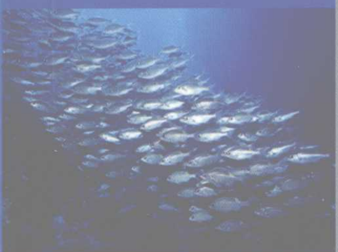
渔业现代化与可持续发展



Modern Fisheries and Sustainable Development

张显良 刘 晴 主编

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专题一　水产生物技术

Session 1　Aquatic Biotechnology

Biochemical composition and nutritional value in the muscle of yellowback seabream *Dentex tumifrons* (Temminck & Schlegel, 1843), wild-caught in the East China Sea

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Abstract: Biochemical composition and nutritional value in the muscle of wild-caught *Dentex tumifrons* in the East China Sea were determined, evaluated and compared with other three maricultured sparids, *Acanthopagrus schlegilii schlegilii*, *Pagrus major* and *Rhabdosargus sarba*. The muscle of *D. tumifrons* consisted of 18.30% crude protein and 0.47% crude lipid; the centent of crude protein was higher and crude lipid lower than those of *A. schlegilii schlegilii*, *P. major* and *R. sarba*. In muscle of *D. tumifrons*, the total essential amino acids (EAA) required by humans comprised 42.88% of total amino acids, higher than that of *A. schlegilii schlegilii*, *P. major* and *R. sarba*. The first limiting amino acid (s) was Threonine (Thr) based on the amino acid score (AAS), and were Methionine (Met) and Cysteine (Cys) based on the chemical score (CS). The EAA index was 65.79. Totally 19 fatty acids were determined. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) contributed to 22.65% of the total fatty acids with 17.25% from DHA. Biochemical composition and nutritional value in the muscle of wild-caught *Dentex tumifrons* provide information on food quality and nutritive requirement and composition of the species, which will help to develop resembling feeds for its mariculture.

Key words: amino acid; *Dentex tumifrons*; fatty acid; nutritive evaluation; Sparidae

1 Introduction

The yellowback seabream *Dentex tumifrons* (Temminck & Schlegel, 1843) distributes in Western Pacific from Japan to northwestern Australia (FishBase: http://www.fishbase.org/Summary/species Summary.php? ID = 4710 & genusname = Dentex & speciesname = tumifrons, accessed on June 2008). In China, it occurs in the East China and South China Seas at water depth of 60 – 250 m (Zhu et al, 1963; Chen et al, 1964; Xia et al, 2003). The fish was once of commercially importance in the East China Sea in the 1950s, mainly targeted by Japan and China; the estimated annual catches from the sea were about 7,000 t in the mid-1950s and peaked at more than 11,000 t in the late-1950s (Chen et al, 1964; Oki & Tabeta, 1998). Catches declined since the 1960s and by the early-1990s the estimated annual catches were less than 3,000 t; To date *D. tumifrons* fishery is not significant (Oki & Tabeta, 1998; Xia et al,

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2003). The major market for *D. tumifrons* consumption is in Japan; the price is higher than the popular seafood, red seabream *Pagrus major* (Temminck & Schlegel, 1843; Xia et al, 2003).

In China, studies on *D. tumifrons* have been recently focused on captive breeding for mariculture purposes and population structure for fishery management (Shi et al, 2005; Zhong et al, 2005; Xia & Jiang, 2006). Information on protein and lipid compositions and contents in the muscle of wild-caught *D. tumifrons* will help to understand their nutritive requirement and composition, and further help to develop its mariculture in aspects of broodstock management and grow-out (Lovell, 1989).

In this study, we determined biochemical and nutritive compositions and contents in the muscle of wild-caught *D. tumifrons* at the Zhoushan-offshore fishing ground, the East China Sea. Protein and lipid qualities were evaluated and further compared with other three sparid species, the black porgy *Acanthopagrus schlegilii schlegilii* (Bleeker, 1854), *P. major* and the goldlined seabream *Rhabdosargus sarba* (Forsskål, 1775), which are commonly maricultured in southern China and fed on mixed fish feed (Zhang et al, 2001).

2 Materials and methods

2.1 Fish and muscle collection

Dentex tumifrons were caught by deep-water drift net on 18 March, 2004, at water depth of 100 – 105 m at the Zhoushan-offshore fishing ground (29°38′N and 129°55′E), the East China Sea; fish were kept on ice during transportation, and stored at −80℃ condition in laboratory for further analysis.

