Analysis and evaluation of nutritional components in muscle of *Sinogastromyzon szechuanensis*

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**Abstract.** Based on routine biochemical analysis methods, the nutritional composition in muscle of *Sinogastromyzon szechuanensis* were calculated using the Excel 2019 and SPSS 25.0 software. The results showed that the rates of moisture, crude protein, crude fat and ash in muscles of *S. szechuanensis* are (77.80±0.70) %, (18.38±0.21) %, (2.00±0.10) % and (1.55±0.08) % respectively. 16 kinds of amino acid were detected. The total content of amino acids (TAA), essential amino acids (TEAA) and delicious amino acids (TDAA) were 17.80%, 6.83% and 7.37% respectively. Amino acid score (AAS), chemical score (CS) and essential amino acid index (EAAI) were calculated using Excel 2019 software. The results revealed that the first and second limited acids were Ile and Val respectively. The essential amino acid index (EAAI) was 89.65. Four kinds of delicious amino acids (TDAA) accounted for (7.37±0.32) %, with the 41.43% of the total amino acids. The ratio of branched chain amino acid to aromatic amino acid (F value) were 2.31±0.04. It revealed that *S. szechuanensis* was a kind of delicious and high-quality fish with high-protein and low-fat composition.

1. **Introduction**

*Sinogastromyzon szechuanensis* belongs to Cypriniformes and Homalopteridae, and is a common characteristic fish in the mainstream and tributaries of the upper Yangtze River. At present, there are few studies on *S. szechuanensis*. Those studies mainly focus on the early development of fish and resource survey [1-2]. However, there is no report on the nutritional components of *S. szechuanensis*. In this study, the main nutrient components in the muscle of *S. szechuanensis* were determined and their nutritional value is evaluated comprehensively so as to provide references for the nutritional research of *S. szechuanensis* and the development and utilization of its resources.

2. **Materials and methods**

2.1. **Materials**

The material fish were collected from the Neijiang section of Sichuan Province in the Tuojiang River system in October 2018, with a total of 90 fish. The body weight was (2.62±1.12) g and the length was (5.13±0.55) cm. After peeling each fish, the muscles on both sides of the spinal column behind the head of the fish were removed, and the muscles of each 30 fish were crushed and mixed evenly, as a sample, and stored at low temperature for reserve. The samples were divided into two parts, one for the determination of general nutrients and the other for the determination of amino acid content after freeze-dried and crushed by freeze-drying machine.
2.2. Methods
Determination of general nutrients: moisture: 105 °C drying and constant-weight method (GB/T 5009.3-2003); ash: 550 °C muffle furnace burning method (GB/T 5009.5-2003); crude protein: Kjeldhal method (GB/T 5009.5-2003); crude fat: methanol-chloroform method [3]. Amino acid content determination: determined by JSYKO-S-433D automatic amino acid analyzer. The dates were analyzed using the Excel 2019 and SPSS 25.0 software.

2.3. Quality evaluation of nutritional components
According to FAO/WHO Amino Acid Scoring Model [4] and Whole Egg Protein Scoring Model [5], calculate AAS (Amino acid score), CS (Chemical score), and EAAI (Essential amino acid index) of *S. szechuanensis* using Excel 2019 software. The calculation formula were as follows:

\[ AAS = \frac{aa}{AA_{(FAO/WHO)}} \]
\[ CS = \frac{aa}{AA_{(Egg)}} \]
\[ EAAI = \sqrt{\frac{100A}{AE} \times \frac{100B}{BE} \times \frac{100C}{CE} \times \cdots \times \frac{100F}{FE}} \]

Note: 
- \( aa \): Content of Amino Acid in sample to be measured [mg/g N]; 
- \( AA_{(FAO/WHO)} \): Content of the Same Amino Acid in FAO/WHO Amino Acids Scoring Model [mg/g N]; 
- \( AA_{(Egg)} \): Content of the Same Amino Acid in Whole Egg Protein Scoring Model [mg/g N]; 
- \( A, B, C, \ldots F \) represents the essential amino acid content of the test sample; 
- \( AE, BE, CE, \ldots FE \) represents the essential amino acid content of whole egg protein.

