

Original Research Articles

Nutrition composition of different size of male largemouth bass (*Micropterus salmoides*) and its implications for food processing industry

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To understand the basic nutritional composition and enhance the application of largemouth bass (*Micropterus salmoides*), the nutritional quality of muscle and skin of largemouth bass with body weight of 450.10±1.11g, 650.31±1.20 g, and 850.10±1.13 g was analyzed. Results showed that the skin and muscle of fish with a body weight of 650.31±1.20 g were most suitable for processing and comprehensive utilization. Glycine had the lowest percentage, while glutamic acid was the most prevalent amino acid connected to umami. Total amino acid (TAA), essential amino acid (EAA), and D-aspartic acid (DAA) levels first increased and then decreased as the body weight increased. Largemouth bass of an intermediate size exhibited the highest levels of TAA and DAA, and superior amino acid balance and had the highest nutritional value among the three groups. The most common necessary minerals were Na, Mg, and K. The skin had higher concentrations of these elements than muscle, and their amounts rose and reduced in proportion to body weight. Our results demonstrated that the male largemouth bass with a body weight of 650.31±1.20 g had the muscle with the highest nutritional quality and the greatest application potential.

INTRODUCTION

With the development of the times, human beings pay more attention to healthy aquatic products.¹⁻³ Thus, it is important to evaluate the nutritional composition of aquatic animals. The relationship between the weight of aquatic animals and their nutritional composition is also an important reference for designing the breeding cycle and the processing of aquatic products. The nutritional composition of aquatic animals is closely related to the growth environment, habitat space, growth stage, and feed composition.³⁻⁶

Largemouth bass (*Micropterus salmoides*), also known as California perch, has been globally cultured, especially in China.^{3,7} Currently, most research focuses on the replacement of fishmeal with alternative protein sources and processing technologies of largemouth bass.⁴ However, reports on the nutritional components of muscle relative to the body weight of largemouth bass are scarce.^{3,8,9} Moreover, there is a lack of in-depth research on the differences in nutritional composition between male and female largemouth

bass. In aquaculture, understanding the specific nutritional characteristics of male largemouth bass is of great significance. For example, male largemouth bass may have different growth rates and nutritional accumulation patterns compared to females, which could potentially affect their market value and processing utilization. This study specifically focuses on male largemouth bass to fill this research gap.¹⁰

The main objectives of this study are to comprehensively analyze the basic components, amino acid composition, collagen content, and mineral elements of male largemouth bass of different sizes. We hypothesize that the nutritional composition of male largemouth bass muscle and skin is significantly affected by body weight, and that male largemouth bass with a body weight of 650.31 ± 1.20 g may possess the most suitable nutritional profile for further processing and utilization. By conducting this research, we aim to provide basic information for the largemouth bass culture industry and offer a data-driven basis for the marketing and further utilization of male largemouth bass as well as other aquatic products. This research can also contribute

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to a more in-depth understanding of the nutritional characteristics of male largemouth bass, which is expected to guide the optimization of aquaculture strategies and improve the overall quality and economic benefits of the industry.

MATERIALS AND METHODS

REAGENTS AND INSTRUMENTS

The largemouth bass in this study were cultured in a local fish farm in Handan City, Hebei Province. The aquaculture environment adopted a Recirculating Aquaculture System (RAS). The culture tanks were made of High-Density Polyethylene (HDPE), with a volume of 5 cubic meters per tank. Such a tank setup was designed to provide a stable and suitable growth environment for the largemouth bass.

All the fish were fed with commercial compound feed specifically for largemouth bass. The water temperature was maintained between 24 °C and 30 °C. The water quality was tested weekly, and the parameters were as follows: pH value ranged from 7.4 to 8.2, dissolved oxygen was greater than 0.004 g/L, nitrite nitrogen was less than 0.15 mg/L, and the transparency was 35-50 cm.¹¹

During the experiment, 21 healthy male largemouth bass were carefully selected from the fish farm. According to the weight differences, they were randomly divided into three groups. The fish in Group A had an average weight of 450.10 ± 1.11 g, and 3 tanks were prepared for each group for replicate culture, with a culture period of 10 months. The fish in Group B had an average weight of 650.31 ± 1.20 g, and 3 tanks were also arranged for each group, with a culture period of 15 months. The fish in Group C had an average weight of 850.10 ± 1.13 g, and 3 tanks were assigned for each group, with a culture period of 20 months.

