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ХАРЧОВА ТА БІОЛОГІЧНА ЦІННІСТЬ БІЛОГО АМУРА *(CTENOPHARYNGODON IDELLA)* ЯК СИРОВИНИ ДЛЯ ПРОДУКТІВ ЗДОРОВОГО ХАРЧУВАННЯ

Лі Сюй
Аспірант, викладач
https://orcid.org/0009-0000-3762-1714
Університет Бенгбу
233030, дорога Каошань, м. Бенгбу, провінція Аньхой, Китай
Аліна Анатоліївна Менчинська
Кандидат технічних наук, доцент
https://orcid.org/0000-0001-8593-3325
Національний університет біоресурсів і природокористування України
03041, вул. Героїв Оборони, 15, м. Київ, Україна

Анотація. У статті теоретично обґрунтовано та експериментально підтверджено доцільність використання білого амура (Ctenopharyngodon Idella) для виготовлення рибних продуктів здорового харчування. Актуальність дослідження обумовлена необхідністю використання доступних джерел рибної сировини для виготовлення продуктів, що відповідають сучасним тенденціям ринку. Мета статті - підтвердити харчові переваги білого амура, оцінити його потенціал застосування у розробці здорових продуктів харчування та надати рекомендації щодо високоцінного використання ресурсів прісноводних риб. У статті розглянуто споживчі властивості, хімічний склад, біологічну цінність та корисні характеристики білого амура, як інгредієнта для здорового харчування. На основі аналізу літературних джерел встановлено, що білий амур багатий на білок високої біологічної цінності, має низький вміст насичених жирів та містить поліненасичені жирні кислоти (ПНЖК), вітаміни, мінерали. Результати досліджень органолептичних показників показали, що білий амур має ніжне м'ясо, мало міжм'язових кісток та легкий рибний запах, демонструє добру технологічну адаптацію та високий вихід їстівних частин. За результатами дослідження хімічного складу м'яса білого амуру встановлено низький вміст жиру (0,96%), високий вміст білка (19,64%), високий вміст вологи (79,38%). Дослідження амінокислотного складу показали, що білок білого амуру не тільки повноцінний, але й має амінокислотний склад близький до ідеального для людського організму. Домінуючими амінокислотами є лізин, валін та гістидин. За результатами дослідження мінерального складу встановлено, що білий амур є джерелом кальцію, фосфору, калію, магнію, селену для організму людини. Системний аналіз результатів досліджень засвідчив, що регулярне споживання білого амуру допомагає знизити ризик серцево-судинних захворювань, покращує ліпідний обмін, підтримує нормальну масу тіла та рівень цукру в крові, а також позитивно впливає на імунну функцію, ріст і розвиток дітей та здоров'я зору у людей похилого віку.

Ключові слова: прісноводна риба, хімічний склад, вітаміни, мінерали, амінокислотний склад.

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NUTRITIVE AND BIOLOGICAL VALUE OF WHITE AMURAL (*CTENOPHARYNGODON IDELLA*) AS A RAW MATERIAL FOR HEALTHY FOOD PRODUCTS

Li Xu
Postgraduate Student, Lecturer
https://orcid.org/0009-0000-3762-1714
Bengbu University
233030, Caoshan Road, Bengbu, Anhui Province, China
Alina Menchynska
PhD in Technical Sciences, Associate Professor
https://orcid.org/0000-0001-8593-3325
National University of Life and Environmental Sciences of Ukraine
03041, 15 Heroiv Oborony Str., Kyiv, Ukraine

Abstract. The article theoretically substantiates and experimentally confirms the feasibility of using grass carp (Ctenopharyngodon Idella) for the production of healthy fish products. The relevance of the study is due to the need to use available sources of fish raw materials to manufacture products that meet modern market trends. The aim of the article is to confirm the nutritional benefits of grass carp, assess its potential for use in the development of healthy food products, and provide recommendations for the high-value use of freshwater fish resources. The article examines the consumer properties, chemical composition, biological value, and beneficial characteristics of grass carp as an ingredient for healthy eating. Based on an analysis of literature sources, it was found that grass carp is rich in protein of high biological value, has a low content of saturated fats, and contains polyunsaturated fatty acids (PUFA), vitamins, minerals. The results of organoleptic studies showed that grass carp has tender meat, few intermuscular bones, and a light fishy odor, demonstrating good technological adaptation and a high yield of edible parts. The results of the study of the chemical composition of the grass carp meat showed low fat content (0.96%), high protein content (19.64%), and high moisture content (79.38%). Studies of the amino acid composition have shown that the grass carp protein is not only complete, but also has an amino acid composition close to the ideal for the human body. The dominant amino acids are lysine, valine, and histidine. According to the results of the study of the mineral composition, it was found that the grass carp is a source of calcium, phosphorus, potassium, magnesium, selenium for the human body. A systematic analysis of the research results showed that regular consumption of grass carp helps reduce the risk of cardiovascular diseases, improves lipid metabolism, maintains normal body weight and blood sugar levels, and also has a positive effect on immune function, growth and development of children, and vision health in the elderly.

Keywords: freshwater Fish, chemical composition, vitamins, minerals, amino acid composition.

INTRODUCTION. With the growing global demand for healthy diets, developing foods rich in nutrients, low in fat, and with balanced macro- and micronutrient compositions has become a hotspot in food science research.

The international scientific literature emphasizes the importance of fish and fish products in the formation of healthy diets due to their high content of complete proteins, vitamins D, B_{12}, minerals, including selenium, zinc and iodine, and polyunsaturated fatty acids of the ω-3 group (Calder, 2020).

Regular fish consumption is associated with a reduced risk of cardiovascular disease, normalization of blood lipid profiles, maintenance of cognitive functions, and optimization of metabolic processes in the body (Mohanty et al., 2021). New studies demonstrate the positive impact of fish consumption on reducing inflammation and preventing metabolic syndrome (Shahidi & Ambigaipalan, 2019).

