*Forest Chemicals Review*
*www.forestchemicalsreview.com*
*ISSN: 1520-0191*
*March-April 2022 Page No. 211-222*
*Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022*

# Evaluation of Muscle Quality of *Monopterus Albus* from Different Sources

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***Abstract:***

Five kinds of *Monopterus albus* from different sources were used as research objects to study the differences of muscle nutrition and texture characteristics, and to evaluate the quality of *M. albus*, so as to provide reference for purchasing *M. albus*. The results showed that there were significant differences in crude fat content among the five different sources of *M. albus* ($P < 0.05$). The highest content was domesticated *M. albus*, and the lowest content was Chinese wild *M. albus*. There were no significant differences in water and crude fat content ($P > 0.05$). Among the 5 *M. albus*, there were 17 kinds of amino acids, among which, *M. albus* from Vietnam had the highest content of essential amino acids (7.95%), and *M. albus* from Bangladesh had the highest content of total amino acids (19.79%), with no significant difference in flavor amino acid amino acids ($P > 0.05$). All the five species of M. albus were in line with the high quality protein of FAO/WHO model. The contents of saturated fatty acids and polyunsaturated fatty acids were higher than those of domestic *M. albus*, and the content of monounsat urated fatty acids was significantly lower than that of domestic *M. albus* ($P < 0.05$). The hardness, masticability, elasticity and viscosity of wild *M. albus* in China were the highest, and its taste was the best. The results showed that the five different sources of *M. albus* had their own nutritional characteristics. By comprehensive comparison, the domesticated *M. albus* contained higher crude protein, complete amino acids, rich kinds of fatty acids, and taste similar to that of wild *M. albus*, and had higher edible value.

***Keywords****: Monopterus albus; Nutrients; Texture characteristics; Muscle quality*

*Monopterus albus*, which belongs to Monopterus of Synbranchidae of Synbranchi Form, is a freshwater benthic fish in warm temperate zone and tropical zone. *M. albus* tastes delicious and is called "ginseng in water". Its muscle is rich in amino acids, fatty acids, vitamins and mineral elements, and has high protein, low fat and low cholesterol. *M. albus* also has the functions of strengthening brain, promoting intelligence, invigorating qi and blood, diminishing inflammation, disinfecting and eliminating rheumatism, and has rich nutritional and medicinal value[1-2].

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Up to now, there are 6 species of Monopterus in the world, namely Mnopteru cuchia (Hamilton, 1822), M. fossorius (Nayar, 1952), *M. albus*(Zulew, 1793), M. "Indicus" (EAP en, 1963), *M. boueti* (Pellegrin, 1922) and *M.indicus* (Silas & Dawson, 1961). *M.albus* is distributed in China[3]. Monopterus albus is widely distributed in southeast Asia, including the Yangtze River basin and the Pearl River basin in China, and foreign countries such as Korea, Japan, Thailand, Indonesia, Malaysia, Philippines, Vietnam, Myanmar, India, Pakistan and Nepal[3-4]. As one of the origins of *M. albus*, Southeast Asia is easier to cultivate *M. albus* because of its geographical and climatic advantages and other advantages such as fewer diseases, more food, faster growth and low cost[5-7]. Under the situation that the wild *M. albus* resources in China are decreasing, the domesticated *M. albus* is in short supply. Under the high price in the long run, huge market opportunities have led to the influx of *M. albus* in Southeast Asia, M.cuchia and M. fossorius into China through different channels[8-9].

With the improvement of economy and people's demand for diversified life, higher requirements are put forward for the quality of aquatic products. The aquatic products should have good flavor and taste while ensuring safety and nutrition[10]. At present, there are few comparative studies on the nutritional components of muscle between the *M. albus* in southeast Asian and the *M. albus* in China. In this study, the muscle quality of the *M. albus* in southeast Asian and the *M. albus* in China was compared and evaluated, and the reasons for the differences were discussed, so as to provide reference for guiding market consumption.

