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Comparison of the Whole Body Composition of Fatty Acids and Amino Acids between Reared and Wild Snakehead Fish *Channa striata* (Bloch 1793) Juveniles

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Abstract

The whole body compositions of fatty and amino acids of cultured and wild *Channa striata* (Bloch 1793) juveniles in Malaysia were compared. Whole body proximate analysis of both the wild and cultured revealed that moisture content ranged between 68.1 and 70.8%, 52.7 to 55.4% crude protein, 16.2 to 20.9% crude lipid and 15.1 to 21.0% ash, and did not significantly ($P>0.05$) differ among the samples. In the fatty acid (FA) analysis, arachidonic acid (20:4n6) was detected as the most abundant n-6 FA, whereas eicosapentaenoic acid (EPA, 22:6n3) was among the highest n-3 FA. Polyunsaturated fatty acid (PUFA) was also recorded in appreciable quantity among the FA classes tested. Amino acids (AA) analyses in the test samples revealed glutamic acid, glycine and aspartic acid to be the highest. Furthermore, all the essential amino acids were recorded in appreciable quantities in the reared and wild fish samples. Overall, results of the present study suggest that there is no significant ($P<0.05$) difference in the whole body contents of FA and AA between reared and wild *C. striata* juveniles. This suggests that both samples are suitable for the nutritional requirements for which the fish is popularly reared and consumed in the Asia Pacific region.

Introduction

Aquaculture is the fastest growing animal producing sector in the world, where experts predict that by the year 2030, it would supply most of the fish consumed by humans (FAO 2009). This is better appreciated considering that marine and freshwater fish are getting depleted, as wild populations have become harder to catch (MacLennan 1995). Therefore, experts are concerned over the sustainable supply of fish such as *Channa striata* (Bloch 1793), since its seeds for aquaculture (fry and fingerlings) still depend on natural spawning grounds in the wild (Hossain et al. 2008). The alternative opportunity is thus, to breed and rear the fish with feeds, artificially (Qin and Fast 1998).

Snakehead, *Channa striata* is a carnivorous, obligatory air-breather and is indigenous to many tropical countries as a valuable source of protein throughout the Asia Pacific region (Mohsin and Ambak 1983). *Channa. striata* has become a commercially important species because of its firm, white and practically boneless flesh which has agreeable flavour (Hossain et al. 2008).

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Snakehead extract is also important for its putative effects on healing of wounds (Baie and Sheikh 2000; Mat Jais et al. 1997), and it also has anti-inflammatory properties (Somchit et al. 2004) attributed to its high content of particular fatty and amino acids (Zuraini et al. 2006). However, most of the studies on *C. striata* extracts were carried out with the wild population. This could be because locals use it traditionally and believe that the wild fish is better. Unfortunately, FAO (2010) statistics indicate that the total landing of the wild population has steadily declined from year 2006, whereas the aquaculture of the same species globally has increased.

From the pharmacological point of view, fish contain certain polyunsaturated fatty acids (PUFA) which regulate prostaglandin synthesis and induce wound healing (Bowman and Rand 1980; Gibson 1983). On the other hand, authors show that PUFA compositions vary among species, even between fresh water and marine fish (AbdRahman et al. 1995). According to others, this variation is noted between cultured and wild species. Fatty acid (FA) and amino acid (AA) compositions of fish also show high variability between and within species (Shearer 1994). This depends on many factors, including food availability, catch location, fish size, maturity stage, biological variations, sampled tissue (Hardy and King 1989), the ration size (Kiessling et al. 1989) and starvation (Lie and Huse 1992). Consistent with these reports, Orban et al. (2000) noted differences in the FA composition between sharp snout sea bream grown in tanks and in cages. Ozyurt and Polat (2005) studied the seasonal variation in the compositions of FA and AA in the fillet of wild sea bass. A previous study by Rueda et al. (1997) also revealed differences in white muscle compositions of FA and AA between wild and cultured red porgy, *Pagrus pagrus,* (Linnaeus 1758). Koizumi and Hiratsuka (2009) also recorded differences in lipid and FA in muscle samples of wild Japanese, cultured Japanese and cultured Chinese ocellate puffer fish (*Takifugu ruburipes*, Temminck and Schlegel 1850*).* So far to our knowledge, no study has compared the whole body compositions of FA and AA between reared and wild *C. striata*. The lack of scientific knowledge has paved the way for people to speculate that the wild species is more nutritious; even at a time when humans increasingly rely on aquaculture for fish products.