Before conducting relevant measurements, MS-222 (tricaine methanesulfonate) was used to anesthetize the fish. The specific operation was to dissolve an appropriate amount of MS-222 in water to prepare an anesthetic solution with a concentration of 100 mg/L. Then, the largemouth bass was placed into the solution. When the fish lost its balance and showed a slow response to external stimuli, it indicated that the anesthesia was successful. At this point, the fish could be taken out for subsequent operations such as tissue dissection.

MEASUREMENT OF PHYSICAL INDICATORS

Once the fish was anesthetized with MS222, tissue dissection was carried out on it using an ice tray. For each sample, three parallel samples were designed and stored in a freezer at -20°C. The weight ratios of muscle to skin, fat content, and dressing percentage were among the indicators that were measured.^{3,9}

DETERMINATION OF BASIC COMPONENTS

The direct drying method measured the moisture content of the samples,⁷ the Kjeldahl method evaluated the crude protein content (GB 5009.5-2016, 2016), the Soxhlet ex-

traction method evaluated the crude fat content (GB 5009.6-2016, 2016), and the total ash content was assessed using high-temperature combustion (GB 5009.4-2016, 2016). Three measurements were made of each of these elements.

AMINO ACID ANALYSIS AND NUTRITIONAL EVALUATION

Ten specimens of *M. salmoides* were randomly chosen from each of the three weight classes, and then they were separated and homogenized. For methodological details of this trial, refers to prior research and published works.^{3,11}

The following formulas were used to determine the chemical score (CS), amino acid score (AAS), and essential amino acid index (EAAI):

$$AAS = \frac{\text{Content of certain amino acid in the sample}}{\text{Amino acid content in the } \frac{WHO}{FAO} \text{ model spectrum}}$$

$$CS = \frac{\text{Content of certain amino acid in the sample}}{\text{Content of certain amino acid in the egg proteins}}$$

$$EAAI = \sqrt[n]{\frac{t_1 * t_2 * \dots * t_n}{s_1 * s_2 * \dots * s_n}} * 100$$

Where n is the quantity of amino acids that need to be contrasted. The varied amino acid contents in the tested protein are shown by the values $t_1, t_2, \dots, t_n$, and the different amino acid contents in the tested egg protein are indicated by the values $s_1, s_2, \dots, s_n$, mg/g N.

COLLAGEN CONTENT DETERMINATION

Approximately 0.5 g of the sample was crushed and dried to a constant weight. And then it was placed in a 50 - mL stoppered test tube. Add 10 mL of 6 mol/L hydrochloric acid solution to the test tube, shake well, and then hydrolyze it in a constant-temperature drying oven at 110 °C for 24 h. After hydrolysis, the test tubes were cooled to room temperature. The solution was transferred to a 50 mL volumetric flask. The test tube was rinsed multiple times with deionized water, and the rinsing solution was also transferred to the volumetric flask. Finally, deionized water was added up to the mark to obtain the sample hydrolysate.

1 mL of the hydrolysate was transferred to a 10 - mL stoppered test tube. 0.5 mL of 0.05 mol/L chloramine - T solution was added and mixed well, and it was placed in the dark at room temperature for 20 min. Then 1 mL of 3.5 mol/L perchloric acid solution was added, shaken well, and then 1 mL of 10% p - dimethylaminobenzaldehyde solution (using absolute ethanol as the solvent) was added. After shaking, the test tube was heated in a 60 °C water bath for 15 min, and quickly cooled to room temperature. Absorbance was measured at a wavelength of 558 nm using a blank reagent as a reference with a spectrophotometer. Content of hydroxyproline was calculated in the sample hydrolysate according to the pre - drawn standard curve of hydroxyproline. The collagen content (mg/g) = hydroxyproline content (mg/g) $\times$ 7.25 (the conversion coefficient of hydroxyproline in collagen).