## I. MATERIALS AND METHODS

### 1.1 Materials

Experimental materials: 100 Vietnam *M. albus* (200-300g/each) were collected in Huangsha market of Guangzhou; 205 Myanmar *M. albus* (200-300g/each) were collected in Huangsha Market, Guangzhou, Guangdong Province; 141 Bangladesh *M. albus* (200-300g/each), were collected in Huangsha Market, Guangzhou, Guangdong Province; 148 Chinese wild *M. albus* (200-300g/each) were collected in Monopterus albus breeding base in Zhanggou Town, Xiantao City, Hubei Province; 150 Chinese artificially cultured*M. albus* (200-300g/each) were collected in Monopterus albus breeding base in Zhanggou Town, Xiantao City, Hubei Province.

### 1.2 Experimental methods

#### 1.2.1 Determination of basic nutrients

Determination of basic nutritional components was carried out according to relevant national standards. The moisture content was determined by oven drying at 105℃ (refer to GB 5009.3-2016 *Determination of Moisture in Foods*); the crude protein content was determined by Kjeldahl method (refer to GB 5009.5-2010 *Determination of Protein in Food*"; the crude fat content was determined by Soxhlet extraction (refer to GB 5009.6-2016 *Determination of Fat in Foods*). The content of basic nutrients was calculated by fresh weight.

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1.2.2 Determination of amino acid content

The determination of amino acid content referred to GB 5009.124-2016 *Determination of Amino Acids in Foods*, and L-8900 amino acid automatic analyzer was used for determination. Amino acid content was calculated by fresh weight.

1.2.3 Determination of fatty acid content

The content of fatty acids was determined by using Agilent 7890A gas chromatograph according to GB 5009.168-2016 *Determination of Fatty Acids in Foods*. The fatty acid content was calculated by fresh weight.

1.2.4 Determination of muscle texture characteristics

The muscle tissue samples were cut into small pieces of 0.5×0.5×0.5cm, and compressed twice by TVT300XP type property analyzer. The probe was P-cy5s cylindrical, and the TPA mode was as follows: pre-test rate of 5mm/s, test rate of 1mm/s, post-test rate of 5mm/s, compression degree of 30%, trigger force of 10g and residence time of 5s. Each sample was measured in parallel for 6 times.

1.2.5 Data processing

SPSS22.0 was used for statistical analysis of experimental data, and the results were expressed as mean standard deviation (x±SD). Single factor analysis of variance and multiple comparisons among multiple sample means were performed. Different letters were used to show significant differences ($P<0.05$).

## II. RESULTS AND ANALYSIS

2.1 Conventional nutrients

From TABLE I shows that there is no significant difference in water (77.53%-78.67%) and crude protein (19.10%-19.76%) of *M. albus* from different sources ($P > 0.05$), but there is significant difference in crude fat content ($P < 0.05$). Among it, Chinese artificially cultured*M. albus* has the highest crude fat content of 7.93%. The next is Myanmar *M. albus*, which is 7.79%. The crude fat content of Vietnam *M. albus* and Bangladesh *M. albus* is 4.04% and 3.59% respectively, while the Chinese wild *M. albus* has the lowest fat, only 0.97%.

**TABLE I. Muscle essential nutrients of *M. albus* from different sources %**

| | Vietnam *M. albus* | Myanmar *M. albus* | Bangladesh *M. albus* | Chinese wild *M. albus* | Chinese artificially cultured*M. albus* |
|---|---|---|---|---|---|
| Moisture | 77.88±0.42 | 78.67±1.05 | 77.61±0.47 | 77.68±0.74 | 77.53±0.81 |
| Crude protein | 19.24±0.72 | 19.10±1.56 | 19.76±0.55 | 19.66±0.53 | 19.70±0.78 |

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| | | | | | |
|---|---|---|---|---|---|
| Crude fat | 4.04±0.46$^{bc}$ | 7.79±0.35$^{a}$ | 3.59±0.88$^{c}$ | 0.97±0.14$^{d}$ | 7.93±0.42$^{a}$ |

Note: different letters marked on data of the same line indicate significant differences (P<0.05), which is the same as the following table.