The objective of this study was therefore, to compare the whole body compositions of FA and AA among cultured and wild *C. striata* juveniles. For this purpose, 90 samples of wild and reared snakehead fish were analysed for whole body FA and AA compositions.

Materials and Methods

Fish samples

About 200 *C. striata* fingerlings, which ranged in size between 3.8 and 4.3 g (purchased from a commercial hatchery in Rawang, Malaysia) were reared in a canvas tank (measuring 4.5 m x 1.2 m x 0.9 m; length x breadth x height). The tank was connected to a flow-through water system, with the flow rate set at 1.5 $L \cdot min^{-1}$ and continuously aerated. Fish were fed experimental diet containing fish oil (FO, including ~1.5 $g \cdot 100\ g^{-1}$ residual oil from fishmeal) and crude palm oil

(CPO) mixed in the ratio of 1:1 as the lipid sources, added at 65 $g \cdot kg^{-1}$. Fishmeal (supplemented with casein) served as the principal source of protein, added at 450 $g \cdot kg^{-1}$ and mixed together with other ingredients (corn starch, CMC binder, vitamin and mineral pre-mixes, ascorbic acid and cellulose) to produce the diet. This diet supplied a gross energy value of 18.5 $kj \cdot g^{-1}$ to meet the nutritional requirements of the species, as was established previously in our laboratory (Table 1) (Aliyu-Paiko et al. 2010). Other culture conditions included: cleaning the fish tanks of faecal matter once every 2 weeks as well as maintaining temperature, pH and dissolved oxygen concentration between 28-30 ºC, 5.6-7.2 and 5.5-6.8 $mg \cdot L^{-1}$, respectively, throughout the experiment. Fish were reared under natural photoperiod of 12 h light/12 h dark schedule and fed the assigned diet by hand to visual satiation twice daily (0900 and 1600 h) for 8 months. After this time period, 30 juveniles, weighing between 200-250 g were randomly selected for the analysis of whole body compositions of FA and AA after they were starved overnight.

About 400 live juvenile snakehead fish (weight range of between 150 and 600 g), caught from the wild by local fishermen in nets were purchased at Jitra (Kedah state) and Kuala Kangsar (Perak state) in Malaysia. The purchased live, wild fish were transported to the aquaculture complex of Universiti Sains Malaysia in aerated polyethylene bags. Wild fish were identified to be *C. striata* species in the laboratory of fish biology. Thirty juvenile fish (body weight of between 200-250 g) from each of the two locations were randomly selected for the analysis of whole body composition of FA and AA after the fish had stabilised to laboratory conditions overnight.

Sample preparation

In total, 90 snakehead fish (weighed between 200-250 g) were used in the present experiment; 30 fish were taken from cultured fish (reared), 30 wild fish caught at Jitra (wild J) and 30 wild fish caught at Kuala Kangsar (wild KK). Each batch was randomly divided into three equal groups (A, B and C), of 10 fish each. Fish in group A of all the three batches were used for whole body proximate composition analysis, to determine moisture (dry matter), crude protein, crude lipid and crude ash contents. Fish of group B were used for whole body FA analysis, whereas group C fish were used to quantify whole body AA concentration. Fish in group A were oven-dried due to the sizes of fish, to enable whole body moisture content determination, whereas those in groups B and C were cut into small pieces and freeze-dried, for all the batches. Ten dry fish samples per group and batch were pooled together, finely ground, packed separately in screw-capped bottles and stored in a deep freezer maintained at -20 ºC, until used for further analysis. All parameters were determined in triplicate (n=3).

Table 1: Ingredients and proximate composition of experimental diet fed the reared snakehead fish, *C. striata*.

