Agricultural Sciences, 2023, 14, 1675-1687
https://www.scirp.org/journal/as
ISSN Online: 2156-8561
ISSN Print: 2156-8553

Analysis and Evaluation of Nutrient Composition in the Wild, Pond- and Lake-Cultured Topmouth Culter (*Culter alburnus*)

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How to cite this paper: He, Z.G., Wu, H., Li, J.L., Cheng, X.F., Tian, X., Deng, S.M., Liu, X.H. and Wang, D.W. (2023) Analysis and Evaluation of Nutrient Composition in the Wild, Pond- and Lake-Cultured Topmouth Culter (*Culter alburnus*). *Agricultural Sciences*, **14**, 1675-1687.
https://doi.org/10.4236/as.2023.1412108

Received: June 13, 2023
Accepted: December 11, 2023
Published: December 14, 2023

Abstract

Research was conducted on topmouth culter (*Culter alburnus*) grown in ponds and lakes as well as wild types in order to determine their chemical composition and nutritional value. There are three types of fish that differ in their proximate composition, amino acids, fatty acids, and minerals. Wild fish had a significantly lower crude lipid contents than cultured fish ($P < 0.05$), but a higher protein content. Aside from histidine and proline, wild and cultured fish have similar amino acid compositions. A significantly reduction in total monounsaturated fatty acid content (ΣMUFAs) was observed in wild fish compared to cultured fish ($P < 0.05$), while total polyunsaturated fatty acids (ΣPUFAs) showed an obviously opposite trend. As compared with cultured fish, wild fish had significantly higher levels of n-3 PUFAs, arachidonic acid (AA), eicosapentaenoic acid (EPA) and docosahxaenoic acid (DHA) ($P < 0.05$). The mineral content of wild and cultured fish did not differ significantly ($P > 0.05$), except for Na, Fe and Se. In conclusion, diet composition and external aqueous environment may determine the differences between wild and cultured topmouth culter.

Keywords

Topmouth Culter (*Culter alburnus*), Cultured and Wild Fish, Amino Acids, Fatty Acids, Mineral Composition

1. Introduction

Topmouth culter (*Culter alburnus*), a carnivorous freshwater fish which is

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widely distributed in China, and has been considered as a high-quality protein source for humans [1] [2] [3]. The production and consumption of topmouth culter (hereinafter abbreviated as TC) have mark extremely expanded over the past few decades because of its excellent nutritional value, delectable flavor, and fine texture [4] [5]. Whereas, the pollution, overfishing, and habitat destruction caused by human activities had destroyed the natural population resources of this fish, leading to the sharp decline of available resources [2] [6]. Furthermore, accompanying with the implementation of ten years fishing ban in the Yangtze River from January 2021, most of the sources of topmouth culter come from farming [7]. In fact, the great potential and huge economic value for culturing this species had been found in inland areas, including ponds, lakes, and reservoirs [8] [9]. Many reports have focused on investigating genetics and evolution [1] [2] [3] [4] [6], nutritional requirement [5] [9] [10], anatomy [11] and hybridization [12] of this species.

It is well known that the meat composition of wild and cultured fish may differ including amino acid and fatty acid profiles [13] [14], vitamin contents [15], and mineral contents [16]. Generally, the proximate chemical composition of fish often affected simultaneously by intrinsic and extrinsic factors had been reported [14]. Muscle tissue amino acid composition is considered an important indicator of fish amino acid needs [17]. Additionally, the composition of fatty acids in muscle also reflects the profile of fatty acids in the diet [13]. Currently, the flesh composition of culture species is largely dependent on the compound diet composition that provides energy and essential nutrients for normal physiological activity, particularly the profiles of fatty acids [13]. Therefore, there is rising interest for aquaculture enterprises and researchers to study the commonalities and differences in flesh quality between wild and cultured fish. Despite that, there is little previous study conducted to compare the nutritional indicators between the wild and cultured TC. Hence, the object of the current study was to investigate the differences among wild, pond and lake cultured TC in terms of chemical composition, mineral contents, amino acids and fatty acid composition, and the relevant results of this paper will facilitate the development of speciality aquaculture.

