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Fatty acid profiles of muscle from large yellow croaker (*Pseudosciaena crocea* R.) of different age

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Abstract: We investigated the fatty acid profiles of muscle from large yellow croaker (*Pseudosciaena crocea* R.) of different age. One- and two-year-old fish were cultured in floating net cages and sampled randomly for analysis. Moisture, protein, lipid and ash contents were determined by methods of Association of Analytical Chemist (AOAC) International. Fatty acid profile was determined by gas chromatography. Crude protein, fat, moisture and ash contents showed no significant differences between the two age groups. The contents of total polyunsaturated fatty acids and docosahexaenoic acid (DHA) were significantly higher and eicosapentaenoic acid (EPA) content was significantly lower in the two-year-old large yellow croaker than in the one-year-old (P<0.05). No significant differences were observed in the contents of total saturated fatty acids and monounsaturated fatty acids, or the ratio of n-3/n-6 fatty acids among the large yellow croakers of the two age groups. We conclude that large yellow croakers are good food sources of EPA and DHA.

Key words: Fatty acid, Large yellow croaker, Age
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INTRODUCTION

Marine fish possesses sufficient amounts of important nutritional components required in human diets. High quality protein and long-chain polyunsaturated fatty acids were studied widely (Ackman 1989; George and Bophal, 1995). Long-chain n-3 polyunsaturated fatty acids (PUFAs), including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are very beneficial to human nutrition and disease prevention (Horrocks and Yeo, 1999; Skonberg and Perkins, 2002; Ward and Singh, 2005). Flesh quality is becoming of increasing concern to the aquaculture industry as total production increases (Johnston, 1999). Flesh quality can be influenced by the biochemical composition of fish fillets (Hernández *et al*., 2002). The biochemical composition may be affected by species, environmental factors, size, age, and diets (Gruger, 1967; Bandarra *et al*., 1997).

Large yellow croaker (*Pseudosciaena crocea* R.) is an economically important carnivorous species. Due to excessive harvest, wild large yellow croaker was nearly depleted prior to the 1980s. It has been widely cultured since the success of artificial hatchery. There are some studies on nutrient requirements and immunity of large yellow croaker (Jian and Wu, 2003; Mai *et al*., 2006; Ai *et al*., 2007; Tang *et al*., 2008), while little information is available on body composition of this species. The aim of this study was to compare the nutritive values and fatty acid profiles in large yellow croaker of two different ages. Sampled fish are representative during growth stages; the 1-year-old has the fastest growth speed and the 2-year-old reaches the commercial size of large yellow croaker.

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MATERIALS AND METHODS

Fish sampling

Large yellow croakers from Tai-chu race were obtained at Xiangshan Port aquaculture field, Ningbo City, Zhejiang Province, China. The fish were caught as fingerlings and reared in floating net cages (3.0 m×3.0 m×3.0 m, seawater salinity 3.2%~3.5%). They were fed with raw fish (frozen *Sardinella* spp.) twice daily (5:00 and 17:00) to satiation. Raw large yellow croakers used contained 25.5% dry matter, 70.6% protein, 13.1% fat, and 15.5% ashes. Twenty fish were sampled in two ages (1-year-old and 2-year-old), respectively. Body length and weight of the sampled fish were measured. Average length and weight were (21.3±0.56) cm, (168.3±10.47) g in the 1-year-old fish, and (28.2±0.65) cm, (283.5±13.32) g in the 2-year-old.

Five large yellow croakers per age were kept in plastic bags and shipped in an insulated icebox to the laboratory. After discarding the skin, a part of the epaxial and hypaxial muscle was removed respectively from the left side of each fish. Flesh samples were ground and mixed together, stored in liquid nitrogen until analysis.

Proximate analysis

The proximate analysis of flesh was carried out by methods of Association of Analytical Chemist (AOAC) International (1999). Samples were dried to a constant weight at 105 °C to determine moisture. Protein was determined by measuring nitrogen (N×6.25) using the Kjeldahl method. Fat was assayed by ether extraction using Soxhlet method. Crude ash was determined following combustion at 550 °C for 6 h.