Ingredients (g 100 g^{-1})	
Fishmeal[1]	44.9
Casein	14.3
Corn Starch	26.8
Fish oil (FO)	1.3
Crude Palm Oil (CPO)	2.8
CMC[2]	2.0
Vitamin mix[3]	1.5
Vitamin C (Ascorbic Acid)[4]	0.5
Minerals mix[5]	2.0
Cellulose[6]	3.9
Proximate composition (g 100 g^{-1}, Dry matter)	
Protein	45.2
Lipids	6.5
Ash	8.5
Moisture	3.7
NFE[7]	36.1
Gross Energy (GE)[8], KJ g^{-1}	18.5

[1]TripleNine fish protein, Esbjerg, Denmark; containing (g Kg^{-1},DM), protein: 720, total fat: 50, defatted

[2]Carboxy methyl cellulose (sodium salt), binder

[3]Vitamin premix (Rovimix 6288, F. Hoffman La-Roche Ltd, Basel, Switzerland), containing (Kg^{-1}, dry weight): Vit. A 50 million I. U., Vit. D3 10 million I. U., Vit. E 130g, Vit. B1 10 g, Vit. B2 25 g, Vit. B6 16 g, Vit. B12 100 mg, Biotin 500 mg, Pantothenic acid 56 g, Folic acid 8 g, Niacin 200 g, Anti-cake 20g, Antioxidant 200 mg, Vit. K3 10 g and Vit. C 35 g

[4]Vitamin C-stay (F. Hoffman La-Roche Ltd, Basel, Switzerland)

[5]Mineral premix, contains (Kg^{-1}, dry weight): Calcium phosphate (monobasic) 397.5 g; Calcium lactate 327 g; Ferrous sulphate 25 g; Magnesium sulphate 137 g; Potassium chloride 50 g; Sodium chloride 60 g; Potassium iodide 150 mg; Copper sulphate 780 mg; Manganese oxide 800 mg; Cobalt carbonate 100 mg; Zinc oxide 1.5g and Sodium selenite 20 mg.

[6]α-Cellulose, filler

[7]Nitrogen free extract, calculated as 1000 – (Protein + Lipid + Ash+ fiber) g Kg^{-1}

[8]Gross energy content, measured in a bomb calorimeter (Model 6200, Parr Instrument Company, Moline, Illinois, USA).

Whole body proximate composition analysis

Proximate composition of dry matter (moisture), crude protein, crude lipid and ash content were determined following standard methods of AOAC (1997); dry matter (moisture content) was determined by oven drying fresh samples at 100 ºC to constant weights. Dry samples were weighed, finely ground, separately packed in labeled, screw-capped bottles and stored at -20 ºC until used for further analyses. Crude protein was calculated according to the Kjeldahl procedure (crude protein= nitrogen x 6.25). Samples were extracted with chloroform: methanol (2:1, v/v) to quantify crude lipid. Crude ash was measured by heating samples in a muffle furnace for 5 h at 550 ºC.

Lipid extraction

Lipid from samples was extracted in triplicate according to a modified method of Folch et al. (1957), using chloroform: methanol (2:1, v/v) solvent system. Briefly, ~2 g of dry, finely ground samples were weighed into clean, dry test tubes, in which was added 100 mL each of chloroform: methanol (2:1, v/v) and thoroughly homogenised for 5 min. The homogenate was filtered by a vacuum pump and the filtrate quickly transferred into a separatory funnel, to which 20 mL of distilled water was added and shaken vigorously. The mixture was then allowed to stand overnight for the formation of two distinct layers, a lower lipid and an upper aqueous layer. The lower layer was collected into a pre-weighed, oven-dried beaker. The beakers containing the extracted lipids dissolved in chloroform: methanol was taken into an oven maintained at 60-80 ºC for 5 h, to evaporate the organic solvents. Total lipid content of samples was determined by calculating the weight of lipids in the beakers as percentage of the initial sample weight. The result of triplicate determinations was expressed as mean ± SD.