2.2 Amino acid content and evaluation

It can be seen from TABLE II that there are 17 kinds of amino acids in *M. albus* from different sources (tryptophan acidolysis is destroyed), among which there are 7 kinds of essential amino acids and 4 kinds of savory amino acids. There are significant differences in contents of essential amino acids and total amino acids of *M. albus* from different sources, but there is no significant difference in total amino acid content of flavor amino acid. In the total amino acid content, Bangladesh *M. albus* has the highest content (19.79%), followed by Vietnam *M. albus* (19.66%), Myanmar *M. albus* (18.79%) and Chinese artificially cultured*M. albus* (18.53%), and Chinese wild *M. albus* (17.60%) has the lowest content. In the total content of essential amino acids, Bangladesh *M. albus* has the highest content (8.17%), which is significantly higher than Myanmar *M. albus* (7.60%), Chinese artificially cultured*M. albus* (7.19%) and Chinese wild *M. albus* (6.79%). And there is no significant difference with Vietnam *M. albus* (7.95%). Among it, the contents of Thr, Ala and Arg are not significantly different (P > 0.05), but the other 14 amino acids are significantly different (P < 0.05). The amino acid content of *M. albus* from different sources shows the same trend, with Glu being the highest (3.08~2.79%), followed by Asp(2.00~1.84%), Lys(1.99~1.54%) and Leu(1.83~1.45%), and Cys (0.39) being the lowest. According to the ideal model of FAO/WHO, the ∑EAA/∑TAA of protein with good quality is about 40%, and ∑EAA/∑NEAA is over 60%. The results show that ∑EAA/∑TAA and ∑EAA/∑NEAA from five different sources all conform to the high-quality protein of FAO/WHO model and have high nutritional value in protein.

**TABLE II. The amino acid composition and content of *M. albus* from different sources %**

| Amino acid species | Vietnam *M. albus* | Myanmar *M. albus* | Bangladesh *M. albus* | Chinese wild *M. albus* | Chinese artificially cultured*M. albus* |
|---|---|---|---|---|---|
| Asp◆ | 1.98±0.09$^{ab}$ | 1.88±0.04$^{ab}$ | 2.00±0.08$^{a}$ | 1.84±0.07$^{b}$ | 1.95±0.16$^{ab}$ |
| Thr* | 0.92±0.05$^{a}$ | 0.87±0.01$^{a}$ | 0.92±0.04$^{a}$ | 0.87±0.04$^{a}$ | 0.94±0.09$^{a}$ |
| Ser | 0.81±0.03$^{a}$ | 0.77±0.01$^{ab}$ | 0.80±0.03$^{ab}$ | 0.75±0.03$^{b}$ | 0.82±0.08$^{a}$ |
| 谷 lu◆ | 2.99±0.14$^{ab}$ | 2.85±0.06$^{ab}$ | 3.07±0.12$^{a}$ | 2.79±0.12$^{b}$ | 3.08±0.30$^{a}$ |