Table 1. Physical indicators of largemouth bass

Indicator	Weight Class		
	A	B	C
Muscle-to-body weight ratio %	46.51±0.10 ^a	69.11±0.10	60.12±0.10 ^b
Skin-to-body weight ratio %	10.22±0.02 ^a	17.92±0.03 ^b	15.12±0.03 ^b
Fullness	1.73±0.03 ^a	2.66±0.02 ^b	2.38±0.02 ^b
Dressing percentage %	48.22±0.12 ^a	70.77±0.09 ^b	61.10±0.08 ^b

Note: Different lowercase letters in the same row indicate significant differences ($P < 0.05$).

DETERMINATION OF MINERAL ELEMENTS

Approximately 1 g of the sample was accurately weighed to an accuracy of 0.0001 g and placed into a crucible. The sample was then subjected to carbonization over a low-intensity flame on an electric furnace until no visible smoke evolved. Subsequently, the crucible was transferred to a muffle furnace set at 550 °C for ashing for a duration of 6 hours. If the ashing process was incomplete, the crucible was allowed to cool, a few drops of 1:1 nitric acid were added, the solution was evaporated to dryness, and the ashing process was resumed until the sample was completely ashed. The test solution was then prepared by adding hydrochloric acid to the resulting ash.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was employed to determine the concentrations of mineral elements, including Na, Mg, K, Ca, Mn, Fe, and Zn, within the test solution. Prior to the measurement, the instrument's operating parameters were meticulously optimized to their optimal state. A standard curve was generated using a multi-element mixed standard solution. Based on this standard curve, the content of each element in the sample was calculated and expressed in milligrams per kilogram (mg/kg).

DATA ANALYSIS

The Statistica 6.0 program (Statsoft Inc.) was used to conduct the analysis of variance. Significant differences between the groups were found using Duncan's multiple comparison test. The data were presented as mean ± standard deviation, with a significance level of $P < 0.05$.

RESULTS AND ANALYSIS

PHYSICAL INDICATORS OF LARGEMOUTH BASS

The results of physical indicators, including muscle-to-body weight ratio (%), skin-to-body weight ratio (%), fullness content and dressing percentage (%), are shown in [Table 1](#). Compared with those of group B and group C, the physical indicators in group A were the lowest. Moreover, intermediate-sized largemouth bass in group B exhibited the highest dressing percentage (70.77%) and fullness content (2.66%). The difference in these physical indicators among the three group increased significantly with body weight and then decreased markedly ($P < 0.05$).

MUSCLE AND SKIN NUTRIENTS OF LARGEMOUTH BASS

The muscle and skin nutrients of largemouth bass in each group are listed in [Table 2](#). The results showed that the contents of moisture, protein, fat and ash in the muscles of *Micropterus salmoides* first increased and then decreased, and among them, the contents in Group B were the highest ($P > 0.05$). The fish in Group B exhibited the highest collagen contents in muscle and skin, which reached 10.15 mg/g and 84.44 mg/g, respectively.

AMINO ACID COMPOSITION IN MUSCLE AND SKIN OF LARGEMOUTH BASS

The amino acid contents of the muscle and skin of largemouth bass in Group A, Group B, and Group C are shown in [Table 3](#). The EAAs in the muscle of largemouth bass in Group A, Group B, and Group C were 6.71 ± 0.02 mg/g, 9.02 ± 0.03 mg/g, and 8.58 mg/g, respectively, and those of skin in the three groups were 6.90 ± 0.02 , 9.42 ± 0.03 , and 8.87 ± 0.03 . The ratios of DAA/TAA and EAA/TAA in the three groups showed no significant changes.

[Table 4](#) indicates the AAS and CS in the muscle and skin of largemouth bass in the three groups. As shown in [Table 4](#), in comparison to muscle, the skin had higher AASs and CSs ($P > 0.05$). The most restricting amino acids in muscle and skin were Met and Cys. The sample tissues of each group had a good amino acid balance and nutritional value, indicating that they were high-quality protein sources. The EAAI values for this experiment were all greater than 95.00%.

