SHORT COMMUNICATION

Nutritional compositions in different parts of muscle in the longfin batfish, Platax teira (Forsskål, 1775)

Bo Liu\textsuperscript{a,b,c}, Hua-Yang Guo\textsuperscript{a,b,d}, Ke-Cheng Zhu\textsuperscript{a,b,d}, Bao-Suo Liu\textsuperscript{a,b,d}, Liang Guo\textsuperscript{a,b,d}, Nan Zhang\textsuperscript{a,b,d}, Shi-Gui Jiang\textsuperscript{a,b,d,e} and Dian-Chang Zhang\textsuperscript{a,b,d,e}

\textsuperscript{a}South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou, People’s Republic of China; \textsuperscript{b}Key Laboratory of South China Sea Fishery Resources Exploitation and Utilization, Ministry of Agriculture and Rural Affairs, Guangzhou, People’s Republic of China; \textsuperscript{c}College of Fisheries and Life Science, Shanghai Ocean University, Shanghai, People’s Republic of China; \textsuperscript{d}Guangdong Provincial Engineer Technology Research Center of Marine Biological Seed Industry, Guangzhou, People’s Republic of China; \textsuperscript{e}Guangdong Provincial Key Laboratory of Fishery Ecology and Environment, Guangzhou, People’s Republic of China

ABSTRACT

Longfin batfish (Platax teira) is a coastal marine fish life. The aims of this study are to investigate the compositions and content of amino acid and fatty acid in three parts of P. teira. The results showed that P. teira muscle protein content was as high as 21.00%. For amino acid composition, seventeen kinds of amino acids were detected in three parts. The essential amino acid score (EAAS) and essential amino acids (EAA) / total amino acids (TAA) ratio of P. teira were both above 70 and 0.4. EAAS in the upper part of the abdominal muscle showed higher than those two parts. The content of saturated fatty acids (SFA) and the polyunsaturated fatty acids (PUFA) in the upper part of the abdominal muscle was higher than that in other groups. No significant differences in monounsaturated fatty acids (MUFA) and n-3/n-6 were detected among three parts. Overall, the upper part of the abdominal muscle was thought to have a higher nutritious value. These results showed P. teira is a high quality marine fish with high protein content and low fat, abundant amino acids with proper proportion, however, it was regarded as an excellent breeding varieties.

Introduction

With the improvement of people’s living standards, people need more nutrients and food quality than adequate food supplies. The same requirements were imposed on the nutrition and quality of fishery products (He et al. 2017). People pay more and more attention to the quality and safety of aquatic products and the quality of fish. Fish is popular with consumers for its high protein, low fat, rich in EPA and DHA, as well as many essential amino acids in the human body. Fish muscle nutrient is one of the most important indicators for consumers. There are also significant differences in nutrient composition of fish muscles due to different culture conditions and cultured species. The evaluation content of fish muscle quality includes nutrition, sensory characteristics, and texture characteristics (Huss 1995), which are usually measured from the three aspects of fish safety, human health and food satisfaction (Listrat et al. 2016). The main nutrients of fish in muscle are protein, amino acid, fat and fatty acid (Sargent et al. 1995). Muscle nutrients are closely related to muscle quality, the fat and protein content of fish muscles affects the sensory characteristics of muscles (Lie 2002).

Recently, many studies have already reported the diversity of nutritional quality in aquatic animals, including Catla catla, Labeo rohitai and Cirrhinus migrala (Hussain et al. 2018), Ctenopharyngodon idella (Xu et al. 2018), Dicentrarchus labrax (Orban et al. 2002), Lctalurus punctatus (Refaey et al. 2018), Macrobrachium rosenbergii (Asaikkutti et al. 2016), Pagellus bogaraveo (Castro et al. 2018), Perca fluviatilis (Mairesse et al. 2006), Portunus trituberculatus (He et al. 2017). These studies not only provide more basic references for aquatic nutrition, food development and fish processing, but also provide more support to customers on how to choose their favourite food (He et al. 2017). Therefore, the diversity of nutritional quality of aquatic products has become a major concern.