2. Materials and methods

2.1. Sample Collection and Preparation

Fifteen TC were derived from wild, pond-cultured and lake-cultured populations respectively that defined as three groups, and each group have five fish. All fish obtained from freshwater were described below. Wild fish (body weight 564.15 ± 55.02 g, body length 35.50 ± 0.98 cm) were obtained from Xiangjiang river of the Yangtze River (China). Pond-cultured fish (body weight 514.20 ± 21.35 g, body length 35.40 ± 0.73 cm) reared in a pond with 7326 m^2 area were supplied by a farmer in the Changsha city, while lake-cultured fish (body weight 573.90 ± 24.48 g, body length 37.33 ± 0.98 cm) reared in Qianlong lake with 186

hm^2 were provided by a local farm (Changsha, China). Importantly, the proximate composition of commercial diet fed for the cultured fish were presented as follow: dry matter 91.49%, protein 35.12%, lipid 9.26% and ash 12.09%, and natural forage fishes can eat by wild and lake-cultured TC.

After anesthetized using MS-222, individual body weight (W_s, g per fish) and body length (L_s, cm) from each group were measured to determine condition factor, which was calculated as CF ($g \cdot cm^{-3}$) = $100 \times W_s / L_S^3$. And the fish were sacrificed on the ice and boneless muscle tissue were rapidly collected for subsequent proximate composition analysis. Afterwards, the samples immediately brought back to laboratory and stored at −80˚C to prevent tissue degradation.

2.2. Proximate Composition

The determination of diets and muscle protein, moisture, lipid and ash were according to the method described by the Association of Official Analytical Chemists [18]. Briefly, the sample was dried to a constant weight at 105˚C to obtain the moisture content. The content of crude protein (N × 6.25) was completed by an Auto Kjeldahl System (Kjeltec 8400, Foss Tecator, Höganäs, Sweden). The crude lipid content was determined by a Soxtec System (Soxtec 8000, Foss Tecator, Höganäs, Sweden). The content of ash was obtained using a muffle furnace at 550˚C for 6 h. All analysis were performed in triplicate (n = 3).

2.3. Amino Acid Analysis

All fillet samples (about 0.1 g dry weight) were freeze-dried, and then hydrolysed with 15 ml 6 mol/L HCl and high purity nitrogen (N_2) at 110˚C for 22 h for the amino acid analysis according to the GB 5009.124-2016 [19]. Then, the resulting mixture was cooled and filtered in a volumetric flask, and diluted with ultrapure water to 50 ml. In the next step, 1 ml of hydrolysate was vacuum-dried, dissolved in 2 ml of pH 2.2 sodium citrate solution, and filtered with a 0.22-m filter membrane. Finally, amino acid content was measured by the Sykam S7130 amino acid automatic analyser (Sykam Ltd., Munich, Germany). After acid hydrolysis, the tryptophan could not be detected. The result of amino acids was expressed as g/100g dry weight. Quintuplicate determinations were performed.

Calculate the essential amino acid index (EAAI) using the formula below [20]:

$$\mathrm{EAAI} = \sqrt[n]{\frac{100\mathrm{A}}{\mathrm{AE}} \times \frac{100\mathrm{B}}{\mathrm{BE}} \times \frac{100\mathrm{C}}{\mathrm{CE}} \times \cdots \times \frac{100\mathrm{I}}{\mathrm{IE}}}$$

where n denotes the quantity of EAAs in the formula; A, B, C, ... , I denotes the EAA content (% dry weight) of the protein; and AE, BE, CE, ... , IE denotes the EAA contents (% dry weight) of the whole egg protein standards.

2.4. Fatty Acid Analysis

The determination of fatty acids was according to the previous study described by Joseph & Ackman (1992) [21]. The analysis of fatty acids was based on tran-

sesterification with methanol boron trifluoride. Gas chromatography-mass spectrometry (GC-MS, 7890A-5975C, Agilent Technologies, Palo Alto, CA, USA) which was loaded with a HP-5MS capillary column (30 m length × 0.25 mm width × 0.25 μm diameter, Agilent Technologies, Palo Alto, CA, USA). The electron energy was 70 eV and the ion source temperature was 230˚C. Splitless injection using an automatic sampler. Helium was used as the carrier gas with a flow rate of 1 mL/min. The oven temperature warm up from 40˚C (holding for 1 min) to 220˚C at 3˚C/min (holding for 25 min), and then up to 250˚C at a rate of 5˚C/min. Helium was used as the carrier gas, flowing at a rate of 1 mL/min. The content of each fatty acid was quantified by calculating their chromatographic peak areas (% total fatty acids).