Fatty acid profiles

Total lipid extraction of the samples was carried out in triplicate by the Bligh and Dyer (1959) method. Fatty acids were transesterified to methyl esters with 0.5 mol/L NaOH in methanol and 0.14 g/ml methanolic boron trifluoride. The fatty acid methyl esters were recovered with hexane, and separated and measured by the method described in (Mourente *et al*., 1999) with minor modifications, using Agilent 6890N gas chromatograph (Agilent Technologies, CA, USA) equipped with Supelcowax 10 capillary column (length 30 m, internal diameter 0.32 mm, film thickness 0.25 μm; Supelco, PA, USA) and a flame ionization detector. Individual fatty acids were identified by comparing the retention time of fatty acid methyl ester (FAME) with standard FAME mixture from Supelco (Bellefonte, PA, USA). The values of fatty acids are presented as area percentage of total fatty acids.

Statistical analysis

The results are presented as the mean±*SD* (standard deviation). All data were analyzed by one-way analysis of variance (ANOVA) using the software of the SPSS 11.0 for Windows. Student's *t*-test was performed to separate differences among means. The differences are considered significant at $P<0.05$.

RESULTS

Proximate analysis

The results of proximate analysis are presented in Table 1. Crude protein, fat and ash levels showed a tendency to increase with age. No significant differences were observed between the two age groups.

Table 1 Proximate composition of large yellow croaker*

Age (year)	Moisture (%)[1]	Crude protein (%)[2]	Crude fat (%)[2]	Ash (%)[2]
1	74.9±0.36[a]	76.6±0.30[a]	17.9±0.38[a]	2.5±0.12[a]
2	74.3±0.43[a]	76.9±0.47[a]	18.2±0.45[a]	2.6±0.16[a]

*n=5. [1]The content is expressed as percentage of wet weight; [2]The content is expressed as percentage of dry weight. Values (mean±*SD*) in the same column with the same superscript letter are not significantly different ($P>0.05$)

Fatty acid profiles

Table 2 shows the fatty acid profiles in large yellow croaker of the two different ages. From Table 2, we can find that three fatty acids, C16:0, C18:1 (*n*-9), C22:6 (*n*-3), were particularly abundant. Palmitic acid was the primary saturated fatty acid, and oleic acid was the primary monounsaturated fatty acid. No significant differences were found in total contents of saturated fatty acids or monounsaturated fatty acids between the two age groups. Total polyunsaturated fatty acid content in the 2-year-old fish was significantly higher [(28.5±0.32)%] than that in the 1-year-old fish ($P<0.05$). The 2-year-old fish contained

higher DHA and lower EPA level compared to the 1-year-old (P<0.05). The n-3/n-6 fatty acid ratios in both ages were high, approximately 6.7.

Table 2 Fatty acid profile of large yellow croaker

Fatty acids	Fatty acid content (%)	
	1-year-old	2-year-old
C14:0	3.0±0.10	2.5±0.66
C15:0	0.6±0.01	0.6±0.15
C16:0	27.9±0.30[a]	30.3±2.97[b]
C17:0	1.0±0.03	1.0±0.25
C18:0	5.7±0.45	6.4±0.43
C20:0	0.4±0.04	0.4±0.10
C22:0	1.1±0.18	0.6±0.44
∑SFA	39.7±0.80	41.8±3.97
C16:1 (n-9)	9.6±0.05	10.1±1.20
C17:1 (n-11)	0.2±0.01	0.3±0.00
C18:1 (n-9)	23.0±0.21[a]	20.3±2.40[b]
C18:1 (n-7)	3.2±0.03	3.1±0.33
C18:1 (n-6)	0.2±0.03	0.2±0.01
C20:1 (n-9)	1.0±0.10	1.0±0.28
C22:1 (n-9)	0.6±0.11	0.6±0.24
C24:1 (n-9)	0.3±0.03	0.2±0.08
∑MUFA	37.9±0.26	35.8±4.44
C16:2 (n-4)	0.3±0.01	0.3±0.04
C16:3 (n-3)	0.2±0.04	0.2±0.02
C18:2 (n-6)	1.1±0.07	1.4±0.20
C18:3 (n-3)	0.7±0.04	0.6±0.02
C18:5 (n-3)	0.6±0.11[a]	0.3±0.02[b]
C20:4 (n-6)	1.5±0.17	1.8±0.01
C20:5 (n-3)/EPA	5.3±0.44[a]	4.3±0.04[b]
C22:4 (n-6)	0.4±0.02[a]	0.5±0.01[b]
C22:5 (n-3)	1.2±0.09	1.2±0.09
C22:6 (n-3)/DHA	12.1±0.49[a]	17.9±0.24[b]
∑PUFA	23.2±1.07[a]	28.5±0.32[b]
∑n-3 PUFA	19.9±0.82[a]	24.5±0.20[b]
∑n-6 PUFA	3.0±0.24[a]	3.7±0.19[b]
n-3/n-6 ratio	6.68±0.26	6.71±0.35

