limited intake of n-3 HUFAS from other food sources for potential human health benefits.

In general, freshwater fish require n-6 fatty acids for maximal growth (Rodriguez, Perez, Diaz, Izquierdo, Fernandez-Palacios, & Lorenzo, 1997). In addition, freshwater fish have an innate ability to convert C18 PUFA to HUFA and hence can

presumably satisfy their EFA requirement with diets containing C-18 PUFA, which occurs in vegetable oils (Sargent, Henderson, and Tocher, 2002). One disadvantage, however, is that the use of high levels of vegetable oils in fish diets will decrease the concentrations of beneficial n-3 HUFA in fish fillets and hence fillet nutritional quality declines (Kaushik, 2004). Given this, the use of "wash-out" feeding strategy just prior to harvesting is the best solution to enrich the flesh levels of beneficial n-3 HUFA (Ng and Chang, 2004). This feeding strategy depends on using diets containing vegetable oils over the major part of growing period and finishing with diet based on linseed or fish oil or linseed oil as the major lipid source, thus providing cost savings without significantly altering the health benefits of the resultant fish fillet in the human diet (Ng, 2004; Kaushik, 2004). The fatty acid compositions of NL in fish muscle generally follow those of the feed quite closely than are those of PL (Jobling, 2001; Sargent *et al.,* 2002). Therefore, the wild fatty fish which are poor sources of n-3 HUFA fatty acid, have characteristics that make them a promising species for wash-out strategy application when these species are reared in captivity system, such as high lipid level, and the fillet lipids are dominated by NL. Also, more neutral lipids are expected to be added to the existing stores as a result of feeding fish with diets based on vegetable oils over the major part of the growing period which means much more response to change in fatty acids profiles during wash-out period.

From the above results and discussion, it may be concluded that the wild tropical freshwater fish species studied here are not good sources of n-3 HUFAs. In addition, there is a nutritional deficit of n-3 HUFA in the human diet, especially in developing countries which are located in tropical or sub-tropical areas. Therefore, aquatic nutritionists and farmers should combine their efforts in order to manipulate the nutritional quality of these species to enhance their n-3 HUFAs concentrations especially when these species are reared in captivity system. The wash-out strategy may provide an adequate description of the changes in the fillet lipid fatty acid profiles of fatty fish.

Table 1. Composition of total lipid (%, dry basis), neutral lipid (NL, % of total lipid) and polar lipid (PL, % of total lipid) of wild tropical freshwater fish studied.

English name	Scientific name	TL%	NL%	PL%
Nile tilapia	*Oreochromis niloticus*	2.54±0.27	24.50±4.09	75.50±4.09
Snakehead	*Channa striatus*	2.98±0.02	28.19±1.81	71.81±1.81
Climbing Perch (Anabas)	*Anabas testudineus*	19.51±1.78	86.96±0.33	13.04±0.33
Silver perch (Ayungin)	*Leiopotherapon plumbeus*	12.55±3.73	94.28±2.53	5.72±2.53
African catfish	*Clarias gariepinus*	4.77±1.09	42.00±8.43	58.00±8.43
Longsnouted catfish	*Arius argyropleuron*	10.29±3.52	36.32±5.77	63.68±5.77

Table.2. Neutral lipid fatty acid composition (expressed as percentage of total fatty acids) wild tropical freshwater fish studied.