Biochemical compositions of a fish species can be influenced by size, age and body part (Zhang & Chen, 1996); therefore, six individuals of *D. tumifrons* with similar body weight (86.5 ±0.5) g, (mean ± SE) were selected for muscle analysis in this study. Scales were peeled and muscles taken from dorsal part; spines and skin were removed. Muscles from every two fish were pooled randomly, i. e. a total of three muscle samples for analysis ($n = 3$).

2.2 Muscle and analusis

Muscle analyses were conducted using standard methods. Biochemical contents were presented as percentage of wet weight (% wet weight). Moisture content was determined by drying samples at 105℃ for 24 hours to a constant weight. Crude protein content was determined by the Kjeldahl's Nitrogen Analysis Method after acid digestion. Crude lipid content was determined by the Soxhlet's Extraction Method using petroleum ether (BP 40 – 60 ℃) as the solvent. Ash content was determined gravimetrically after total combustion in a furnace at 550℃ for 12 hours. Triplicates were applied for each of the three muscle samples.

Amino acid compositions and contents (% wet weight) were determined using Amino Acid 20 Analyzer (Biopharmaceutical Company, Sweden). Fatty acid compositions and contents (% of total fatty acids) were determined following total lipid extraction, lipid class separation, quantification and final analysis using Agilent 6890 Gas Chromatograph (Datu Inc, Switzerland).

2.3 Calculations

Crude protein (CP) content (% wet weight) was calculated from $CP = 6.25N$, where N is the nitrogen content (% wet weight).

Non-nitrogen extract (NNE) content (% wet weight) was calculated from NNE = 100% − (moisture% + crude protein% + crude lipid% + ash%).

Protein quality evaluation was conducted based on the compositions and contents (milligram of amino acid in one gram of nitrogen, mg/g N) of the essential amino acids (EAA) (FAO/WHO, 1973; Pellett & Young, 1980) and as below:

Amino acid score (AAS) was calculated from AAS = $aa(AA_{FAO/WHO})^{-1}$, where aa is the specific EAA content (mg/g N) in the muscle sample and $AA_{FAO/WHO}$ is the reference content (mg/g N) for the same EAA.

Chemical score (CS) using the whole-egg protein as a standard was calculated from CS = $aa(AA_{Egg})^{-1}$, aa is the specific EAA content (mg/g N) in the muscle sample and AA_{Egg} is the reference content (mg/g N) of the same EAA in the whole-egg protein.

EAA index using the whole - egg protein as a standard was calculated from EAA index = $[100A(A_{Egg})^{-1} 100B(B_{Egg})^{-1} \cdots 100G(G_{Egg})^{-1}]^{-n}$, where n is the total number of EAA determined in the muscle sample, A *to G* are the all EAA contents (mg/g N) in the muscle samples, and A_{Egg} to G_{Egg} are the reference EEA contents (mg/g N) of the same EAA in the whole-egg protein.

Ratio of branched-chain amino acids to aromatic amino acids (Bcaa/Aaa ratio) was calculated from Bcaa/Aaa ratio = $(Ile + Leu + Val)(Phe + Tyr)^{-1}$, where Ile, Leu, Phe, Tyr and Val are the amino acid contents (mg/g N) of Isoleucine, Leucine, Phenulalanine, Tyrosine and Valine, respectively.

Data were presented as mean ± SE from triplicates for each of the three muscle samples (n = 3).

3 Results

3.1 Biochemical compositions

Major biochemical compositions and contents (% wet weight) in the muscle of wild-caught *D. tumifrons* were summarized in Table 1. Crude protein content in *D. tumifrons* was higher than and crude lipid content lower than *A. schlegilii schlegilii*, *P. major* and *R. sarba*, maricultured in southern China (Zhang et al, 2001).