Content of amino acid to be measured [mg/g N] = \( \frac{\text{content of amino acid in the sample% (fresh)}}{\text{content of crude protein in the sample% (fresh)}} \times 6.25 \times 1000 \)

\[ F = \frac{\text{Leu + Ile + Val}}{\text{Phe + Tyr}} \]

3. Results

3.1. General nutritional components
According to the test, the moisture content in the muscle of *S. szechuanensis* was 77.80%, the crude protein was 18.38%, the crude fat was 2.00% and the ash was 1.55%.

**Table 1.** The main biochemical compositions in muscle of *S. szechuanensis*

| Components        | Moisture | Crude protein | Crude fat | Crude Ash |
|-------------------|----------|---------------|-----------|-----------|
| wet weight        | 77.80±0.70 | 18.38±0.21    | 2.00±0.10 | 1.55±0.08 |

3.2. Composition and content of amino acids
The composition and content of amino acids in the muscle of *S. szechuanensis* are shown in Table 2. Totally 16 amino acids were detected (tryptophan and cystine were not detected), including 7 essential amino acids (Thr, Val, Met, Ile, Leu, Phe, Lys), 2 half-essential amino acids (Arg, His) and 7 non-essential amino acids (Ser, Pro, Tyr, Asp, Ala, Gly, Glu). Among them, the content of Glu (2.92%) was the highest, followed by Asp, Lys, Ala and Leu. The content of His is the lowest. The total contents of amino acids (TAA), essential amino acids (TEAA), non-essential amino acids (TNEAA) and delicious amino acids (TDAA) in muscle of *S. szechuanensis* were 17.80%, 6.83%, 9.40% and
7.37%, respectively. The ratio of branched chain amino acids (Leu, Ile, Val) to aromatic amino acids (Phe, Tyr) in muscle of *S. szechuanensis* is 2.31 (*F* value).

### Table 2. Amino acids composition in muscle of *S. szechuanensis* mean ± SD, *n* = 3, %, fresh weight

| Amino acids | Content | Amino acids | Content |
|-------------|---------|-------------|---------|
| Asp         | 1.82±0.07 | Gly         | 1.13±0.04 |
| Thr         | 0.78±0.02 | Glu         | 2.92±0.14 |
| Val         | 0.92±0.02 | TAA         | 17.80±0.75 |
| Met         | 0.47±0.03 | TEAA        | 6.83±0.24 |
| Ile         | 0.73±0.02 | THEAA       | 1.56±0.09 |
| Leu         | 1.49±0.05 | TNEAA       | 9.40±0.44 |
| Phe         | 0.77±0.03 | TDAA        | 7.37±0.32 |
| Lys         | 1.67±0.07 | BCAA        | 3.14±0.09 |
| Ser         | 0.70±0.04 | AAA         | 1.36±0.06 |
| Pro         | 0.74±0.05 | TEAA/TAA (%) | 38.40±0.32 |
| Arg         | 1.12±0.05 | TEAA/TNEAA (%) | 72.70±1.08 |
| Tyr         | 0.59±0.03 | TDAA/TAA (%) | 41.43±0.42 |
| His         | 0.44±0.03 | F(BCAA/AAA) | 2.31±0.04 |
| Ala         | 1.50±0.08 |             |         |

Note: TAA: total amino acids; TEAA: total essential amino acids; THEAA: total half-essential amino acids; TNEAA: total non-essential amino acids; TDAA: total delicious amino acids; BCAA: branched chain amino acid; AAA: aromatic amino acid.