Fatty acids determination of whole fish samples

Fish sample used in FA composition analysis was freeze-dried (freeze drier model Labconco Freezone 2.5, Labconco Corporation, Kansas City, USA). Total lipid in the samples was extracted according to a slightly modified, direct fatty acid methyl esters (FAME) synthesis method of Indarti et al. (2005), before FA analyses. Briefly, dry samples (~100 mg) were weighed into clean, 10 mL screw-top glass bottles, to which 4 mL fresh solution of a mixture of methanol, concentrated sulphuric acid and chloroform (1.7:0.3:2.0 v/v/v) was added. The bottles were vortex mixed for 30 s and nitrogen gas was bubbled in, closed tightly with Teflon caps to prevent leakage and weighed.

Trans-esterification of the lipids was carried out by placing the bottles inside a heating block at 100 ºC for 30 min. On completion of the reaction, the bottles were cooled to ambient temperature in desiccators and weighed again to dispose of leaking samples. Subsequently, 1 mL of distilled water was added to the mixture and thoroughly vortex mixed for 1 min and allowed to stand. After the formation of two phases, the lower phase containing FAME was transferred into clean, 10 mL

bottles and dried with anhydrous Na_2SO_4. Samples were stored in a freezer (-20 ºC) until GC analysis.

Amino acids determination of fish samples

The amino acid component of experimental fish was assessed by hydrolysing freeze dried samples with 6N HCl at 110 ^oC for 24 h, and then derivatised with AccQ reagent (6-aminoquinolyl-N-hydroxysuccinimdyl carbamite) before the use of chromatographic separation in AccQTag™ reversed phase (3.9 x 150mm) analytical column (Waters®); according to slightly modified method of Vidotti et al. (2003). The amino acid analysis was performed on an HPLC system which consisted of Waters 1525 Binary HPLC pump, 717 Plus auto-sampler (Waters®) and Waters® 2475 Multi λ fluorescence detector (wavelength excitation 250 nm, emission 395 nm). Chromatographic peaks were integrated, identified and quantified with Breeze™ software, version 3.20, and compared to known standards (Amino acid standard H, Pierce, Rockford, Illinois, USA). To determine methionine and cystine, the same method of acid hydrolysis was adopted but after oxidation treatment with performic acid.

The method used in this study permitted the detection and analysis of 17 amino acids, as shown in Table 4. Asparagine and glutamine were hydrolysed to aspartic and glutamic acids respectively, during acid hydrolysis. Therefore, values shown for aspartic acid represent the sum of the content for asparagine and aspartic acid, while glutamic acid content reported is the sum for glutamine and glutamic acid accordingly. Tryptophan was destroyed during acid hydrolysis and as such, was not detected.

Statistical analysis

Data for all analyses are expressed as mean values (±SD), of 3 replicate determinations (n=3). A single factor analysis of variance (1- way ANOVA) was carried out at a significance level of 0.05, followed by Duncan's Multiple Range post hoc Test (all values of $P<0.05$ were considered significant), with SPSS statistical analysis software, version 14.

Results

Whole body proximate composition

Results of whole body proximate composition analysis for the reared and wild snakehead juveniles are shown in Table 2. No significant differences were found for carcass moisture content (wet weight basis) among the reared and wild *C. striata* samples, in a range of between 68.1 and 70.8%. Whole body crude protein content was detected to be relatively high and ranged between 52.7 and 55.4% (dry weight basis), which was similar and not significantly varied between the reared and wild samples. Crude protein was recorded to be the lowest in wild (KK) fish (52.7%). In

crude fat analyses, wild fish (KK) was observed to contain significantly (P<0.05) higher (20.9%) crude lipid content than the reared fish (16.2%). However, whole body lipid content of the wild (J) fish was not significantly different from both wild (KK) and reared samples. Carcass ash content was similar among both wild samples (19.6 and 21.0%), but was detected in significantly (P<0.05) higher concentration compared to the reared fish (15.1%).

Table 2: Whole body proximate composition of moisture, protein, lipids and ash (%) of reared and wild *C. striata* juveniles.