Table 1 Major biochemical compositions and contents (% wet weight, mean ± SE, *n* = 3) in the muscle of wild-caught *Dentex tumifrons*, in comparison with other three sparids, *Acanthopagrus schlegilii schlegilii*, *Pagrus major* and *Rhabdosargus sarba*, maricultured in southern China (Zhang et al, 2001)

Biochemical composition	Biochemical content (% wet weight)			
	D. tumifrons	*A. schlegilii schlegilii*	*P. major*	*R. sarba*
Moisture	78.80 ± 0.8	81.18	78.25	79.01
Crude protein	18.30 ± 0.37	13.12	13.60	13.60
Crude lipid	0.47 ± 0.03	2.53	2.54	2.05
Non-nitrogen extract	1.03	1.37	1.94	1.84
Ash	1.40 ± 0.07	1.21	1.53	2.04

3.2 Compositions and contents of amino acids

Seventeen amino acids were determined in the muscle of *D. tumifrons*, and compositions and contents (% wet weight) were summarized in Table 2. They included seven EAA (Ile, Leu, Lys, Met, Phe, Thr and Val) which required by humans, two half-EAA (Arg and His) and eight non-EAA (Ala, Asp, Cys, Glu, Gly, Pro, Ser and Tyr). Tryptophan (Trp) was not determined because it was resolved during acid digestion.

Table 2 Compositions and contents (% wet weight, mean ± SE, $n = 3$) of the total 17 amino acids determined in the muscle of wild-caught *Dentex tumifrons*, in comparison with other three sparids, *Acanthopagrus schlegilii schlegilii*, *Pagrus major* and *Rhabdosargus sarba*, maricultured in southern China (Zhang et al, 2001)

Amino acid composition	Amino acid content (% wet weight)							
	D. tumifrons		*A. schlegilii schlegilii*		*P. major*		*R. sarba*	
	% wet weight	% of total *AA*	% wet weight	% of total *AA*	% wet weight	% of total *AA*	% wet weight	% of total *AA*
Alanine (Ala) [a]	0.94 ± 0.03	6.39	0.98	6.32	0.67	6.20	0.99	6.31
Aspartate (Asp) [a]	1.56 ± 0.02	10.65	1.97	12.70	1.01	9.38	1.63	10.42
Glutamate (Glu) [a]	2.25 ± 0.01	15.39	2.42	15.63	1.70	15.78	2.53	16.2
Glycine (Gly) [a]	0.65 ± 0.02	4.41	0.77	5.00	0.59	5.42	0.75	4.81
Arginine (Arg) [b]	0.87 ± 0.01	5.92	0.92	5.94	0.67	6.21	0.91	5.81
Histidine (His) [b]	0.35 ± 0.02	2.41	0.37	2.36	0.31	2.87	0.43	2.77
Isoleucine (Ile) [c]	0.74 ± 0.01	5.08	1.30	8.42	0.93	8.58	1.31	8.38
Leucine (Leu) [c]	1.41 ± 0.01	9.63	0.64	4.15	0.51	4.72	0.71	4.58
Lysine (Lys) [c]	1.42 ± 0.01	9.67	1.50	9.71	1.09	10.12	1.54	9.89
Methionine (Met) [c]	0.42 ± 0.02	2.89	0.50	3.24	0.42	3.85	0.40	2.55
Phenylalanine (Phe) [c]	0.68 ± 0.01	4.62	0.68	4.40	0.48	4.40	0.71	4.52
Threonine (Thr) [c]	0.65 ± 0.01	4.46	0.79	5.08	0.50	4.66	0.70	4.46
Valine (Val) [c]	0.96 ± 0.02	6.53	0.72	4.64	0.58	5.39	0.77	4.94
Cysteine (Cys)	0.18 ± 0.01	1.21	0.17	1.10	0.17	1.60	0.18	1.15
Proline (Pro)	0.51 ± 0.01	3.51	0.54	3.48	0.39	3.61	0.97	6.21
Serine (Ser)	0.55 ± 0.02	3.78	0.69	4.49	0.46	4.24	0.62	3.94
Tyrosine (Tyr)	0.51 ± 0.03	3.46	0.52	3.35	0.32	2.97	0.48	3.05
Total EAA	6.28 ± 0.02	42.88	6.13	39.64	4.51	41.72	6.14	39.32
Total non-EAA	7.15 ± 0.12	48.79	8.06	52.07	5.31	49.20	8.15	52.09
EAA / Non-EAA ratio	0.88 ± 0.01	NA	0.76	NN	0.75	NA	0.75	NA
Total DAA	5.40 ± 0.07	36.84	6.14	39.65	3.97	36.78	5.90	37.74
Bcaa/Aaa ratio	2.61 ± 0.01	NA	2.22	NA	2.53	NA	2.35	NA
Total AA	14.65 ± 0.14	100.00	15.48	100.00	10.80	100.00	15.63	100.00

Note: a. Delicate amino acid (DAA); b. Half-essential amino acid; c. Essential amino acid (EAA).