Longfin batfish, Platax teira is a tropical and temperate regions of coastal marine fish life (Li et al. 2016; Leu et al. 2018). P. teira is a targeted ornamental species because they have very long dorsal fins, anal and pelvic fins. It is a potential fine marine aquaculture species. Currently, the research on P. teira mainly focused on the mitochondrial genome, embryonic development and growth (Leu et al. 2018). However, the difference in muscle quality between different parts of P. teira has not been reported. Therefore, it is important practical value to systematically study on the basic characteristics of P. teira in different parts, fully understanding the composition characteristics of the raw materials, providing basic data and theoretical support for the processing of P. teira, further promoting the promotion and sustainable development of P. teira.
Materials and methods

Sample collection

Three experimental fish were obtained from the Tropical Fisheries Research and Development Centre, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Science, Lingshui (Hainan, China). The mean body weight of the experimental fish was 450.07 ± 20.13 g. Fish were fasted for 24 h before sampling, and were anesthetized with 100 mg/L Eugenol (Shanghai Medical Instruments Co., Ltd., Shanghai, China). After this, they were anatomy and their relevant parts (the dorsal muscle, the upper part of the abdominal muscle; the bottom part of the abdominal muscle) were totally taken for weighing. The extracted tissues were immediately stored in liquid nitrogen immediately until used. All experiments in this study were approved by the Animal Care and Use Committee.

Biochemical analysis

Proximate chemical composition

The moisture content was determined by drying the sample at 105°C until constant weight. Protein was determined by Kjeldahl method and crude lipid was determined using a Soxhlet extraction method and estimated by multiplying nitrogen by 6.25. Ash content was determined using a muffle furnace at 550°C for 8 h.

Amino acid composition

Total amino acids were determined by referencing to the method of Chen et al. (2007). Details about the extraction of total amino acids follow below. A hundred of sample was placed in 10 mL ampules with 3 mL of 6 mol/L HCl. The ampules were then vacuum-sealed, and these samples were hydrolysed at 110°C for 24 h. Hydrolysates were dissolved to 50 mL using distilled water. After centrifuging, the supernatants were filtered through 0.22 mm pore size membrane. Then, 1 mL of the liquid was placed at 50°C to remove HCl. If necessary, the above step can be repeated two times. After this, 2–5 mL of 0.02 mol/L HCl was supplemented for solution. Finally, 1 mL of sample was analysed by the amino acid auto-analyser S-433D, Sykam Ltd., Germany. For analysis of tryptophane, the results of previous studies. The proximate chemical composition of other commercial fishes was shown (Table 1). The crude fat content of P. teira was 21.00%. The proximate chemical composition of Trachinotus ovatus was obtained by this subject (unpublished data). The proximate chemical composition of other fish was based on the results of previous studies.

Fatty acid composition

The fatty acid profile of fish tissues were analysed as described by (Zuo et al. 2013) with few modifications. The freeze-dried samples (~120 mg muscle sample) were added into a 20 mL volumetric screwed tube with cover. Then 3 ml potassium hydroxide methanol (1 N) was added and heated in a water bath at 72°C for 20 min. After cooling, 3 ml HCL–methanol (2 N) was added and the mixture was heated at 72°C in a water bath for another 20 min. Previous tests were conducted to make sure that all fatty acids can be esterified following the procedures above. Finally, 1 ml hexane was added to the mixture above, shaken vigorously for 1 min, and then allowed to separate into two layers. Fatty acid methyl esters were separated, and measured by GC-MS (Agilent technologies 7890B -5977A, USA).

Statistical analysis

Data are expressed as the means ± standard error of mean (SE). The mean values were compared using one-way analysis of variance (ANOVA), followed by Tukey’s test. All statistical analyses were performed using SPSS 22.0 (SPSS Inc., Chicago, USA). The significance level adopted was 95% (p < .05).

Results

Proximate chemical composition

The proximate chemical composition of P. teira and other commercial fishes was shown (Table 1). The crude fat content of P. teira was 3.70%. The crude protein content of P. teira was 21.00%. The proximate chemical composition of Trachinotus ovatus was obtained by this subject (unpublished data). The proximate chemical composition of other fish was based on the results of previous studies.

Amino acid composition and nutritional quality evaluation

In muscle of three parts, seventeen kinds of amino acids were detected including nine essential amino acids (Table 2). There were some differences in the amino acids detected in the three muscle parts of P. teira. The contents of 11 amino acids of upper part of the abdominal muscle were significantly higher than the dorsal muscle, especially Ile, Leu, Lys, Phe, Thr, Val, Trp, Asp, Ser, Glu and His (P < .05). The amino acid

| Table 1. Nutritional components in the muscle of Platax teira and other commercial fishes (%). |   |
|-----------------------------------------------|---|
| Species                                      | Moisture | Ash | Crude fat | Crude protein |
| Platax teira                                  | 72.65    | 1.55 | 3.70      | 21.00        |
| T. ovatus                                    | 75.64    | 1.30 | 3.17      | 21.23        |
| Rainbow trout                                | 73.60    | 1.78 | 3.34      | 20.50        |
| Epinephelus septemfasciatus                  | 74.10    | 1.70 | 2.70      | 19.60        |
| Pampus argenteus                             | 73.11    | 1.21 | 4.90      | 20.16        |
| Pampus cinereus                              | 74.08    | 0.85 | 6.12      | 18.45        |
| Pampus sinensis                              | 77.24    | 1.15 | 2.31      | 18.71        |
| Dicentrarchus labrax                         | 68.28    | 1.21 | 10.57     | 19.75        |
content in the bottom part of the abdominal muscle were higher than in the dorsal muscles, but there were no difference (P > 0.05).