MINERAL ELEMENTS IN MUSCLE AND SKIN OF LARGEMOUTH BASS

The essential mineral elements in the muscle and skin of largemouth bass in the three groups are indicated in [Table 5](#). According to [Table 5](#), the fish in Group B had the highest contents of key mineral elements (Na, Mg, K, and Ca), compared with those of group A and group C ($P < 0.05$). Importantly, the contents of Fe and Zn in skin of fish in all the three groups were significantly higher than that in muscle of fish in all the three groups ($P < 0.05$).

Table 2. Nutrient contents in muscle and skin of largemouth bass in the three groups

Measurement index	Muscle			Skin		
	A	B	C	A	B	C
Moisture %	68.21±1.05 ^a	72.31±1.15 ^a	71.12±1.14 ^a	69.54±1.03 ^a	73.13±1.20 ^a	72.81±1.11 ^a
Protein %	16.31±0.87 ^a	22.33±0.84 ^b	21.37±0.77 ^b	17.01±0.85 ^a	23.22±0.91 ^b	22.74±0.88 ^b
Fat %	6.11±0.52	7.21±0.56 ^b	6.88±0.53 ^{ab}	6.01±0.45 ^a	7.11±0.50 ^b	6.80±0.45 ^{ab}
Ash content %	1.30±0.27 ^a	1.68±0.46 ^b	1.59±0.34 ^b	1.37±0.32 ^a	1.75±0.34 ^b	1.67±0.48 ^b
Collagen mg/g	8.29±0.12 ^a	10.15±0.12 ^b	9.91±0.11 ^{ab}	60.21±0.32 ^a	84.44±0.42 ^b	77.63±0.31 ^b

Note: Different lowercase letters among groups for different tissue samples indicate significant differences ($P<0.05$).

Table 3. Amino acid contents in muscle and skin of largemouth bass in the three groups

Amino acids in protein/(mg/g)	Muscle			Skin		
	A	B	C	A	B	C
* Threonine	0.63±0.01 ^a	0.86±0.02 ^b	0.81±0.03 ^b	0.65±0.02 ^a	0.89±0.02 ^b	0.85±0.02 ^b
* Valine	1.00±0.02 ^a	1.34±0.05 ^b	1.27±0.03 ^b	1.01±0.02 ^a	1.39±0.02 ^b	1.29±0.02 ^b
* Methionine	0.62±0.02 ^a	0.83±0.03 ^b	0.80±0.02 ^b	0.63±0.01 ^a	0.87±0.02 ^b	0.82±0.02 ^b