AA. Amino acid; Bcaa/Aaa ratio. A ratio of branched-chain amino acids to aromatic amino acids; NA. No available.

The total content of amino acids in the muscle of *D. tumifrons* was 14.65% of wet weight, which was lower than those of *A. schlegilii schlegilii* and *R. sarba*, but higher than *P. major*. The total EAA was 42.88% and the Bcaa/Aaa ratio was 2.61; both were higher than those of *A. schlegilii schlegilii*, *P. major* and *R. sarba*. The total content of delicate amino acids (DAA) was 36.84%, which was lower than *A. schlegilii schlegilii* and *R. sarba*, but higher than *P. major*. Glutamate (Glu, a DAA) was 15.39%, which was the highest content among all the 17 amino acids and same as to *A. schlegilii schlegilii*, *P. major* and *R. sarba*. Among the seven EAA, Lysine (Lys) was the highest content (9.67%), same as to *A. schlegilii schlegilii*, *P. major* and *R. sarba*.

3.3 Evaluation of protein quality

The seven EAA in the muscle of *D. tumifrons*were evaluated based on the FAO/WHO and whole-egg protein standards; Amino acid contents (% wet weight) were transferred to mg/g N for evaluation purposes (Table 3).

The total EAA content in the muscle of *D. tumifrons* was 2 028 mg/g N, which was lower than those of FAO/WHO (2 190 mg/g N) and whole-egg protein (2 959 mg/g N) standards, and *A. schlegilii schlegilii*, *P. major*and *R. sarba*. The total EAA was 46.96% of the total amino acids, which was higher than the FAO/WHO standard (35.38%) but lower than the whole-egg protein standard (48.08%). The EAA index was 65.79.

The contents of AAS and CA in the muscle of *D. tumifrons* were compared with those in *A. schlegilii schlegilii*, *P. major*and *R. sarba*(Table 4). Based on the AAS, the first limiting amino acid was Threonine (Thr), and the second was Ile and (Phe + Tyr). Based on the CS, the first limiting amino acid was (Met + Cys), and the second was Ile, Thr and (Phe + Tyr).

3.4 Compositions and contents of fatty acids

A total of 19 fatty acids were determined in the muscle of *D. tumifrons*, including seven saturated (SFA) and 12 unsaturated Fatlyacids (UFA) (Table 5). The highest SFA and UFA were $C_{16:0}$ and $C_{18:1}$, contributing to 25.97% and 23.13% of the total fatty acids, respectively. Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) together contributed to 22.65% of the total fatty acids with 17.25% from DHA.

4 Discussion

Protein is the most important nutrition required by humans. In this study, the muscle of wild-caught *D. tumifrons* has higher crude protein content than the maricultured sparids such as *A. schlegilii schlegilii*, *P. major*and *R. sarba* (Zhang et al, 2001). However, compared to other wild-fcaught marine fishes, such as the yellowfin tuna *Thunnus albacares*(Bonnaterre, 1788) and red drum *Sciaenops ocellatus*(Linnaeus, 1766), the crude protein content in *D. tumifrons*(18.30%) was lower than those in the two species (i. e. 26.2% and 24.0%, respectively) (Liu et al, 2002; Hong et al, 2006). Crude lipid content in *D. tumifrons*(0.47%) was lower than those in maricultured *A. schlegilii schlegilii*, *P. major* and *R. sarba*(all >2.0%) (Zhang et al, 2001). There is no data available on crude protein and lipid contents from maricultured *D. tumifrons* for the comparison between same species; however, it is common that maricultured individuals have lower protein and higher lipid contents than wild-caught individuals. Such differences are believed to come from fish feed and under mariculture condition. For example, the main composition of mixed fish feed was the jacks (Carangidae) for the Hong Kong grouper *Epinephelus akaara*(Temminck & Schlegel, 1842) mariculture in southern China; however, the fish in the wild mainly fed on crustaceous, i. e. >80% in their diet (Chen et al, 1994; Okumura et al, 2004). Moreover, under mariculture conditions such as in floating cage or indoor tank, fish has limited