2.5. Mineral Element Analysis

In a microwave digestion oven (MarsXpress, CEM Corporation, Matthews, NC, USA), the samples (1 g) of fillets were wet digested using 6 mL concentrated nitric acid and 2 mL hydrogen peroxide. After cooling down to room temperature, the solution was filtered by a 0.45-μm ultrafiltration membrane, then transferred to a 25 ml volumetric flask and diluted with ultrapure water. The blank sample was prepared as the same method.

According to the method of Agah *et al.* (2009) [22], Major elements (K, Ca, Mg, Na) and minor elements (Zn, Fe, Ai, Se, Cu, Cr, Ni, Cd) was identified using an ICP-MS Inductively loaded plasma mass spectrometry (Xseries2, Thermo Fisher Scientific, Waltham, MA, USA).

2.6. Statistical Analyses

Data were expressed as mean ± SE ($n = 5$), and one-way ANOVA was performed by SPSS 17.0 (SPSS, Chicago, IL, USA). Significance difference was considered at $P < 0.05$ and Turkey's multiple range test was used to find difference among all the groups.

3 Results and Discussion

3.1. Biometric Parameters and Proximate Composition

The biometric parameters and chemical composition of TC from different cultured environments were presented in **Table 1**. Compared with pond- and lake-cultured TC, wild TC had significantly higher protein content and lower crude lipid content ($P < 0.05$). The results of this study are coincidence with those previous research conducted on gilthead seabream *Sparus aurata* [23], as well as, for a variety of carnivorous fishes, like silver pomfret *Pampus argenteus* [24] [25], seabass *Dicentrachus labrax* [26], and yellow fin sea bream *Acanthopagrus latus* [27]. In contrast with our results, Hossain *et al.* (2012) found wild fish in blue fin sea bream *Sparidentex hasta* and grouper *Epinephelus coioides* to have significantly higher levels of crude lipid contents than cultured fish [27].

Table 1. Proximate composition of wild, pond- and lake-cultured topmouth culter *Culter alburnus* (%, $\bar{x} \pm s$, $n = 5$, wet weight).

Item	Pond-cultured	Lake-cultured	Wild
Moisture	77.18 ± 0.19	76.09 ± 0.71	77.29 ± 0.90
Crude protein	18.14 ± 0.35[b]	18.79 ± 0.30[b]	19.16 ± 0.76[a]
Crude fat	2.79 ± 0.21[a]	3.10 ± 0.27[a]	2.04 ± 0.11[b]
Ash	1.11 ± 0.03	1.07 ± 0.02	1.10 ± 0.02
CF	1.17 ± 0.06	1.25 ± 0.06	1.25 ± 0.04

The different letters in the same column denote significant difference ($P < 0.05$).

Furthermore, It was reported by Gao *et al.* (2012) that wild fish contain significantly lower crude protein than cultured fish for Dojo loach *Misgurnus anguillicaudatus* [28]. In present study, there is no significant difference was observed in the condition factor among all the groups.

In general, the composition of fish was greatly influenced by the components of diets [29]. The wild TC diet consists of forage fishes, whereas cultured TC is often fed more abundant and more accessible commercially formula feed [9]. Therefore, cultured and wild TC have different protein and lipid contents seems to be related to dietary source [24]. In addition, the species, reproductive status, living habitat, and other governing conditions can all have an impact on the chemical composition of fish [14] [30].

3.2. Amino Acid Composition

The composition of amino acids in the muscle of wild and cultured TC is shown in Table 2. Amino acid content did not differ significantly among all the groups ($P > 0.05$), except wild fish had considerably ($P < 0.05$) lower histidine content than lake-cultured TC, but appreciably higher proline content than pond-cultured TC ($P < 0.05$).