### 3.3. Evaluation of muscle nutrition value

After converting the essential amino acid content data in Table 2, the results were compared respectively with the amino acid scoring criteria model recommended by FAO/WHO and the egg protein amino acid scoring model. The amino acid score (AAS), chemical score (CS) and the essential amino acid index (EAAI) are shown in Table 3. According to AAS and CS scoring criteria, the AAS (1.67) and CS (1.29) of Lys were all the highest. The first limiting amino acid is Ile and the second limiting amino acid is Val of *S. szechuanensis*. The essential amino acid index (EAAI) of *S. szechuanensis* is 89.65.

### Table 3. Evaluation of essential amino acids composition in muscle of *S. szechuanensis*

| Essential amino acids | S. szechuanensis | FAO/WHO | TEPA | AAS | CS |
|-----------------------|-----------------|---------|------|-----|----|
| Ile                   | 248             | 250     | 331  | 0.99| 0.75 |
| Leu                   | 508             | 440     | 534  | 1.15| 0.95 |
| Lys                   | 567             | 340     | 441  | 1.67| 1.29 |
| Thr                   | 265             | 250     | 292  | 1.06| 0.91 |
| Val                   | 313             | 310     | 410  | 1.01| 0.76 |
| Phe+Tyr               | 462             | 380     | 565  | 1.22| 0.82 |
| EAAI (Essential amino acids index) |         |         |    | 89.65|

### 4. Discussion

#### 4.1. The comparison of muscle composition of *S. szechuanensis* with that of other fishes

Nutritional composition of fish muscle is related to the species, age, size, sampling season and other factors of fish. From Table 4, we can see that the moisture content in muscle of *S. szechuanensis* is lower than that of *Paramisgurnus dabryanus*, *Mastacembelus armatus* and *Triplophysa siluroides*, slightly higher than that of other fishes. The protein content in muscle of *S. szechuanensis* is 18.38%,
which is higher than that of *Paramisgurnus dabryanus*, *Misgurnus anguillicaudatus*, *Mastacembelus armatus*, *Triplophysa siluroides* and *Triplophysa dalaica*. The ash content is lower than that of *Parabotia fasciata Dabry*, *Misgurnus anguillicaudatus* and *Mastacembelus armatus*, and the fat content was lower than that of *Paramisgurnus dabryanus*, *Mastacembelus aculeatus*, *Triplophysa siluroides* and *Ctenopharyngodon idellus*. The results indicated that the muscle of *S. szechuanensis* has high water content, low ash content, making the fish taste tender, and it belongs to relatively high-protein and low-fat food, which meets the dietary needs of people in modern society.

**Table 4. Comparison of approximate composition in muscle of *S. szechuanensis* with other fishes**

| Species                        | Moisture   | Crude protein | Crude fat | Crude Ash |
|--------------------------------|------------|---------------|-----------|-----------|
| *S. szechuanensis*             | 77.80      | 18.38         | 2.00      | 1.55      |
| *Parabotia fasciata Dabry*[6]   | 76.25      | 20.73         | 1.25      | 1.62      |
| *Paramisgurnus dabryanus*[7]    | 78.80      | 17.40         | 2.57      | 1.13      |
| *Misgurnus anguillicaudatus*[7] | 76.60      | 17.90         | 2.00      | 1.80      |
| *Mastacembelus aculeatus*[8]    | 76.74      | 21.42         | 2.66      | 1.49      |
| *Mastacembelus armatus*[8]      | 79.54      | 17.72         | 1.63      | 1.64      |
| *Sinibotia superciliaris*[9]    | 76.65      | 20.05         | 1.56      | 1.34      |
| *Triplophysa siluroides*[10]    | 81.04      | 16.98         | 2.14      | 1.13      |
| *Triplophysa dalaica*[11]       | 78.30      | 17.77         | 1.77      | 1.14      |
| *Carassius auratus*[12]         | 77.80      | 20.50         | 1.20      | 1.40      |
| *Ctenopharyngodon idellus*[12]  | 76.60      | 19.80         | 4.20      | 1.20      |