Table 3 Evaluation of the contents (mg / g N) of seven essential amino acids (EAA) determined in the muscle of wild-caught *Dentex tumifrons*, in comparison with the FAO / WHO and whole-egg protein standards, and other three sparids, *Acanthopagrus schlegilii schlegilii*, *Pagrus major* and *Rhabdosargus sarba*, maricultured in southern China (FAO / WHO, 1973; Pellett & Young, 1980; Zhang et al, 2001)

Amino acid	FAO/WHO	Whole-egg protein	*D. tumifrons*	*A. schlegilii schlegilii*	*P. major*	*R. sarba*
Isoleucine (Ile)	250	331	218	620	398	601
Leucine (Leu)	440	534	416	306	219	328
Lysine (Lys)	340	441	419	716	470	709
Threonine (Thr)	250	292	192	374	216	320
Valine (Val)	310	410	283	342	250	354
Methionine + Cysteine (Met + Cys)	220	386	351	320	253	266
Phenylalanine + Tyrosine (Phe + Tyr)	380	565	218	571	409	543
Total	2190	2959	2028	3249	2215	3121
Of total *AA*/%	35.38	48.08	46.96	50.95	53.77	50.95
EAA index	NA	NA	65.79	NA	NA	

Note: NAAA, amino acid; EAA, essential amino acid; NA, no available.

Table 4 Amino acid score (AAS) and chemical score (CS) in the muscle of wild-caught *Dentex tumifrons* and other three maricultured sparids, *Acanthopagrus schlegilii schlegilii*, *Pagrus major* and *Rhabdosargus sarba*, maricultured in southern China (Zhang et al, 2001)

Amino acid	AAS				CS			
	D. tumifrons	*A. schlegilii schlegilii*	*P. major*	*R. sarba*	*D. tumifrons*	*A. schlegilii schlegilii*	*P. major*	*R. sarba*
Isoleucine (Ile)	0.87**	2.48	1.59	2.40	0.66**	1.24	0.79	1.20
Leucine (Leu)	0.94	0.70*	0.50*	0.75*	0.78	0.36*	0.26*	0.39*
Lysine (Lys)	1.23	2.11	1.38	2.09	0.95	1.10	0.72	1.09
Threonine (Thr)	0.77*	1.50	0.86	1.28	0.66**	0.93	0.54	0.79
Valine (Val)	0.91	1.10**	0.81**	1.14**	0.69	0.57	0.42**	0.59
Methionine + Cysteine (Met + Cys)	0.92	1.46	1.15	1.21	0.62*	0.55**	0.43	0.45**
Phenylalanine + Tyrosine (Phe + Tyr)	0.87**	1.50	1.08	1.43	0.66**	0.60	0.43	0.57
Total	6.51	10.85	7.37	10.3	5.05	5.35	3.59	5.08

Note: *, the first limiting amino acid; **, the second limiting amino acid.

space to move, which also led to the accumulation of lipids in fish body such as in the muscle (Chen et al, 1994).

Seafood quality is determined not only by total protein content but also by amino acid compositions and contents. In the muscle of *D. tumifrons*, the total EAA content was 42.88% of the total amino acids and the ratio of the total EAA to total non-EAA was 0.88; both were higher than those of maricultured sparids, *A. schlegilii schlegilii*, *P. major* and *R. sarba* (Zhang et al, 2001). The total EAA content in *D. tumifrons* was also higher than that in grouper species, the blacktip grouper *Epinephelus fasciatus* (Forskål, 1775), honeycomb grouper *E. merra* Bloch, 1793, greasy grouper *E. tauvina* (Forskål, 1775), and three spot grouper *E. trimaculatus* (Valenciennes, 1828), all were wild-caught in southern water of China (Zhang & Chen, 1996). In the four *Epinephelus* species, the total EAA content did had not significantly difference among species and location. In the four sparids, *D. tumifrons*, *A. schlegilii*, *P. major* and *R. sarba*, the total DAA contents were lower than those of *Epinephelus* species and *T. albacares* (Zhang & Chen, 1996; Zhang et al, 2001; Hong et al, 2006; this study) which may explain why groupers and tunas are considered as more delicious seafoods and have generally higher prices.