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*ISSN: 1520-0191*
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| | | | | | |
|---|---|---|---|---|---|
| Gly◆ | 1.18±0.17$^{a}$ | 1.12±0.08$^{ab}$ | 1.05±0.04$^{ab}$ | 1.08±0.04$^{ab}$ | 0.99±0.10$^{b}$ |
| Ala◆ | 1.20±0.04$^{ab}$ | 1.14±0.03$^{a}$ | 1.19±0.04$^{ab}$ | 1.22±0.05$^{a}$ | 1.21±0.09$^{ab}$ |
| Cys | 0.28±0.02$^{b}$ | 0.29±0.03$^{b}$ | 0.39±0.04$^{a}$ | 0.15±0.01$^{c}$ | 0.24±0.07$^{b}$ |
| Val* | 0.94±0.05$^{a}$ | 0.90±0.02$^{a}$ | 0.94±0.03$^{a}$ | 0.80±0.04$^{b}$ | 0.89±0.05$^{a}$ |
| Met* | 0.41±0.03$^{b}$ | 0.40±0.03$^{b}$ | 0.51±0.05$^{a}$ | 0.38±0.03$^{b}$ | 0.37±0.10$^{b}$ |
| Ile* | 1.05±0.05$^{a}$ | 1.00±0.02$^{a}$ | 1.05±0.05$^{a}$ | 0.85±0.03$^{c}$ | 0.91±0.05$^{b}$ |
| Leu* | 1.76±0.10$^{ab}$ | 1.69±0.04$^{bc}$ | 1.83±0.07$^{a}$ | 1.45±0.06$^{d}$ | 1.62±0.13$^{c}$ |
| Tyr | 0.74±0.05$^{a}$ | 0.72±0.02$^{a}$ | 0.65±0.23$^{ab}$ | 0.62±0.02$^{ab}$ | 0.50±0.20$^{b}$ |
| Phe* | 0.94±0.04$^{a}$ | 0.89±0.03$^{a}$ | 0.94±0.03$^{a}$ | 0.91±0.04$^{a}$ | 0.80±0.05$^{b}$ |
| Lys* | 1.93±0.10$^{ab}$ | 1.85±0.04$^{b}$ | 1.99±0.06$^{a}$ | 1.54±0.11$^{c}$ | 1.67±0.11$^{c}$ |
| His | 0.54±0.02$^{ab}$ | 0.52±0.02$^{bc}$ | 0.51±0.02$^{bc}$ | 0.50±0.03$^{c}$ | 0.56±0.03$^{a}$ |
| Arg | 1.30±0.04$^{a}$ | 1.25±0.04$^{a}$ | 1.30±0.05$^{a}$ | 1.23±0.04$^{a}$ | 1.25±0.11$^{a}$ |
| Pro | 0.70±0.06$^{ab}$ | 0.66±0.03$^{bc}$ | 0.66±0.02$^{bc}$ | 0.62±0.03$^{c}$ | 0.74±0.07$^{a}$ |
| ∑EAA | 7.95±0.37$^{ab}$ | 7.60±0.16$^{bc}$ | 8.17±0.27$^{a}$ | 6.79±0.25$^{d}$ | 7.19±0.45$^{cd}$ |
| ∑NEAA | 12.45±0.35$^{a}$ | 11.90±0.26$^{ab}$ | 12.42±0.41$^{a}$ | 11.12±0.38$^{b}$ | 11.80±0.93$^{ab}$ |
| ∑DAA | 7.34±0.19$^{a}$ | 6.99±0.16$^{a}$ | 7.30±0.24$^{a}$ | 6.93±0.23$^{a}$ | 7.22±0.56$^{a}$ |
| ∑TAA | 19.66±0.62$^{ab}$ | 18.79±0.39$^{abc}$ | 19.79±0.63$^{a}$ | 17.60±0.59$^{c}$ | 18.53±1.34$^{bc}$ |
| ∑EAA/∑TAA (%) | 40.44 | 40.45 | 41.28 | 38.60 | 38.80 |
| EAA/NEAA (%) | 63.86 | 63.87 | 65.78 | 61.06 | 60.93 |
| ∑DAA/∑TAA (%) | 37.33 | 37.20 | 36.89 | 39.38 | 38.96 |

Note: ◆ refers to flavor amino acid amino acid; * refers to an essential amino acid; ∑EAA is the total

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amount of essential amino acids; ∑NEAA is the total amount of nonessential amino acids; ∑DAA is the total amount of flavor amino acid amino acid; ∑TAA is the total amount of all amino acids.