	Parameters monitored			
Fish samples	**Moisture (% WW)**[b]	**Proteins (% DW)**[c]	**Lipids (% DW)**	**Ash (% DW)**
Reared *Channa striata*	70.8 ± 0.3[a]	55.4 ± 0.3 [a]	16.2 ± 1.3 [a]	15.1 ± 0.9 [a]
Wild *Channa striata* (J)[d]	70.5 ± 0.3 [a]	55.3 ± 4.3 [a]	18.6 ± 1.5[ab]	21.0 ± 3.1 [b]
Wild *Channa striata* (KK)[e]	68.1 ± 2.1[a]	52.7 ± 6.1 [a]	20.9 ± 1.0 [b]	19.6 ± 1.3 [b]

All values expressed as mean ± SD of triplicate determinations (n=3)

[b]WW- Wet weight

[c]DW- Dry weigh;

[d]J- Wild fish caught at Jitra, Malaysia

[e]KK- Wild fish caught at Kuala Kangsar, Malaysia

Mean values in the same column with same superscript letters are not significantly different (P>0.05)

Whole body FA composition

The whole body FA composition (% of total FA detected) of all fish samples and the diet fed to the reared fish is presented in Table 3. High content of SFA was detected compared to other FA, which was significantly (P<0.05) different among the samples. SFA content ranged between 48.3 and 57.3%, and composed principally of 16:0. Lower concentration of monounsaturated fatty acid (MUFA) was detected, but was not significantly different among the samples. Whole body MUFA was also detected in comparatively lower concentrations than in the diet fed to the reared fish. High level of PUFA was detected and ranged between 37.5 and 44.9%. Among the PUFA detected, concentration of ArA (20: 4n6) was not significantly different in both cultured and wild fish, although the content in the wild samples was numerically varied [this ranged between 5.0% in wild (KK) and 8.0% in wild (J)]. Content of n-6 FA was similar among all the samples, except 18:2n-6 which was significantly (P<0.05) higher in the cultured compared to the wild fish. Variable concentrations of most n-3 PUFA were also detected among the fish samples tested. Nonetheless, similar levels of 20:5n-3 (EPA) and DHA were measured. Furthermore, the ratio of n-3: n-6 FA was low and significantly lower for the reared (2.4) and wild (J) fish (2.1) compared to wild (KK)(2.9) samples.

Table 3: Whole body compositions[a] of fatty acids (mean ±SD, % total FA detected) in reared and wild *C. striata* juveniles and experimental diet fed to the reared fish.

	C.striata	***C.striata***	***C.striata***	
Fatty acids	**Reared**	**Wild (J)**	**Wild (KK)**	**Diet[g]**
14:0	4.2± 0.2	3.7± 0.9	3.5±0.4	1.4 ± 0.1
16:0	34.7±2.6	29.2±5.8	29.0±1.8	37.1 ± 0.6
18:0	10.9±0.8[c]	15.4±8.2[b]	24.9±1.4[a]	4.8 ± 0.2
Total SFA[b]	**49.8**±3.6[b]	**48.3**±4.1[b]	**57.4**±3.6[a]	**43.3**±0.9
161n7	0.8±0.2[b]	0.8±0.1[a]	0.6±0.0[b]	4.3 ± 0.1
18:1n9	1.9±1.0	3.1±1.3	2.6±0.5	14.3 ± 0.4
18:1n7	0.7±0.2	0.9±0.1	0.7±0.1	15.2 ± 0.5
20:1n9	2.0±0.5	2.0±0.7	1.4±0.4	4.3 ± 1.1
20:1n11	0.0	0.0	0.0	0.2 ± 0.0
Total MUFA[c]	**5.4**±1.9	**6.8**±2.5	**5.3**±1.0	**38.3**±2.1
16:2n4	0.0	0.0	0.0	0.6 ± 0.1
16:3n4	0.0	0.0	0.0	0.1 ± 0.1
18:3n4	0.0	0.0	0.0	0.0 ± 0.0
18:2n6	4.0±0.3[a]	2.2±0.3[b]	2.3±0.3[b]	5.4 ± 0.3
18:3n6	0.8±0.1	0.8±0.02	0.5±0.3	0.1 ± 0.0
20:3n6	3.2±1.0	3.7±1.8	1.9±0.7	0.4 ± 0.2
20:4n6	5.4±3.2	8.0±3.3	5.0±1.8	1.5 ± 02
18:3n3	1.6±0.1[a]	2.1±0.4[b]	1.7±0.4[b]	0.1 ± 0.0
18:4n3	1.3±0.1	1.3±0.3	2.1±0.9	0.4 ± 0.1
20:4n3	3.1±0.02[a]	2.0±1.6[b]	2.1±0.6[b]	0.4 ± 0.1
20:5n3	2.8±0.5	3.9±0.8	3.6±1.8	7.0 ± 0.6
22:5n3	11.7±0.6[a]	7.7±2.4[b]	5.6±0.5[b]	0.2±0.1
22:6n3	11.0±1.8	13.3±1.8	12.7±0.3	6.1±0.3
n-3 PUFA[d]	**31.5**±1.5[a]	**30.3**±1.1[a]	**27.8**±0.9[b]	**14.2**±0.1
n-6 PUFA[e]	**13.4**±0.1[a]	**14.7**±0.1[a]	**9.7**±0.2[b]	**7.4**±0.2
n3/n6[f]	**2.4**±0.1[a]	**2.1**±0.1[a]	**2.9**±0.2[b]	**1.9**±0.1