According to the FAO/WHO/UNU standards, EAAS in three parts of muscle was evaluated (Table 3). As a result, the EAAS in these three parts of P. teira were above 70. Meanwhile, the EAAS in the upper part of the abdominal muscle showed higher than those two parts (P < 0.05). EAAS in the bottom part of the abdominal muscle were higher than in the dorsal muscle.

### Fatty acid composition

The fatty acid composition of P. teira was shown (Table 4). In three parts, 27 kinds of fatty acids were detected in their muscle, including 11 saturated fatty acids (SFA), 6 monounsaturated fatty acids (MUFA), and 10 polyunsaturated fatty acids (PUFA). Among them, SFA was dominated by C16:0 and C18:0. Among them, SFA was dominated by C16:0 and C18:0. According to the FAO/WHO/UNU standards, EAAS in three parts of muscle was evaluated (Table 3). As a result, the EAAS in these three parts of P. teira were above 70. Meanwhile, the EAAS in the upper part of the abdominal muscle showed higher than those two parts (P < 0.05). EAAS in the bottom part of the abdominal muscle were higher than in the dorsal muscle.

### Discussion

As an important marine fish in China, P. teira is a good source of protein in the national diet. This study found that the content of crude protein in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of P. teira was 21.00%, which is higher than Rainbow trout (Song et al. 1996), E. septemfasciatus (Cheng et al. 2009), D. labrax (Orban et al. 2012), P. argenteus, P. cineus and P. sinensis (Xu et al. 2012), except for T. ovatus; the content of crude fat in the muscle of
**Conclusions**

The nutritional components of the dorsal muscle, the upper part of the abdominal muscle and the bottom part of the abdominal muscle were determined, and their nutritional value was synthetically evaluated. Results showed that there were the muscle protein content was as high as 21.00%. Overall, the upper part of the abdominal muscle nutrition levels was the best, followed by the bottom part of the abdominal muscle. Different parts of *P. teira* had different nutritional composition, but the overall difference was not large. *P. teira* was a high quality marine fish with high protein content and low fat, abundant amino acids with proper proportion. It was a fine food protein source, however, *P. teira* was regarded as an excellent breeding varieties.

**Disclosure statement**

No potential conflict of interest was reported by the authors.

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**References**

Asaikkutti A, Bhavana SP, Vimala K. 2016. Effects of different levels of dietary folic acid on the growth performance, muscle composition, immune response and antioxidant capacity of freshwater prawn, *Macrobrachium rosenbergii*. Aquaculture. 464:136–144.

Castro PL, Rincón L, Álvarez B, Rey E, Ginés R. 2018. Blackspot seabream (*Pagellus barbaceus*) fed different diets. Histologic study of the lipid muscle fiber distribution and effect on quality during shelf life. Aquaculture. 484:71–81.

Chang GL, Wu XG, Cheng YX, Wang ZK, Liu Q, Yang XZ, Lu JF. 2008. Effect of lipid nutrition on hepatosomatic index and biochemical composition of juvenile *Eriocheir sinensis*. Oceanol Limnol Sin. 39:276–283.

Chen DW, Zhang M, Shrestha S. 2007. Compositional characteristics and nutritional quality of Chinese mitten crab (*Eriocheir sinensis*). Food Chem. 103:1343–1349.

Cheng B, Chen C, Wang YG, Li SZ, Yu H, Zhang JS, Yang Z, Yu WS, Qu JB. 2009. Nutritional components analysis and nutritive value evaluation in *Epinephelus septemfasciatus* muscles. Prog Fishery Sci. 30:51–57.

FAO/WHO. 1994. Fats and oils in human nutrition. Report of a joint expert consultation. Rome (Italy): Food and Agriculture Organization of the United Nations.