2.4 Fatty acid content and cluster analysis

As can be seen from TABLE III, the *M. albus* from Vietnam, Myanmar and Bangladesh all contain 10 kinds of fatty acids. There are 19 species of wild *M. albus* in China and 17 species of domesticated *M. albus* in China. The fatty acids of domestic *M. albus* are richer than those from foreign countries. The total saturated fatty acids and polyunsaturated fatty acids of *M. albus* from three Southeast Asian countries are higher than those of two domestic *M. albus*. The total saturated fatty acid content of Vietnam *M. albus* (38.55%) is significantly higher than that of Chinese wild *M. albus* (32.51%) and Chinese artificially cultured*M. albus* (33.04%). There is no significant difference with Myanmar *M. albus* (35.64%) and Bangladesh *M. albus* (36.02%). Among the polyunsaturated fatty acids, Bangladesh has the highest content (41.58%), followed by Myanmar *M. albus* (35.64%), Vietnamese *M. albus* (35.92%) and domestic *M. albus* (31.52%). The wild *M. albus* in China has the lowest content (23.04%). Besides, the wild *M. albus* in China has the highest content of monounsaturated fatty acids (41.00%), which is significantly higher than that in Chinese artificially cultured*M. albus* (33.04%) and overseas *M. albus*. Compared with Chinese artificially cultured *M. albus*, the Chinese wild *M. albus* has additional two kinds of fatty acids, C14:1 and arachidonic acid. Compared with *M. albus* from foreign countries, it has additional nine kinds of fatty acids, C14:1, C15:1n5, C17:ln7, linolenic acid, Arachidic acid C20:0,C20:1, C20:2, C20:3n6 and timnodonic acid. Among the five species of *M. albus* from different sources, the Chinese artificially cultured*M. albus* has the highest content of n-3 polyunsaturated fatty acid, accounting for 14.35%, while that in Chinese wild *M. albus* is the lowest, accounting for 6.95%. There is no significant difference in the total content of n-6 unsaturated fatty acids in three kinds of *M. albus* from abroad, but they are all significantly higher than those in China. The fatty acid contents of *M. albus* from different sources are quite different. The domestic *M. albus* has the highest oleic acid content. The Vietnam *M. albus* has the highest palmitic acid. And Myanmar and Bangladesh *M. albus* has the highest arachidonic acid content.

**TABLE III. Fatty acid composition and content of *M. albus* from different sources (%)**

| Fatty acid type | Vietnam *M. albus* | Myanmar *M. albus* | Bangladesh *M. albus* | Chinese wild *M. albus* | Chinese artificially cultured *M. albus* |
|---|---|---|---|---|---|
| C14:0 | 1.59±0.26 [a] | 1.25±0.51 [ab] | 1.50±0.51 [a] | 1.26 ±0.57 [a] | 1.65 ±0.19[ac] |
| C14:1 | - | - | - | 0.11±0.06 | - |
| C15:0 | 0.85±0.39 [a] | 0.92±0.56 [a] | 0.86±0.19 [a] | 0.23±0.10[b] | 0.49±0.09 [ab] |
| C15:1n5 | - | - | - | 1.87±0.3 | 2.55±0.86 |

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|---|---|---|---|---|---|
| C16:0 | 21.75±3.42[a] | 19.55±1.64[a] | 19.04±1.84[a] | 20.05±2.665[a] | 21.55±1.36[a] |
| C16:1n7 | 2.84±1.69[b] | 2.98±1.63[b] | 2.26±1.72[b] | 5.57±1.74[a] | 5.68±1.40[a] |
| C17:0 | 1.56±0.40[a] | 1.59±0.17[a] | 1.58±0.09[a] | 0.32±0.10[c] | 0.76±0.13[b] |
| C17:ln7 | - | - | - | 1.04±0.06 | 0.68±0.35 |
| C18:0 | 12.80±1.85[a] | 12.61±0.83[a] | 13.03±0.93[a] | 10.51±0.63[b] | 8.58±1.10[b] |
| C18:ln9t | 18.19±5.19[bc] | 15.41±2.21[c] | 14.76±2.43[c] | 30.67±4.70[a] | 21.75±3.18[b] |
| C18:2n6t | 9.97±2.06[a] | 9.26±3.23[a] | 10.90±2.02[a] | 11.61±5.11[a] | 10.33±2.73[a] |
| C18:3n6 | - | - | - | 0.55±0.15[b] | 2.08±0.70[a] |
| C20:0 | - | - | - | 0.14±0.05 | - |
| C20:1 | - | - | - | 1.74±0.28[a] | 1.01±0.25[b] |
| C20:2 | - | - | - | 0.28±0.11[b] | 0.52±0.13[a] |
| C20:3n6 | - | - | - | 0.20±0.03[b] | 0.46±0.10[a] |
| C20:4n6 | 18.22±6.34[a] | 20.88±3.02[a] | 20.17±1.73[a] | 3.46±2.07[b] | 3.78±0.87[b] |
| C20:5n3 | - | - | - | 3.33±0.78 | 3.28±1.07 |
| C22:6n3 | 7.74±2.43[ab] | 9.40±3.45[a] | 10.51±4.90[a] | 3.62±1.08[b] | 11.06±2.72[a] |
| Saturated fatty acid∑SFA | 38.55±2.89[a] | 35.64±0.86[ab] | 36.02±0.90[ab] | 32.51±2.71[b] | 33.04±2.06[b] |
| Monounsaturated fatty acid ∑MUFA | 21.04±6.29[c] | 18.33±2.93[c] | 17.02±3.10[c] | 41.00±5.02[a] | 31.66±3.82[b] |
| n-3 fatty acid ∑n-3PUFA | 7.74±2.25[b] | 9.57±3.43[ab] | 10.51±4.00[ab] | 6.95±1.52[b] | 14.35±3.49[a] |
| n-6 fatty acid∑n-6PUFA | 28.19±6.33[a] | 30.43±2.39[a] | 31.07±0.78[a] | 15.81±5.97[b] | 16.65±3.14[b] |