	Tilapia	Snakehead	Anabas	Ayungin	African catfish	Catfish Arius
14:0	4.67 ±0.72	1.56 ±0.02	1.85 ±0.06	2.59 ±0.31	2.41 ±0.89	2.96 ±0.37
15:0	0.77 ±0.12	0.61 ±0.00	0.54 ±0.10	0.49 ±0.05	0.69 ±0.11	0.95 ±0.01
16:0	38.18 ±1.83	33.19 ±0.42	24.35 ±1.62	41.28 ±2.27	33.08 ±2.08	43.13 ±0.54
16:1n-7	11.96 ±1.25	7.51 ±0.01	4.24 ±0.16	10.34 ±0.56	7.96 ±0.98	11.39 ±2.22
17:0	1.26 ±0.23	1.18 ±0.00	0.87 ±0.12	1.07 ±0.13	1.76 ±0.09	1.83 ±0.20
18:0	11.77 ±2.20	12.03 ±0.01	9.08 ±0.31	8.51 ±0.79	10.55 ±0.35	12.74 ±1.56
18:1n-9	15.13 ±1.68	27.48 ±0.06	48.76 ±2.04	16.78 ±1.70	21.01 ±1.32	9.50 ±0.22
18:1n-7	5.67 ±0.55	6.24 ±0.01	4.92 ±0.02	5.07 ±0.22	6.62 ±0.05	4.68 ±0.84
18:2n-6	0.86 ±0.14	0.32 ±0.00	0.95 ±0.51	1.05 ±0.09	1.78 ±0.40	0.82 ±0.05
18:3n-6	0.45 ±0.12	0.25 ±0.01	0.17 ±0.02	0.27 ±0.01	0.42 ±0.02	0.32 ±0.02
18:3n-3	0.45 ±0.07		0.04 ±0.01	0.68 ±0.15	0.56 ±0.10	0.22 ±0.03
20:0	0.47 ±0.18	0.46 ±0.01	0.34 ±0.05	0.22 ±0.02	0.31 ±0.02	0.46 ±0.08
20:1	0.33 ±0.05	0.95 ±0.01	0.51 ±0.02	0.61 ±0.11	0.90 ±0.26	1.04 ±0.34
20:2n-6			0.04 ±0.02		0.48 ±0.22	
20:3n-6						1.21 ±0.06
20:4n-6	0.62 ±0.23			0.93 ±0.08	0.66 ±0.15	0.25 ±0.01
20:3n-3				0.24 ±0.02		0.21 ±0.01
20:5n-3	0.28 ±0.07			1.01 ±0.26	0.36 ±0.08	0.29 ±0.01
22:0	0.35 ±0.10	0.25 ±0.00	0.45 ±0.33	0.30 ±0.03	0.26 ±0.02	0.61 ±0.16
22:4n-6				0.22 ±0.03	0.26 ±0.02	
22:5n-6				0.39 ±0.08	0.33 ±0.01	
22:5n-3	0.42 ±0.14			1.22 ±0.34	0.38 ±0.09	
22:6n-3	0.80 ±0.07			2.47 ±0.72	0.79 ±0.28	0.20 ±0.01
ΣSaturates	57.47 ±3.11	49.26 ±0.42	37.47 ±1.29	54.46 ±3.07	49.05 ±2.33	62.96 ±1.44
ΣMonoenes	33.08 ±2.37	42.18 ±0.07	58.42 ±1.89	33.00 ±1.64	36.49 ±0.86	26.61 ±2.86
PUFA	3.88 ±0.30	0.57 ±0.01	1.19 ±0.51	8.70 ±1.62	6.02 ±1.02	3.52 ±0.13
PUFA/SAT	0.07 ±0.00	0.01 ±0.00	0.03 ±0.01	0.16 ±0.04	0.12 ±0.03	0.06 ±0.00
Σn-6	1.93 ±0.16	0.57 ±0.01	1.16 ±0.51	2.86 ±0.19	3.93 ±0.62	2.59 ±0.09
Σn-3	1.95 ±0.14	0.00 ±0.00	0.04 ±0.01	5.84 ±1.44	2.10 ±0.42	0.93 ±0.04
Σn-3/Σn-6	1.01 ±0.02	0.00 ±0.00	0.04 ±0.02	1.99 ±0.38	0.53 ±0.05	0.36 ±0.01
Σn-3HUFA	1.50 ±0.20	0.00 ±0.00	0.00 ±0.00	5.16 ±1.33	1.53 ±0.40	0.70 ±0.01
AA/EPA	2.31 ±0.61			1.10 ±0.35	1.80 ±0.12	0.84 ±0.01

Table 3. Lipid fatty acid composition (expressed as percentage of total fatty acids) of wild tropical freshwater fish studied.