* Isoleucine	0.71±0.03 ^a	0.98±0.02 ^b	0.92±0.09 ^b	0.73±0.01 ^a	1.02±0.01 ^b	0.96±0.02 ^b
* Leucine	1.22±0.02 ^a	1.63±0.02 ^b	1.59±0.02 ^b	1.25±0.01 ^a	1.70±0.02 ^b	1.62±0.02 ^b
* Histidine	0.50±0.01 ^a	0.74±0.02 ^b	0.66±0.02 ^b	0.51±0.02 ^a	0.82±0.02 ^b	0.71±0.02 ^b
* Phenylalanine	0.71±0.02 ^a	0.92±0.02 ^b	0.89±0.02 ^b	0.73±0.01 ^a	0.95±0.02 ^b	0.91±0.02 ^b
* Lysine	1.32±0.03 ^a	1.72±0.02 ^b	1.64±0.03 ^b	1.39±0.02 ^a	1.78±0.02 ^b	1.71±0.02 ^b
essential amino acids (EAA)	6.71±0.02 ^a	9.02±0.03 ^b	8.58±0.03 ^b	6.90±0.02 ^a	9.42±0.03 ^b	8.87±0.03 ^b
^A aspartic acid	1.60±0.03 ^a	1.98±0.02 ^b	1.85±0.02 ^b	1.62±0.02 ^a	2.02±0.03 ^b	1.90±0.02 ^b
^A glutamic acid	2.61±0.02 ^a	3.44±0.02 ^b	3.28±0.04 ^b	2.65±0.02 ^a	3.52±0.03 ^b	3.33±0.03 ^b
^A glycine	0.83±0.01 ^a	1.11±0.04 ^b	0.91±0.03 ^{ab}	0.83±0.04 ^a	1.11±0.03 ^b	0.97±0.03 ^{ab}
^A alanine	1.05±0.04 ^a	1.11±0.03 ^b	1.08±0.05 ^a	1.08±0.06 ^a	1.16±0.04 ^b	1.11±0.02 ^a
^A tyrosine	0.75±0.03 ^a	0.84±0.02 ^b	0.79±0.03 ^a	0.78±0.03 ^a	0.87±0.03 ^b	0.80±0.02 ^a
Umami amino Acids (DAA)	6.84±0.02 ^a	8.48±0.02 ^b	7.91±0.02 ^{ab}	6.96±0.02 ^a	8.68±0.02 ^b	8.11±0.02 ^{ab}
Serine	0.63±0.02 ^a	0.78±0.02 ^b	0.72±0.03 ^{ab}	0.65±0.01 ^a	0.81±0.02 ^b	0.74±0.01 ^{ab}
Arginine	1.11±0.02 ^a	1.29±0.02 ^b	1.17±0.02 ^{ab}	1.13±0.01 ^a	1.34±0.02 ^b	1.21±0.02 ^{ab}
Proline	0.69±0.02 ^a	0.89±0.03 ^b	0.80±0.02 ^{ab}	0.71±0.01 ^a	0.93±0.01 ^b	0.82±0.02 ^{ab}
Total amino Acids (TAA)	15.98±0.03 ^a	20.46±0.05 ^b	19.18±0.04 ^{ab}	16.35±0.03 ^a	21.18±0.04 ^b	19.75±0.02 ^b
DAA/TAA	0.43	0.42	0.43	0.43	0.41	0.41
EAA/TAA	0.42	0.44	0.45	0.42	0.45	0.45