FAO/WHO/UNU. 1985. Energy and protein requirement. Report of a joint FAO/WHO/UNU expert consultation. Geneva (Switzerland): WHO.
He J, Xuan FJ, Shi H, Xie JJ, Wang W, Wang GS, Xu WJ. 2017. Comparison of nutritional quality of three edible tissues of the wild-caught and pond-reared swimming crab (Portunus trituberculatus) females. LWT – Food Sci Technol. 75:624–630.

Huss HH. 1995. Quality and quality changes in fresh fish. FAO Fisheries Technical Paper.

Hussain B, Sultana T, Sultana S, Ahmed Z, Mahboob S. 2018. Study on impact of habitat degradation on proximate composition and amino acid profile of Indian major carps from different habitats. Saudi J Biol Sci. 25:755–759.

Leu MY, Tai KY, Meng PJ, Tang CH, Wang PH, Tew KS. 2018. Embryonic, larval and juvenile development of the longfin batfish, Platax teira (Forsskål, 1775) under controlled conditions with special regard to mitigate cannibalism for larviculture. Aquaculture. 493:204–213.

Li SS, Xie ZZ, Chen P, Tang JZ, Tang L, Chen HP, Wang DD, Zhang Y, Lin HR. 2016. The complete mitochondrial genome of the Platax teira (Ostelchthyes: Ephippidae). Mitochondrial DNA Part A. 27:796–797.

Lie Ø. 2002. Flesh quality-the role of nutrition. Aquac Res. 32:341–348.

Listrat A, Lebret B, Louveau I, Astruc T, Bonnet M, Lefaucheur L, Picard B, Bugeon J. 2016. How muscle structure and composition influence meat and flesh quality. Scientific World J. 1–14.

Mairesse G, Thomas M, Gardeur JN, Brun-Bellut J. 2006. Effects of geographic source, rearing system, and season on the nutritional quality of wild and farmed Perca fluviatilis. Lipids. 41:221–229.

Matheson NA. 1974. The determination of tryptophan in purified proteins and in feeding-stuffs. Br J Nutr. 31:393–400.

Muskiet FAJ, Goor SAV, Kuipers RS, Velzing-Aarts FV, Smit EN, Dijck-Brouwer DAJ, Boersma ER, Hadders-Algra M. 2006. Long-chain polyunsaturated fatty acids in maternal and infant nutrition. Prostaglandins. Leukotrienes and Essential Fatty Acids. 75:135–144.

Orban E, Dilena G, Nevigato T, Casini I, Santaroni G, Marzetti A, Caproni R. 2002. Quality characteristics of sea bass intensively reared and from lagoon as affected by growth conditions and the aquatic environment. Food Chemistry and Toxicology. 67:542–546.

Refae MM, Li DP, Tian X, Zhang ZM, Zhang X, Li L, Tang R. 2018. High stock-density alters growth performance, blood biochemistry, intestinal histology, and muscle quality of channel catfish Ictalurus punctatus. Aquaculture. 492:73–81.

Sargent JR, Bell JG, Bell MV, Henderson RJ, Tocher DR. 1995. Requirement criteria for essential fatty acids. J Appl Ichthyol. 11:183–198.

Song SX, Sun DJ, Fan ZT, Liu HB. 1996. An analysis of the nutritive compositions in the muscle of rainbow trout. Journal of Dalian Fisheries College. 11:70–73.

Spindler M, Stadler R, Tanner H. 1984. Amino acid analysis of feedstuffs: Determination of methionine and cystine after oxidation with performic acid and hydrolysis. J Agric Food Chem. 32:1366–1371.

Wu XG, Wang Q, Lou B, Liu ZJ, Cheng YX. 2014. Effects of fattening period on ovarian development and nutritional quality of female swimming crab (Portunus trituberculatus). Journal of Fisheries of China. 38:170–181.

Xu J, Feng L, Jiang WD, Wu P, Liu Y, Jiang J, Kuang SY, Tang L, Zhou XQ. 2018. Different dietary protein levels affect flesh quality, fatty acids and alter gene expression of Nrf2-mediated antioxidant enzymes in themuscle of grass carp (Ctenopharyngodon idellus). Aquaculture. 493:272–282.

Xu SL, Wang DL, Xu JL, Yan XJ. 2012. Analysis and evaluation of nutritional components in muscle of Pampus argenteus, P. cinctus and P. sinensis from the East China Sea. Oceanologia & Limnologia Sinica. 43:775–782.

Zuo R, Ai Q, Mai K, Xu W. 2013. Effects of conjugated linoleic acid on growth, non-specific immunity, antioxidant capacity, lipid deposition and related gene expression in juvenile large yellow croaker (Larmichthys crocea) fed soyabean oil-based diets. Br J Nutr. 110:1220–1232.