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|---|---|---|---|---|---|
| Polyunsaturated fatty acid ∑PUFA | 35.92±8.30[a] | 40.00±4.46[a] | 41.58±3.55[a] | 23.04±7.13[b] | 31.52±4.63[ab] |

Note:- indicates that it is not detected.

Ten kinds of fatty acids (C14:1, C15:0, palmitic acid, C16:1n7, C17:0, stearic acid, oleic acid, linoleic acid, arachidonic acid and docosahexaenoic acid) contained in both domestic *M. albus* and *M. albus* from Southeast Asia were selected for cluster analysis. Seen from Figure 1, among *M. albus* from three South Asia countries, *M. albus* from Bangladesh and Myanmar has close genetic relationship. Domestic *M. albus* has distant genetic relationship with *M. albus* from Vietnam, Myanmar and Bangladesh.

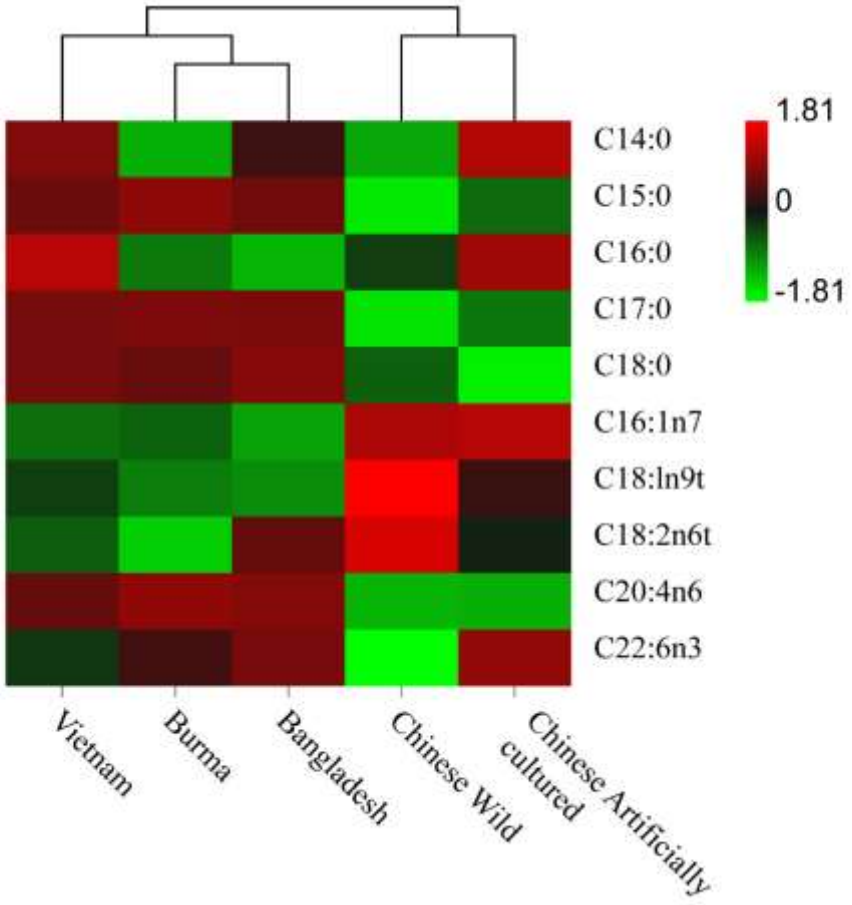


Fig. 1 Cluster analysis of fatty acids of *M. albus* in different areas

2.4 Comparison of texture characteristics of *M. albus* from different sources

From TABLE IV, it can be seen that there is significant difference in the texture characteristics of muscle of *M. albus* from five different sources, except cohesion. The hardness (1486.77g), chewiness (798.02g), elasticity (0.78mm) and viscosity (1009.42g) of Chinese wild *M. albus*are the highest, and they are significantly higher than those of Myanmar *M. albus*. Vietnam *M. albus* has the highest resilience

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(0.64), significantly higher than those of Bangladesh *M. albus* (0.53), Myanmar *M. albus* (0.54) and Chinese artificially cultured*M. albus* (0.59), and similar to Chinese wild *M. albus* (0.63).

**TABLE IV. Muscle texture characteristics of *M. albus* from different sources**

| Species of *M. albus* | Vietnam *M. albus* | Myanmar *M. albus* | Bangladesh *M. albus* | Chinese wild *M. albus* | Chinese artificially cultured *M. albus* |