[a]All values are % of total fatty acids detected, expressed as mean ± SD of triplicate determinations (n=3). Different superscripts in the same row indicate significant differences (P<0.05).

[b]Total SFA- Sum of all saturated fatty acids;

[c]Total MUFA- Sum of all mono unsaturated fatty acids;

[d]n-3 PUFA- Sum of omega 3 fatty acids;

[e]n-6 PUFA- Sum of omega 6 fatty acids;

[f]n3/n6- Ratio of omega 3: omega 6 fatty acids.

Whole body AA composition

Table 4 summarises the data for whole body compositions of AA in reared and wild *C. striata* juveniles. Glutamic acid (7.7-8.1%), glycine (5.5-5.9%) and aspartic acid (4.6-4.7%) were detected as the most abundant AA among the fish samples tested. All the essential amino acids (particularly methionine) were recorded in appreciable amounts in the reared and both wild samples. Except formethionine, cysteine, isoleucine and valine which were significantly ($P<0.05$) varied among the fish samples, no significant ($P>0.05$) differences were recorded between the reared and wild fish in the composition of the amino acids tested. Furthermore, a relatively higher level of cysteine was recorded in the current study compared to that reported by other researchers [Gam et al. (2005); Zuraini et al. (2006)]

Table 4: Whole body amino acid composition[a] of reared and wild *C. striata* juveniles

Amino Acids	**Reared *C. striata***	**Wild *C. striata* (J)**	**Wild *C. striata* (KK)**
Histidine	1.9±0.4	1.5±0.1	1.5±0.04
Argenine	5.4±1.2	4.7±0.2	4.7±0.1
Threonine	3.7±0.8	3.0±0.2	3.0±0.1
Tyrosine	2.7±0.8	1.9±0.1	2.0±0.04
Valine	2.7±0.03[a]	2.5±0.1[b]	2.5±0.02[b]
Lysine	3.5±1.1	4.1±0.1	3.8±0.1
Isoleusine	2.6±0.01[a]	2.3±0.1[b]	2.3±0.04[b]
Leusine	4.4±0.1	4.1±0.1	4.1±0.1
Phenylalanine	3.1±0.9	2.5±0.1	2.5±0.03
Methionine	2.3±0.2[a]	1.9±0.1[b]	1.9±0.1[b]
Aspartic acid	4.6±0.8	4.7±0.2	4.6±0.2
Glutamic acid	7.7±0.9	8.1±0.2	7.7±0.4
Glycine	5.5±0.9	5.9±0.2	5.7±0.04
Serine	3.0±0.4	2.7±0.1	2.7±0.1
Alanine	3.7±0.5	4.0±0.1	3.9±0.1
Proline	3.5±0.1	3.5±0.2	3.5±0.03
Cysteine	3.0±0.1[b]	2.6±0.6[b]	4.4±0.6[a]

[a]All values are expressed as percentage (%) of total amino acids, mean ± SD (n=3)

Discussion

In this study, the whole body compositions of FA and AA were compared between reared and wild *C. striata* juvenile samples. Shearer (1994) reported that fish body compositions, especially of FA and AA are varied between and within species and that the variability depends on such factors as food availability, catch location, fish size, maturity stage and biological variations. Furthermore, the body lipid content and as such, the FA composition of reared fish tissues is reported to be directly related to the dietary composition (Caballero et al. 2004).