The top three essential amino acids (EAA) contained lysine, leucine and arginine, and the top three non-essential amino acids (NEAA) included glutamic acid, aspartic acid and alanine in TC. Similar findings were observed for other fish species, such as longsnout catfish *Leiocassis longirostris* [14], dojo loach [28], and gilthead seabream [15]. Despite significant differences in histidine levels and proline levels between wild and cultured TC, no noticeable difference in total amino acid and total EAA content was found. Our results showed that wild and cultured TC potentially had a balanced proportion of amino acids. Additionally, Gao *et al.* (2012) showed that this alteration might also be a result of the diet's balanced amino acid pattern or the likelihood that the EAA levels may be close to what is needed for dojo loach [28].

3.3. Fatty Acid Profile

The composition of fatty acids in the muscle of wild and cultured TC is listed in

Table 2. Amino acid composition in muscle of wild, pond- and lake-cultured topmouth culter *Culter alburnus* (%, $\bar{x} \pm s$, $n = 5$, g/100g dry weight).

Amino acids	Pond-cultured	Lake-cultured	Wild
Threonine*	3.28 ± 0.05	3.27 ± 0.06	3.41 ± 0.06
Valine*◆	4.01 ± 0.07	3.82 ± 0.05	3.97 ± 0.06
Methionine*	2.31 ± 0.07	2.28 ± 0.07	2.24 ± 0.02
Leucine*◆	5.97 ± 0.22	5.97 ± 0.11	5.97 ± 0.09
Isoleucine*◆	3.33 ± 0.16	3.39 ± 0.11	3.39 ± 0.08
Phenylalanine*▪	3.64 ± 0.05	3.64 ± 0.08	3.43 ± 0.04
Lysine*	7.58 ± 0.17	7.37 ± 0.19	7.66 ± 0.05
Histidine★	2.03 ± 0.06[a]	2.27 ± 0.12[b]	1.98 ± 0.05[a]
Arginine★	4.08 ± 0.11	3.93 ± 0.11	4.25 ± 0.04
Aspartic acid#	8.21 ± 0.13	8.13 ± 0.19	8.11 ± 0.06
Glutamic acid#	12.94 ± 0.15	12.67 ± 0.25	13.24 ± 0.04
Glycine#	3.37 ± 0.05	3.40 ± 0.05	3.33 ± 0.05
Alanine#	4.96 ± 0.11	4.82 ± 0.10	4.88 ± 0.06
Tyrosine▪	2.79 ± 0.03	2.81 ± 0.07	2.72 ± 0.03
Serine	2.51 ± 0.09	2.48 ± 0.04	2.64 ± 0.03
Proline	2.47 ± 0.10[a]	2.58 ± 0.04[ab]	2.78 ± 0.08[b]
Cystine	0.26 ± 0.09	0.23 ± 0.06	0.20 ± 0.04
TAA	73.76 ± 1.11	73.08 ± 1.31	74.20 ± 0.38
EAA	36.24 ± 0.79	35.94 ± 0.60	36.30 ± 0.10
NEAA	37.52 ± 0.40	37.14 ± 0.71	37.89 ± 0.31
DAA	29.48 ± 0.73	29.03 ± 1.22	29.56 ± 0.38
BCAA	13.30 ± 0.97	13.18 ± 0.53	13.33 ± 0.23
AAA	6.43 ± 0.20	6.46 ± 0.33	6.16 ± 0.14
EAA/TAA	49.13	49.18	48.92
EAA/NEAA	96.59	96.77	95.80
DAA/TAA	39.70	39.72	39.84
EAAI	66.93	66.11	66.52

HEAA, total half-essential amino acids; DAA, delicious amino acids; BCAA, branch chain amino acids; AAA, aromatic amino acids; EAAI essential amino acid index; *: EAA; ★: HEAA; #: DAA; ◆: BCAA; ▪: AAA; values with different letters in the same line denote significant difference ($P < 0.05$).

Table 3. Total saturated fatty acids (ΣSFAs) showed no significant difference among all the groups ($P > 0.05$). The predominant SFAs were palmitic acid (C 16:0) in TC, and lake-cultured fish had significantly higher palmitic acid than

Table 3. Fatty acid profile of commercial feed and muscle of wild and cultured topmouth culter *Culter alburnus* ($\bar{x} \pm s$, %, $n = 5$).