Note: *Essential amino acid, Aumami amino acid. Different lowercase letters among groups for different sampled tissues indicate significant differences ($P<0.05$).

DISCUSSION

PHYSICAL INDICATORS OF LARGEMOUTH BASS

The principal nutritional constituents of aquatic products serve as crucial markers for the quality of the final product.⁷ Largemouth bass accumulates a greater proportion of cartilage after reaching a certain size.^{5,12,13} Long-term consumption of largemouth bass can help alleviate lower back discomfort, hair loss, and stomach disorders. It also has high nutritional and therapeutic value.^{12,13}

In this study, we focused on male largemouth bass. We found that as the body weight of male largemouth bass in-

creased, there were no significant changes ($P>0.05$) in the water content of their muscles. The contents of protein, fat, and ash initially increased and then decreased. Intermediate-sized male largemouth bass (650.31±1.20 g) had the highest amounts, with significant variations in fat content ($P<0.05$). These results are consistent with previous research on other aquatic species.^{14,15}

The protein contents in the skin and muscle of intermediate-sized male largemouth bass (650.31±1.20 g) were higher than those of some cold-water fish, such as *Acipenser baerii* and *Acipenser schrenckii*. The reasons may be related to nutrient levels, the environment, and individual species differences. Considering male largemouth

Table 4. AAS and CS in muscle and skin of largemouth bass in the three groups

Essential amino acids (mg/g)	Muscle						Skin					
	A		B		C		A		B		C	
	AAS	CS	AAS	CS	AAS	CS	AAS	CS	AAS	CS	AAS	CS
Ile	1.05±0.02 ^a	0.71±0.01 ^a	1.31±0.01 ^b	0.95±0.02 ^b	1.22±0.02 ^b	0.92±0.01 ^b	1.10±0.01 ^a	0.72±0.02 ^a	1.41±0.01 ^b	0.98±0.02 ^b	1.36±0.02 ^b	0.94±0.01 ^b
Leu	1.09±0.01 ^a	0.72±0.01 ^a	1.23±0.01 ^b	0.96±0.02 ^b	1.21±0.02 ^b	0.92±0.01 ^b	1.12±0.02 ^a	0.73±0.02 ^a	1.36±0.01 ^b	0.99±0.02 ^b	1.30±0.02 ^b	0.93±0.01 ^b
Thr	1.00±0.02	0.80±0.01	1.14±0.01	0.86±0.02	1.11±0.01	0.84±0.01	1.03±0.01	0.82±0.02	1.22±0.01	0.87±0.01	1.16±0.02	0.84±0.02
Val	1.01±0.01 ^a	0.61±0.01	1.29±0.02 ^b	0.68±0.02	1.27±0.02 ^b	0.64±0.02	0.95±0.02 ^a	0.51±0.01	1.35±0.02 ^b	0.61±0.02	1.32±0.02 ^b	0.55±0.01
Met+Cys	0.81±0.02 ^a	1.00±0.01	1.02±0.02 ^b	1.08±0.02	0.97±0.02 ^b	1.04±0.02	0.83±0.01 ^a	1.14±0.01	1.11±0.02 ^b	1.19±0.01	1.05±0.01 ^b	1.16±0.01
Phe+Tyr	1.21±0.01	0.81±0.02	1.30±0.01	0.93±0.02	1.25±0.02	0.90±0.02	1.24±0.02	0.83±0.02	1.35±0.02	0.98±0.02	1.30±0.02	0.95±0.02
Lys	1.65±0.02 ^a	1.11±0.01	1.87±0.02 ^b	1.22±0.02	1.83±0.02	1.16±0.01	1.66±0.01 ^a	1.14±0.01	1.93±0.02 ^b	1.29±0.01	1.87±0.01 ^b	1.26±0.01
Total	1.17±0.01	0.81±0.01	1.22±0.01	0.89±0.02	1.21±0.02	0.85±0.01	1.21±0.01	0.83±0.02	1.35±0.02	0.92±0.02	1.27±0.01	0.88±0.01
EAAI	97.11±0.62	96.77±0.68	98.04±0.61	97.80±0.61	97.81±0.64	97.39±0.62	97.55±0.62	96.89±0.64	98.41±0.61	97.14±0.58	97.99±0.62	96.99±0.61

Note: AAS and CS in muscle and skin of largemouth bass in the three groups.

Table 5. Mineral elements in muscle and skin of largemouth bass in the three groups

Mineral element	Muscle			Skin		
	A	B	C	A	B	C
Na	588.21±6.71 ^a	712.42±7.81 ^b	655.28±7.01 ^{ab}	593.02±7.01 ^a	724.16±7.11 ^b	676.32±7.12 ^{ab}
Mg	332.23±2.14 ^a	387.22±2.55 ^b	374.12±2.01 ^b	342.21±2.15 ^a	393.42±2.12 ^b	385.50±2.22 ^b
K	310.11±1.01 ^a	354.11±1.02 ^b	344.33±1.01 ^b	319.22±1.34 ^a	380.52±1.13 ^b	369.24±1.04 ^b
Ca	60.25±0.87 ^a	80.11±0.83 ^b	72.12±0.74 ^{ab}	62.21±0.66 ^a	82.42±0.73 ^b	76.72±0.78 ^b
Mn	0.85±0.01	0.91±0.02	0.89±0.02	1.17±0.03	1.23±0.01	1.20±0.02
Fe	10.40±0.11	11.24±0.10	11.00±0.09	35.44±0.13	38.42±0.10	37.75±0.15
Zn	11.31±0.25	12.25±0.22	11.92±0.24	27.55±0.54	28.77±0.52	28.33±0.55

Note: Different lowercase letters between groups for different sampled tissues indicate significant differences ($P < 0.05$).

bass specifically, their unique physiological characteristics might also contribute to this difference, potentially due to distinct growth-related metabolic pathways or hormonal regulations compared to other species.