|---|---|---|---|---|---|
| Hardness /g | 1386.00±201.66$^{a}$ | 1310.71±27 7.46$^{ab}$ | 1055.73±203.86$^{c}$ | 1486.77±215.51$^{a}$ | 1376.44±157.49$^{a}$ |
| Chewiness/g | 720.17±251.30$^{a}$ | 697.24±335.66$^{ab}$ | 472.14±161.66$^{c}$ | 798.02±277.83$^{a}$ | 667.86±143.55$^{ab}$ |
| Elasticity /mm | 0.72±0.18$^{a}$ | 0.71±0.16$^{ab}$ | 0.65±0.17$^{b}$ | 0.78±0.16$^{a}$ | 0.70±0.06$^{ab}$ |
| Viscosity/g | 984.77±185.25$^{a}$ | 935.47±243.84$^{a}$ | 728.47±174.92$^{b}$ | 1009.42±218.33$^{a}$ | 949.11±153.11$^{a}$ |
| Recovery | 0.64±0.07$^{a}$ | 0.53±0.09$^{b}$ | 0.54±0.07$^{b}$ | 0.63±0.06$^{a}$ | 0.59±0.08$^{ab}$ |
| Coherence | 0.71±0.06 | 0.71±0.05 | 0.69±0.06 | 0.68±0.07 | 0.69±0.05 |

## III. DISCUSSION

3.1 Basic nutrients

Basic nutritional ingredients are important criteria to measure nutritional value and quality[12]. Individual size, production speed, growth stage and growth environment are the factors that affect the protein and fat content of fish muscle[2, 13]. The crude fat content of Chinese wild *M. albus* is significantly lower than that of *M. albus* from other sources. The main reason may be that the wild *M. albus* has limited growth space and activity larger than that of domesticated *M. albus*. As a result, the crude fat of the wild *M. albus* is not easy to accumulate. However, in Southeast Asia, because of the seasonal climate, the temperature is high, and the bait organisms of *M. albus* are abundant[14]. So, the *M. albus* from South Asia has higher fat content in the body than that of Chinese wild *M. albus*. However, the sufficient feeding, high breeding density and low activity of Chinese artificially cultured*M. albus* lead to the higher fat accumulation in the body.