Fatty acid	Commercial feed	Topmouth culter		
		Pond-cultured	Lake-cultured	Wild
C14:0	0.19 ± 0.01	0.91 ± 0.07	0.94 ± 0.07	1.27 ± 0.29
C15:0	0.02 ± 0.00	0.17 ± 0.02	0.18 ± 0.01	0.32 ± 0.11
C16:0	2.00 ± 0.02	12.06 ± 0.30^{ab}	12.57 ± 0.08^{b}	11.85 ± 0.37^{a}
C17:0	0.02 ± 0.00	0.24 ± 0.08	0.35 ± 0.01	0.46 ± 0.14
C18:0	0.55 ± 0.00	4.22 ± 0.10	4.53 ± 0.14	5.24 ± 0.86
C19:0	/	0.08 ± 0.00	0.11 ± 0.00	0.17 ± 0.05
C20:0	0.04 ± 0.00	0.29 ± 0.01	0.35 ± 0.06	0.36 ± 0.05
C21:0	/	0.07 ± 0.04	0.04 ± 0.00	0.05 ± 0.01
C22:0	0.02 ± 0.00	0.09 ± 0.01	0.11 ± 0.01	0.15 ± 0.02
C23:0	/	0.12 ± 0.01	0.12 ± 0.02	0.12 ± 0.03
C24:0	0.02 ± 0.00	0.05 ± 0.01	0.06 ± 0.01	0.07 ± 0.01
ΣSFA	2.89 ± 0.02	18.32 ± 0.27	19.35 ± 0.18	20.05 ± 0.47
C14:1	/	0.03 ± 0.00	0.03 ± 0.00	0.01 ± 0.01
C16:1n7	0.31 ± 0.00	4.43 ± 0.46	4.26 ± 0.28	3.69 ± 0.37
C17:1	/	0.32 ± 0.04	0.38 ± 0.02	0.34 ± 0.06
C18:1n9	2.51 ± 0.04	39.78 ± 0.83^{b}	36.27 ± 0.07^{b}	28.72 ± 0.82^{a}
C19:1	/	0.07 ± 0.00	0.07 ± 0.01	0.06 ± 0.01
C20:1n9	0.09 ± 0.00	1.63 ± 0.09^{b}	1.59 ± 0.09^{b}	1.30 ± 0.07^{a}
C22:1n9	0.02 ± 0.00	0.47 ± 0.01	0.54 ± 0.02	0.53 ± 0.07
C24:1n9	0.03 ± 0.00	0.09 ± 0.01	0.14 ± 0.01	0.10 ± 0.02
ΣMUFA	2.96 ± 0.03	46.82 ± 0.89^{c}	43.28 ± 0.28^{b}	34.75 ± 0.56^{a}
C16:2n6	/	0.05 ± 0.00	0.04 ± 0.01	0.21 ± 0.08
C18:2n6*	3.37 ± 0.01	21.50 ± 0.99	21.69 ± 0.37	22.17 ± 1.21
C18:3n3*	0.24 ± 0.00	3.07 ± 0.06^{a}	3.38 ± 0.12^{a}	3.97 ± 0.26^{b}
C20:2n6	0.01 ± 0.00	1.06 ± 0.03^{b}	1.21 ± 0.06^{c}	0.81 ± 0.02^{a}
C20:3n3	0.01 ± 0.00	0.90 ± 0.02	1.10 ± 0.15	0.81 ± 0.14
C20:4n6 (AA)	0.10 ± 0.00	1.74 ± 0.08^{a}	2.05 ± 0.02^{a}	3.60 ± 0.66^{b}
C22:2n6	/	0.03 ± 0.00	0.05 ± 0.00	0.02 ± 0.01
C20:5n3 (EPA)	0.40 ± 0.00	1.74 ± 0.13^{a}	2.20 ± 0.09^{a}	4.28 ± 0.20^{b}
C22:6n3 (DHA)	0.64 ± 0.00	3.72 ± 0.32^{a}	5.10 ± 0.68^{a}	8.63 ± 0.10^{b}
ΣPUFA	4.77 ± 0.05	33.81 ± 0.61^{a}	36.82 ± 0.60^{a}	44.50 ± 0.52^{b}
ΣEFA	3.70 ± 0.02	26.32 ± 0.90^{a}	27.12 ± 0.46^{a}	29.74 ± 0.41^{b}