Among the EAA, both contents and ratios are important for protein quality evaluation. Lysine (Lys) is an EAA for humans. The deficiency in Lys can result in a deficiency in niacin and cause various diseases. In both wild and mariculture sparids, they have the highest content in Lys among the all EAA; same in wild and mariculture *Epinephelus* groupers and in freshwater fish species (Zhang & Chen, 1996; Zhang et al, 2001; Yin et al, 2006; this study). High content of Lys in fishes can compensate the low content of Lys in crops in human requirement; Lys is the limiting amino acid in all cereal grains. In human diets, when the ratio of the seven EAA, Thr: (Met + Cys): Val: Ile: Leu: (Phe + Tyr): Lys, is about 2.0: 3.7: 2.8: 2.8: 4.0: 4.0: 3.4, they are more easy for human body absorption. In *D. tumifrons*, the ratio is about 1.95: 1.53: 2.88: 2.22: 4.23: 3.57: 4.26, close to the ratio of human body preference. High ratio of Bcaa / Aaa is also good for humans, which is believed to be good for liver function and play an important role in protein synthesis. In *D. tumifrons*, the ratio of Bcaa / Aaa is higher than those of *A. schlegilii*, *P. major*, *R. sarba* and *S. ocellatus*, and similar to *T. albacares* (Zhang & Chen, 1996; Liu et al, 2002; Hong et al, 2006). In mariculture operation, the EAA contents and ratios in fish body can be used as a model recipe for previous developing commercial feeds.

Omega-3 fatty acids such as EPA and DHA are widely known to be important in human nutrition. In fishes, EPA and DHA are cumulated through food chains; fishes first originate EPA and DHA from the algae in their diet and concentrate as they move up the food chain. In the recent research, it indicated that humans have higher efficiency to obtain EPA and DHA from fish consumption directly rather than from supplementing with fish oil (Elvevoll et al, 2006). In the muscle of *D. tumifrons*, the total content of EPA and DHA was 22.65% of the total fatty acids. Therefore, *D. tumifrons* is good quality seafood for human consumption. The high content of EPA and DHA in *D. tumifrons* merits further investigation. Whether this relates to deep-water habitat of the species is unknown. Understanding feeding ecology will help to find the answers.

The decline of *D. tumifrons* wild stocks was due to overfishing between the 1950s and 1990s (Oki & Tabeta, 1998; Xia et al, 2003). The species to date can be hatchery-produced in southern China and mariculture of the species is developing (Zhong et al., 2005). This study on biochemical composition and nutritional value in the muscle of wild-caught *Dentex tumifrons* can provide information on nutritive requirement of the species, which will help to develop resembling feeds for its mariculture.

Table 5 Compositions and contents (% of total fatty acids, mean ± SE, $n = 3$) of the 19 fatty acids determined in the muscle of wild-caught *Dentex tumifrons*

Saturated fatty acid	Percentage/%	Unsaturated fatty acid	Percentage/%
$C_{14:0}$	2.30 ± 0.12	$C_{16:1}$	5.72 ± 0.17
$C_{15:0}$	0.80 ± 0.03	$C_{17:1}$	0.21 ± 0.04
$C_{16:0}$	25.97 ± 0.81	$C_{18:1}$	23.13 ± 0.30
$C_{17:0}$	2.25 ± 0.10	$C_{20:1n-9}$	1.70 ± 0.16
$C_{18:0}$	9.15 ± 0.19	$C_{21:1n-7}$	0.23 ± 0.04
$C_{19:0}$	0.37 ± 0.05	$C_{18:2n-6}$	0.82 ± 0.11
$C_{20:0}$	0.36 ± 0.01	$C_{20:2n-6}$	0.30 ± 0.02
		$C_{20:3n-3}$	0.14 ± 0.08
		$C_{20:4n-6}$	2.58 ± 0.05
		$C_{21:4n-7}$	1.31 ± 0.02
		$C_{20:5n-3}$ (EPA)	5.40 ± 0.30
		$C_{22:6n-3}$ (DHA)	17.25 ± 0.18
Total SFA	41.20 ± 0.67	Total UFA	58.79 ± 0.69
		Total MUFA	30.99 ± 0.30
		Total PUFA	27.80 ± 0.60
		EPA + DHA	22.65 ± 0.47

Note: DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; MUFA, monounsaturated fatty acid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; UFA, unsaturated fatty acid.

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