*Forest Chemicals Review*
*www.forestchemicalsreview.com*
*ISSN: 1520-0191*
*March-April 2022 Page No. 211-222*
*Article History: Received: 08 February 2022, Revised: 10 March 2022, Accepted: 02 April 2022, Publication: 30 April 2022*

3.2 Amino acid

The nutritional value of protein is determined by the composition of amino acids and the content of essential amino acids, among which essential amino acids are of great significance to maintain the normal activities of life[15-16]. Among the *M. albus* from five different sources, the Bangladesh *M. albus* has the highest content of essential amino acids (8.17%) and total amino acids (19.79%), with the highest nutritional value in protein. Vietnam *M. albus* has the highest content of savory amino acids (7.34%), and its taste is better than other *M. albus*. The amino acid content of Chinese wild *M. albus* is lower than that of other *M. albus*, and its protein nutritional value is the lowest, which may be due to the lack of high-quality protein sources in the living environment[17].

3.3 Fatty acid

Fatty acid is an important chemical component of fat, and it is also an indispensable nutrient to maintain normal physiological function of cells. There are many reasons for the difference of types and contents of fatty acids in *M. albus*. They are not only influenced by genetic factors, but also related to the production stage, breeding environment, overwintering and fat sources in feed. Therefore, the difference in fatty acids of *M. albus* from different sources in this study may be caused by different baits obtained in living environment. Studies have shown that adding high-quality fat source to feed can increase the content of fatty acids in *M. albus* tissues and improve its nutritional value[18-22]. The results show that there are obvious differences in fatty acid types between foreign and domestic *M. albus*. The two domestic *M. albus* are richer in fatty acid types than foreign *M. albus*, containing linoleic acid, linolenic acid, EPA(C20:5n3) and DHA(C22:6n3), while foreign *M. albus* only contains linoleic acid. *M. albus* abroad has great advantages in the total amount of saturated fatty acids and polyunsaturated fatty acids. Among the two kinds of domestic *M. albus*, wild *M. albus* is richer in fatty acids than domesticated *M. albus*, but SFA:MUFA:PUFA in domesticated *M. albus* is close to 1:1:1, which is more in line with the ideal dietary fatty acid composition for human body. The domesticated *M. albus* has higher nutritional value of fatty acids than wild *M. albus*.

3.4 Texture characteristics

Texture characteristics, as one of the elements of food quality, is an important basis for meat taste evaluation. Elasticity simulates the behavior of fish in the mouth[23]. The greater the elasticity is, the more brittle the meat is. Muscles with higher hardness and elasticity will also have better taste. Studies have shown that *M. albus* in the wild environment has higher tenderness, hardness, elasticity and chewiness, which is consistent with the results of this study. The reason may be that the wild *M. albus* wanders around to get enough food, which makes its meat taste better than other *M. albus*.

## IV. CONCLUSION

Chinese artificially cultured*M. albus* and Myanmar *M. albus* have high fat content and good flavor,

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while Chinese wild *M. albus*, Bangladesh *M. albus* and Myanmar *M. albus* have the nutritional characteristics of high protein and low fat. The *M. albus* from five different sources all conform to the high-quality protein of FAO/WHO model. The essential amino acid content of the three overseas *M. albus* is higher than that of the domestic *M. albus*, and there is no significant difference in flavor. The fatty acid composition ratio of three kinds of *M. albus* abroad does not meet the ideal dietary fatty acid for human body, but the fatty acid types and contents of two kinds of domestic *M. albus* are abundant. The muscle taste of Chinese wild *M. albus* is the best, and there is no significant difference with Chinese artificially cultured*M. albus*, Vietnam *M. albus* and Myanmar *M. albus*. On the whole, Chinese artificially cultured *M. albus* can not only supplement nutrients, but also provide better flavor and taste.

## ACKNOWLEDGMENTS

This work was supported by Central Public-interest Scientific Institution Basal Research Fund, CAFS (NO.2021TD74), and Modern Agricultural Industry Technology System (CARS-46).

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