Continued

ΣHUFA	1.15 ± 0.00	8.10 ± 0.54[a]	10.45 ± 0.65[a]	17.32 ± 0.88[b]
EPA + DHA	1.04 ± 0.00	5.46 ± 0.44[a]	7.30 ± 0.77[a]	12.91 ± 0.11[b]
Σn-3	1.29 ± 0.01	9.43 ± 0.52[a]	11.78 ± 0.54[a]	17.70 ± 0.50[b]
Σn-6	3.48 ± 0.01	24.33 ± 0.92	25.00 ± 0.33	26.59 ± 0.61
Σn-3:Σn-6	0.37 ± 0.00	0.39 ± 0.04[a]	0.47 ± 0.02[a]	0.67 ± 0.03[b]

*Essential fatty acid; ΣSFA, total saturated fatty acids; ΣMUFA, total monounsaturated fatty acid; ΣPUFA, total poly-unsaturated fatty acid; ΣEFA, total essential fatty acids; ΣHUFA, total high poly-unsaturated fatty acid. Values with different letters in the same line denote significant difference ($P < 0.05$).

that of wild fish ($P < 0.05$). According to Kinsella *et al.* (1978), SFAs were noticeably stable in a variety of freshwater fish species ($P < 0.05$) [31].

Wild TC had significantly lower total monounsaturated fatty acids (ΣMUFAs) and significantly ($P < 0.05$) higher total polyunsaturated fatty acids (ΣPUFAs) than those of cultured TC. Dietary lipid sources might be a necessary source of the fatty acids composition in the fish flesh [13] [16] [23]. Therefore, this might ascribe to the cultured fish fed artificial diets which contained a high proportion of MUFA and a low proportion of PUFA (**Table 3**).

With regard to MUFAs, oleic acid (C18:1n-9) and eicosenoic acid (C20:1n9) were the primary MUFAs in the muscle of TC, and wild TC were significantly lower in the two MUFAs than cultured TC ($P < 0.05$). The higher levels of MUFAs in cultured TC are probably because of the increased levels of oleic acid in their diets [32]. Our results agree with those of previous studies in gilthead sea bream [23], sea bass [33] and rainbow trout *Oncorhynchus mykiss* [16].

The Σn-3 PUFAs content of wild fish was significantly ($P < 0.05$) higher than that of cultured fish, while n-6 PUFAs showed similar trends ($P > 0.05$). Both linoleic acid and alpha linolenic acid (ALA, C18:3n-3) are essential fatty acid that cannot be synthesised by the TC. In the present study, wild TC had significantly higher levels of ALA than that of cultured TC ($P < 0.05$). In the commercial feed of farmed fish, especially freshwater species, vegetable oils is wildly applied as a substitute for fish oil [28] [34], which might further reduce n-3 PUFAs in fish [35]. There was a significant increase in arachidonic acid (ARA, C20:4n-6) in wild TC compared with farmed TC. In other species, similar results were observed too, such as gilthead sea bream [23] [36], dojo loach [28], sea bass [33] [37]. Generally, the low ARA content in farmed fish is a result of the low ARA content of the feed oil used [16] [23] [37].

In addition to eicosapentaenoic acid (EPA, C20:5n-3) and docosahxaenoic acid (DHA, C22:6n-3), n-3 PUFAs play an important role in human health [38] [39]. In the present study, the content of EPA and DHA were significantly ($P < 0.05$) higher in wild TC than in cultured TC. In other species, including rainbow trout [16], silver pomfret [24] and sea bass [33] [37] also reported similar results to our present study. By contrast, a higher proportion of EPA and DHA in cul-

tured dojo loach and gilthead seabream than in wild fish was reported by Gao *et al.* (2012) [28] and Kaba *et al.* (2009) [15], respectively. In cultured fish, n-3 PUFA levels are commonly lower than in wild fish, which may ascribe to the insufficiency of lipids originating from phytoplankton and other aquatic organisms in commercial feeds [40]. Therefore, the declined levels of EPA and DHA in cultured fish are possibly due to the lack in feed. Our study suggests that more attention should be paid to the content of HUFAs, especially EPA and DHA in the artificial feed of TC for maintaining a fatty acid balance.