	Tilapia	Snakehead	Anabas	Ayungin	African catfish	Catfish Arius
14:0	0.72 ±0.14	0.23 ±0.02	0.90 ±0.17	0.53 ±0.02	0.36 ±0.06	0.31 ±0.04
15:0	0.26 ±0.00	0.16 ±0.01	0.38 ±0.01	0.19 ±0.00	0.28 ±0.02	0.20 ±0.02
16:0	23.92 ±0.40	29.26 ±0.46	22.72 ±2.18	19.80 ±0.37	20.77 ±0.97	19.33 ±0.11
16:1n-7	2.21 ±0.45	0.84 ±0.00	2.27 ±0.33	2.25 ±0.15	1.13 ±0.09	1.73 ±0.17
17:0	0.92 ±0.06	0.53 ±0.00	0.93 ±0.05	1.08 ±0.06	0.71 ±0.04	0.84 ±0.05
18:0	9.23 ±0.55	8.53 ±0.08	11.37 ±0.34	16.83 ±0.11	9.89 ±0.20	11.43 ±0.91
18:1n-9	6.46 ±0.53	6.16 ±0.07	25.02 ±0.03	10.96 ±1.56	8.31 ±0.95	10.61 ±0.25
18:1n-7	3.33 ±0.40	4.19 ±0.03	4.85 ±0.13	3.42 ±0.27	6.80 ±0.35	5.10 ±0.29
18:2n-6	1.43 ±0.09	0.86 ±0.01	6.52 ±0.16	1.27 ±0.09	2.74 ±0.40	1.61 ±0.18
18:3n-6	0.41 ±0.02	0.22 ±0.00	0.42 ±0.14	0.39 ±0.11	0.46 ±0.04	0.30 ±0.03
18:3n-3	0.56 ±0.08	0.15 ±0.00	0.41 ±0.15	0.54 ±0.06	0.59 ±0.03	0.49 ±0.06
20:0			0.39 ±0.04	0.26 ±0.04	0.53 ±0.04	0.18 ±0.01
20:1		0.23 ±0.01	1.28 ±0.10	0.51 ±0.03	0.32 ±0.02	0.19 ±0.02
20:2n-6	0.19 ±0.02	0.16 ±0.00	0.24 ±0.05	0.20 ±0.02	0.43 ±0.13	0.17 ±0.01
20:3n-6	0.50 ±0.02	0.22 ±0.00	0.53 ±0.07	0.46 ±0.06	0.55 ±0.06	0.33 ±0.04
20:4n-6	9.36 ±0.47	10.67 ±0.13	3.35 ±0.32	4.25 ±0.20	10.32 ±0.32	7.89 ±0.36
20:3n-3			0.21 ±0.01			
20:4n-3	0.66 ±0.01			0.28 ±0.01	0.30 ±0.03	0.30 ±0.04
20:5n-3	4.52 ±0.40	1.98 ±0.00	0.42 ±0.15	2.12 ±0.21	4.73 ±0.64	4.74 ±0.35
22:0	0.33 ±0.03	0.18 ±0.00	0.33 ±0.06	1.10 ±0.04	0.25 ±0.02	0.28 ±0.02
22:4n-6	0.91 ±0.08	1.84 ±0.01	0.60 ±0.02	0.74 ±0.10	1.30 ±0.22	0.70 ±0.04
22:5n-6	4.89 ±0.23	5.78 ±0.05	0.56 ±0.05	2.74 ±0.21	3.70 ±0.20	2.10 ±0.10
22:5n-3	5.06 ±0.43	2.02 ±0.00	1.04 ±0.18	3.02 ±0.28	2.67 ±0.02	2.97 ±0.31
22:6n-3	16.27 ±0.30	17.09 ±0.03	4.21 ±0.67	17.64 ±1.98	14.01 ±0.86	20.71 ±1.00
24:0	0.29 ±0.02	0.31 ±0.00	0.83 ±0.00	1.39 ±0.14	0.29 ±0.03	0.29 ±0.02
24:1		1.18 ±0.01	0.83 ±0.09	2.85 ±0.48		
ΣSaturates	35.67 ±0.24	39.19 ±0.52	37.83 ±2.64	41.16 ±0.22	33.07 ±0.87	32.86 ±0.92
ΣMonoenes	12.00 ±0.62	12.59 ±0.05	34.24 ±0.24	19.99 ±2.36	16.57 ±0.76	17.63 ±0.25
PUFA	44.76 ±0.40	40.99 ±0.21	18.47 ±1.37	33.63 ±2.83	41.79 ±1.27	42.32 ±0.43
PUFA/SAT	1.25 ±0.02	1.05 ±0.01	0.49 ±0.07	0.82 ±0.07	1.27 ±0.06	1.29 ±0.04
Σn-6	17.69 ±0.26	19.75 ±0.18	12.19 ±0.22	10.04 ±0.57	19.50 ±0.53	13.10 ±0.08
Σn-3	27.07 ±0.15	21.24 ±0.03	6.28 ±1.15	23.58 ±2.51	22.30 ±1.55	29.22 ±0.38
Σn-3/Σn-6	1.53 ± 0.02	1.08 ±0.01	0.52 ±0.09	2.35 ±0.23	1.15 ±0.11	2.23 ±0.03
Σn-3HUFA	26.51 ±0.22	21.09 ±0.03	5.88 ±1.01	23.05 ±2.46	21.71 ±1.51	28.73 ±0.43
AA/EPA	2.10 ±0.20	5.38 ±0.06	8.82 ±2.40	2.05 ±0.20	2.25 ±0.24	1.69 ±0.20

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