4.2. Composition of amino acids and evaluation of nutritional value of *S. szechuanensis*

The composition and content of amino acids is one of the important indicators for evaluating the nutritional composition of food. Proteins containing many kinds of essential amino acids and high content of amino acids have relatively high nutritional value. According to the ideal FAO/WHO model, when the TEAA/TAA value is about 40% and the TEAA/TNEAA value is more than 60% of a protein, it can be considered a high-quality protein. In this study, seven kinds of essential amino acids were detected in the muscle of *S. szechuanensis*, and the types of essential amino acids are abundant. The TEAA/TAA and TEAA/TNEAA values are 38.40% and 72.70%, respectively. Therefore, they can be considered to be high-quality protein. In the amino acid composition of *S. szechuanensis*, the top three amino acids are Glu, Asp and Lys, which are similar to those of *Mastacembelus armatus* [8] and *Triplophysa dalaica* [11].

According to AAS and CS scores, we can see that the content of Lys is the highest in the essential amino acids contented in the muscle of *S. szechuanensis*, and the first and second limiting amino acids are Ile and Val, respectively. The AAS scores of all kinds of essential amino acids in *S. szechuanensis* are all greater than 0.9, and CS scores all greater than 0.7, which indicates that the content of essential amino acids in *S. szechuanensis* is rich and its composition is relatively balanced. The essential amino acid index (EAAI) in muscles of *S.szechuanensis* is 89.65, which is higher than that of *Sinibottia reevesae* [14], *Mastacembelusaculeatus* [8], *Mastacembelusarmatus* [8], *Parabotiafasciata-Dabry* [6] and *Leptobotiaelongata*. It shows that *S. szechuanensis* has high nutritional value.

The flavor of food is mainly related to the composition and content of delicious amino acids (Asp, Glu, Gly, Ala), especially Glu and Asp, which have the strongest flavor. The total content of four kinds of delicious amino acids in the muscles of *S. szechuanensis* is 7.37%, accounting for 41.43% of the total amino acids, which is higher than that of *Triplophysa dalaica* [11] (38.40%), *Triplophysa siluroides* [10] (39.56%), *Sinibotia superciliaris* [9] (36.73%), *Parabotia fasciata Dabry* [6] (41.41%) and *Mastacembelus armatus* (37.51%). The content of Glu in the muscle of *S. szechuanensis* is the highest, followed by Asp, which is consistent with that of *Triplophysadalaica* [11], *Sinibotiasuperciliaris* [9], *Mastacembelusaculeatus* [8] and *Mastacembelusarmatus* [8] and other kinds of fish. It is concluded
that the content of delicious amino acids in *S. szechuanensis* is rich, which makes it have delicious taste. Branchedchain amino acids in food can reduce cholesterol and protect the liver. In this study, the ratio of branchedchain amino acids to aromatic amino acids in muscle of *S. szechuanensis* is 2.31, which is higher than that of *Triplophysasiliroides* [10] (2.24), *Mastacembelusarmatus* [8] (2.06) and *Mastacembelusaculeatus* [8] (2.17), lower than that of *Triplophysadalaica* [11] (2.48) and *Simbotiasuperciliaris* [9] (2.61), indicated that it could be used as a supplementary source of branchedchain amino acids.

5. Conclusion

The muscle of *S. szechuanensis* has high moisture content, low ash content and tender meat. It also has the characteristics of high-protein and low-fat composition, which belongs to high-quality protein. The content of amino acids and delicious amino acids in muscle of *S. szechuanensis* are abundant, and its composition ratio is reasonable, which makes it have delicious flavor and high nutritional value, and its development and utilization prospects are broad. However, due to environmental pollution, deterioration of water quality, human activities and other factors, the living environment of *S. szechuanensis* is deteriorating, and its wild resources are declining. We suggest that we should strengthen the research on *S. szechuanensis*, carry out artificial domestication and reproduction, develop suitable artificial feed according to its nutrient characteristics, and rationally develop and utilize *S. szechuanensis* resources to promote the healthy development of its resources.

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