In freshwater fish species, the ratio of n-3/n-6 PUFAs is an important indicator of the relative nutritional value of lipids [16]. In our study, the ratio was significantly ($P < 0.05$) higher in wild TC than in pond- and lake-cultured TC, which is in agreement with those studies for rainbow trout [16], silver pomfret, grouper, blue fin sea bream and yellow fin sea bream [27]. Generally, wild freshwater fish are characterized by the higher n-3/n-6 ratio [23]. Therefore, the nutritional quality of the lipid composition in cultured TC can be improved by dietary lipid regulation.

3.4. Elemental Content

Table 4 shows the mineral components of farmed and wild TC, K, Ca, Mg and Na were the major elements among the all analyzed elements. Na was significantly ($P < 0.05$) higher in lake-cultured TC compared with wild TC. The mineral composition of the fish could be also affected by the composition of commercial feed in farmed fish [33].

Table 4. Mineral element contents in muscle of wild, pond- and lake-cultured topmouth culter *Culter alburnus* (mg/kg, $\bar{x} \pm s$, $n = 3$).

Mineral element	Pond-cultured	Lake-cultured	Wild fish
K	3721.60 ± 252.89	3925.60 ± 316.29	2865.33 ± 300.55
Ca	751.80 ± 124.67	735.20 ± 214.31	357.33 ± 87.91
Mg	552.42 ± 60.60	391.12 ± 51.64	360.43 ± 22.36
Na	316.08 ± 56.05^{ab}	392.20 ± 46.37^{b}	193.04 ± 80.25^{a}
Zn	5.69 ± 1.51	3.89 ± 0.52	2.46 ± 0.21
Fe	6.48 ± 1.16^{b}	4.33 ± 0.71^{ab}	1.95 ± 0.43^{a}
Ai	0.37 ± 0.07	0.53 ± 0.11	0.42 ± 0.05
Se	0.20 ± 0.02^{a}	0.19 ± 0.02^{a}	0.43 ± 0.09^{b}
Cu	0.41 ± 0.11	0.33 ± 0.07	0.10 ± 0.11
Cr	0.10 ± 0.01	0.09 ± 0.01	0.07 ± 0.01
Ni	0.04 ± 0.01	0.09 ± 0.02	0.02 ± 0.01
Cd	0.003 ± 0.00	0.003 ± 0.00	0.002 ± 0.00

Values with different letters in the same line denote significant difference ($P < 0.05$).

Microminerals present in Table 4 were categorized as necessary trace minerals (Fe, Zn, Ai, Se, Cu, Cr and Ni) and toxic trace minerals (Cd). No variation between wild and cultured TC in microminerals was found ($P > 0.05$), except for Fe and Se content. Pond-cultured TC had significantly higher concentrations of Fe than wild TC. On the contrary, the Se content of wild TC was significantly higher than that of cultured TC. Fish flesh is a favorable essential mineral for the customer [41]. Essential trace minerals, for example, selenium as an antioxidant, an anticancer agent, a regulator of thyroid hormone metabolism, and an antagonist of the toxicological effects of mercury [16] [42]. On the other hand, we found that the toxic element (Cd) is present in amounts below the hazard level [43].

4. Conclusion

The differences in the content of crude protein and lipid, histidine and proline, and several fatty acids among wild, pond- and lake-cultured topmouth culter can be influenced by the food derived and other factors such as environment conditions. The decreased proportion of PUFAs, n-3 PUFAs, EPA and DHA in the muscle of pond- and lake-cultured fish reflected a decrease in the nutritional quality of cultured fish. Higher levels of ALA, ARA, EPA, DHA, Σn-3 PUFA, ΣEFA and ΣHUFA in the muscle of wild fish suggested the requirement for quality enhancement in farmed fish. Finally, the observed differences in the fatty acid composition of wild, pond- and lake-cultured topmouth culter need to be addressed by means such as feed supplementation or other means to improve the nutritional quality and optimize the fatty acid balance of cultured fish.

Acknowledgements

This work was supported by the earmarked fund for China Agriculture Research System (CARS-48-39) and the innovation program of aquatic seed industry in Hunan Province (2021-2023).

The authors would like to thank Dr. Zhiqiang Liang and Mr. Xinghua Chen for their helps in sample collection, preparation and technical assistance.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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