Fat content influences the quality and flavor of fish. The fat content of male largemouth bass was approximately 13 - 18%, which is comparable to that of hybrid sturgeon,⁵ but higher than that of freshwater fish such as *Cyprinus carpio* and *Carassius auratus*.¹⁶ Intermediate-sized male largemouth bass had the highest collagen concentrations in the skin and muscle, at 9.85% and 89.24%, respectively. This finding is in line with previous studies on sturgeon.⁵ The diverse applications of fish collagen, which can be used to produce fish collagen or collagen peptides, account for the significant variation in collagen concentration between tissues. Understanding these characteristics in male largemouth bass can provide valuable insights for the development of high-value-added products in the aquaculture industry.

AMINO ACID COMPOSITION OF LARGEMOUTH BASS

Fish freshness depends on the amino acid composition and quantity. Their flavors, mainly fresh, sweet, or bitter, vary with the amino acid content.^{5,17,18} In male largemouth bass muscle, among the EAAs, lysine is most abundant and histidine least. Lysine is vital for human metabolism.¹⁹

Both skin and muscle of male largemouth bass show a strong umami flavor, as can be seen from the equal DAA/TAA ratios. An EAA/TAA ratio of 0.4 indicates high-quality protein,²⁰⁻²² and the ratios in male largemouth bass meet this standard. Therefore, it's an excellent high-quality protein source for a balanced human diet.

Muscle amino acid scores (AAs) and chemical scores (Cs) are lower than those in the skin. Methionine (Met) and cysteine (Cys) are scarce in the epidermis and muscles, like in some freshwater fish.^{22,23} An Essential Amino Acid Index (EAAI) > 0.95 means high-quality protein, and male largemouth bass has EAAI over 0.95 in both tissues, showing good amino acid balance. This can enhance its marketability in the food market due to its nutritional advantage.

MINERAL ELEMENTS OF LARGEMOUTH BASS

Mineral elements are crucial for fish nutrition, growth, disease - prevention, and metabolism.^{5,11,24} In male largemouth bass, essential mineral element content first rose and then decreased ($P > 0.05$). In one - year - old *Brachymystax lenoks*, muscle Mn, Zn, and Fe concentrations were higher, their high growth rate and metabolic activities. Given the fish's limited intake, digestion, and absorption capacity,^{3,24,25} we assume mineral element concentration changes may relate to rapid growth, likely also true for male largemouth bass.

Magnesium (Mg), potassium (K), and sodium (Na) are highly concentrated in male largemouth bass muscle and skin. They maintain skin shape and normal metabolism. Mg activates enzymes; it's needed for bone-forming enzymes and all ATP - catalyzed enzymes.^{7,26} Fish bones can be used to create calcium- and magnesium-rich snacks, with magnesium playing a vital role in protecting the human cardiovascular system. The fact that muscle has less mineral content than skin^{10,26} also applies to male largemouth bass. More study is needed on quality, value, and mineral function relationships for new applications in male largemouth bass utilization.

In summary, male largemouth bass muscle and skin nutritional composition is affected by body weight. Those weighing 650.31±1.20 g is the most nutritionally beneficial and ideal for further processing. This research supports male largemouth bass breeding, processing, and marketing, aiding the aquaculture industry. It can help farmers optimize breeding for better-quality fish and gives processors information for new consumer-friendly products.

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AUTHORS' CONTRIBUTION

Conceptualization: Quansen Xie (Lead). Writing – review & editing: Quansen Xie (Lead). Supervision: Quansen Xie (Supporting), Jiaying Cai (Lead). Project administration: Jiaying Cai (Lead). Writing – original draft: Jiaying Cai (Lead), Miao Wang (Supporting). Methodology: Yiran Liu (Lead). Formal Analysis: Zhihua Zhang (Lead). Investigation: Zhihua Zhang (Lead). Resources: Mingjian Yang (Lead), Haochun Xing (Supporting).

ETHICAL CONDUCT APPROVAL – IACUC

Our experiment was conducted within the ethical guidelines of the author's institution and country. We adhered

to the Convention on Biological Diversity and the Convention on International Trade in Endangered Species of Wild Fauna and Flora and confirmed that every effort had been made to alleviate any suffering of the animals.

INFORMED CONSENT STATEMENT

All authors and institutions have confirmed this manuscript for publication.

DATA AVAILABILITY STATEMENT

All are available upon reasonable request.

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