The relatively higher moisture content recorded in both reared and wild samples agree with the conclusion of Osman et al. (2001), that low to medium fat-fleshed fish species (such as *C. striata*) contain higher moisture content. The slight difference noted in the whole body protein and lipid contents between the reared and wild fish samples is likely due to differences in their feeding habits (artificial feed containing 450 $g \cdot kg^{-1}$ protein for the reared fish and natural food containing phytoplankton, zooplankton and small live animals for the wild fish). Boonyaratpalin et al. (1985) described *Channa* species as voracious carnivores in nature, feeding on live animals. Higher body ash content (in the wild population) may be attributed to the differences in the variety of food available at the catch locations. This naturally exposes the wild fish to a variety of minerals, compared to regulated amounts provided in the diet of fish reared in captivity. Results of proximate composition analysis in the current study however, differ from those reported by AbdRahman et al. (1995) and Zuraini et al. (2006), likely due to; (1) different sizes of fish tested (0.25 kg vs. not stated vs. 1-2 kg) and (2) the tissues sampled (whole fish vs eviscerated fish vs. fish fillet), respectively.

The data for whole body FA composition in this trial showed PUFA as one of the most abundant classes of FA in both reared and wild fish. This concurs with the report of Simopoulos (1999), that n-6 and n-3 PUFA are important structural components of the phospho-lipid cell membranes of tissues, which serve multiple physiological functions. The abundance of ArA in both the reared and wild samples indicates that both are suitable for use for wound healing (Baie and Sheikh 2000), one of the qualities which makes the species to be popular. Furthermore, several workers suggest that the FA composition of fish tissues reflects that of the diet fed (Piedecausa et al. 2007). The relatively higher n-3: n-6 FA ratio measured in the whole body of reared fish sample compared to that in the diet fed (Table 3) suggests that n-3 FA in the diet was accumulated. This agrees with the observation made by Almaida-Pagán et al. (2007) suggesting that n-3 FA (especially 22:6n-3) from the diet would, for the most part be stored and preserved in tissue membranes of fish. Similarly, the observation of comparatively higher dietary MUFA concentration relative to the amount in the muscle of the reared fish is likely due to its use for metabolic energy. Henderson (1996) reported that fish preferentially utilise SFA and MUFA for energy production in the mitochondria. Lower content of 20:5n-3 (an intermediary product in the pathway for the biosynthesis of HUFA) in the reared fish relative to the concentration in the diet fed is consistent with established facts in the literature, and is additional evidence to support that *C. striata* demonstrates desaturase/elongase enzyme activity, as was earlier speculated (Aliyu-Paiko et al. 2010).

The major AA (especially aspartic and glutamic acids) detected in both the reared and wild samples in the present study are consistent with that recorded by other authors for the same species (Zuraini et al. 2006; Gam et al. 2005). According to Heimann (1982), glycine is an important component of the human skin collagen that combines with aspartic and glutamic acids to form a polypeptide, which is responsible for tissue growth and the healing of wounds. The relatively higher concentration of cysteine detected in the present study compared to that reported by other authors is

likely due to differences in the fish samples used for analysis (whole fish vs. fish muscle). Cysteine is abundant in alpha-keratin the major protein in animal skin, which was part of the whole fish sample used for AA analysis in the present study.

The relative abundance of these three AA in the samples evaluated suggests that both reared and wild fish are suitable for use for the healing effects on wounds, where the necessary AA for the purpose is taken into account. Similarly, the availability of all essential AA in relatively high concentrations in both the reared and wild samples could explain the preference of snakehead species as a valuable source of protein throughout the Asia-Pacific region (Mohsin and Ambak 1983).

Conclusion

Taken together, results of the present experiment suggest that both reared and wild *C. striata* fish samples contain the crucial essential FA and AA, in comparable concentrations. Therefore, both fish samples are suitable for use to fulfill the nutritional expectations of consumers. Snakehead fish reared in captivity up to 250 g seems to have all the characteristics for which the fish is popularly consumed.

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