SFA: saturated fatty acid; MUFA: monounsaturated fatty acid; PUFA: polyunsaturated fatty acid; EPA: eicosapentaenoic acid; DHA: docosahexaenoic acid. Values (mean±*SD*) in the same row with different superscript letters are significantly different (P<0.05)

DISCUSSION AND CONCLUSION

In the present study, we found that large yellow croaker contains high crude protein content (76.63%~76.87%). The lipid and water contents of the muscle are considered to contribute to the juiciness of the fish in organoleptic tests (Dunajski, 1980). We also observed that lipid content in fillets of large yellow croaker was moderate (17.95%~18.18%). No significant difference was found between the 1- and 2-year-old croakers.

Although long chain PUFA can be synthesized, its amount is not sufficient for human needs. Previous studies have shown that n-3 PUFAs have beneficial effects on coronary heart diseases, arrhythmias, hypertension, inflammation, psoriasis, and cancer (Puwastien *et al*., 1999; Simopoulos, 2002; Schmidt *et al*., 2005; Pardini, 2006). Fish are the main contributors of n-3 PUFA for the human diet. When fed diets with less marine oils, farmed fish will contain lower proportion of n-3 PUFAs. This may reduce their nutritional values and effects on disease prevention (Moreira *et al*., 2001). Marine fish contain higher levels of n-3 PUFA than freshwater fish (Rahnan *et al*., 1995). A dietary intake of fish with high ratio of n-3/n-6 fatty acids would be beneficial (Økland *et al*., 2005). The ratio of total n-3/n-6 fatty acids in marine fish is much higher than that in freshwater fish, varying from 5 to 10 or more (Özogul and Özogul, 2007). Similar results were observed in the present study.

EPA and DHA are very beneficial to human health (Nestel *et al*., 2002). EPA has been reported to be useful in the treatment of cancer and brain disorders (Fenton *et al*., 2000). DHA is a major component of the brain, the eye retina, and heart muscles, which plays a vital role in the brain and the eye development (Ward and Singh, 2005). The levels of EPA and DHA in seawater fish are higher than those in freshwater fish (Czesny *et al*., 1999). In the present study, EPA and DHA contents in dorsal muscle from large yellow croaker were particularly abundant, consistent with previous findings that they were higher than those from any other cultured fish (Chen *et al*., 1995; Karahadian *et al*., 1995; Paleari *et al*., 1997).

Fatty acid composition of fish tissues may be affected by species, environmental factors, size, age, and diets (Gruger, 1967; Saito *et al*., 1999; Kiessling *et al*., 2001). In this trial, all fish sampled for analysis were reared with the same diet and cultured under the same exogenous conditions. Therefore, the age could be considered the sole factor that affect fatty acid profiles of large yellow croaker examined in this study. We found no significant differences in

saturated fatty acid and monounsaturated fatty acid contents between the fish of the two different ages. Total *n*-3 PUFA and DHA contents in the 2-year-old increased, while EPA content decreased significantly ($P<0.05$). The differences may be caused by the lower fat content in large yellow croaker.

Fatty acid composition of feed can affect the fatty acid profiles of cultured fish (Mnari *et al*., 2007). Due to lower levels of *n*-3 PUFAs and DHA, the nutritive value of 1-year-old croaker decreased. To solve this problem, adding fish oil which contains more *n*-3 PUFAs (especially EPA and DHA) to the diets of experimental fish seems to be feasible in future studies.

It was found that large yellow croaker possesses higher content of protein in the present study. The difference of total fat content between the two age groups was not significant, but some changes in fatty acid profiles were observed. The proportions of *n*-3 PUFAs (especially EPA and DHA) were high in both age groups. We conclude that large yellow croakers are good food sources of EPA and DHA.

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