Among freshwater fish species, grass carp (Ctenopharyngodon idella) is of significant scientific and practical interest. This fish is widely cultivated worldwide, in countries with developed and transitional fisheries.

China is the world's largest freshwater aquaculture country. As one of the "Four Major Chinese Carps," grass carp has an annual production exceeding 5.5 million tons, constituting a significant

proportion of China's freshwater fish supply. Grass carp, primarily fed with plant-based feed, grows rapidly, has low production costs, and high yield, making it one of the most common fish on the dining table (FAO, 2022; Tran et al., 2022).

Recently, with rising consumer trends towards "high-protein, low-fat, functional foods," the nutritional value of grass carp and its role in healthy diets have garnered increasing attention.

Grass carp meat is characterized by a favorable amino acid profile, high biological value of protein and moderate fat content, which makes it a promising raw material for healthy food products (Zhou et al., 2020). The lipid profile of grass carp includes unsaturated fatty acids, with a significant proportion of PUFA, which are involved in anti-inflammatory and cardioprotective processes (Zhang et al., 2021). In addition, the fish contains B vitamins, as well as phosphorus, potassium, calcium and magnesium, which play an important role in maintaining energy metabolism and functioning of the nervous system. This determines the high value of grass carp as a raw material for the creation of health and preventive products (Wang et al., 2023).

Modern research focuses on the prospects of processing grass carp for the production of dietary and functional food products (Tran et al., 2022). Given the growing demand for these products, it is important to study in-depth the nutrient composition of grass carp and substantiate the possibilities of its use in the production of innovative fish products.

The aim of the work is a comprehensive study of the nutritional and biological value of grass carp (*Ctenopharyngodon idella*) as a promising raw material for the production of healthy food products, with an assessment of its nutrient composition, biologically active components and potential advantages in the formation of health and preventive diets.

Research objectives:

- determine the organoleptic characteristics of grass carp;
- determine the chemical composition of grass carp meat, including the content of proteins, fats, minerals and moisture;
- assess the amino acid composition of grass carp proteins and their biological value;
- determine the mineral content in the meat of the grass carp;
- substantiate the feasibility of using grass carp in the production of healthy food products and possible technological directions for its processing.

Based on domestic and international research, this review comprehensively summarizes the advantages of grass carp from aspects of nutritional composition, physicochemical properties, and health functional effects, providing a scientific basis for the future development of high-value grass carp food products.

MATERIALS AND METHODS. This study used live Chinese grass carp. The grass carp, captured in autumn, originated from Longzi Lake, Bengbu City, China.

Sensory quality evaluation was conducted according to DSTU 2284:2010 "Live Fish. General Technical Requirements."

Chemical composition was analyzed using standard methods. The mass fraction of moisture was determined by drying samples in an SNOL drying oven (Ansheng Company, China) at 100–105°C to constant weight, referencing DSTU 8029:2015. The mass fraction of ash was determined by incinerating samples in a muffle furnace (Ansheng Company, China) at 500–600°C, followed by gravimetric analysis, referencing DSTU 8718:2017. The mass fraction of lipids was determined using a SOX 406 fat extraction unit via Soxhlet extraction-gravimetric method, referencing DSTU 8718:2017. The mass fraction of protein was determined by measuring total nitrogen content using the Kjeldahl method, based on the ability of organic matter in the product sample to be oxidized by concentrated sulfuric acid in the presence of a catalyst (compliant with DSTU 8030:2015), with sample ashing performed in a DK6 digester (Velp). Distillation was carried out using a UDK 129 steam distillation unit (Velp) equipped with a JP vacuum pump. The mass fraction of amino acids was determined by ion-exchange liquid column chromatography on an automatic analyzer T 339

manufactured by "Mikrotechna" (Czech Republic), and tryptophan by colorimetric method with prior alkaline hydrolysis.

Potassium (K) and Sodium (Na) were determined according to GB/T 5009.91-2003 using flame emission spectrometry with a flame emission photometer (Shanghai Jingke, China). Phosphorus (P) was determined according to GB/T 5009.87-2003 (Method 1) using spectrophotometric colorimetric analysis with a visible spectrophotometer (Shanghai Jingke, China). Calcium (Ca) was determined according to GB/T 5009.92-2003, while Iron (Fe), Manganese (Mn), and Magnesium (Mg) were determined according to GB/T 5009.90-2003, all using atomic absorption spectrophotometry with an atomic absorption spectrophotometer (Shanghai Spectrum, China). Zinc (Zn) and Copper (Cu) were determined using atomic absorption spectroscopy according to GB/T 5009.14-2003 and GB/T 5009.13-2003 (flame method), respectively. Selenium (Se) was determined following GB 5009.93-2010 using a hydride generation-atomic fluorescence spectrometer (Shanghai Spectrum, China).

RESULTS AND DISCUSSION. The quality of fish raw material and consumer acceptance depend on its sensory indicators. Table 1 presents the sensory evaluation results for the quality of live chinese grass carp.

Table 1. Sensory characteristics of live grass carp

Indicators	Requirement
Fish Condition	A fish exhibiting signs of life: natural movement of body, lower jaw, fins, gill covers, and swimming with its back up. It is healthy, showing no signs of disease.
Skin	Firm flesh, natural color characteristic of this fish type, and tightly adhering to the muscle. No damage.
Fins	Natural shape and color, smooth fin edges.
Gills	Surface covered with a viscous, clear, transparent mucus. Color is bright pink or light red, without a mosaic pattern.
Eyes	Cornea typically convex, cornea transparent, iris color varies according to fish species.
Abdomen	Shape characteristic of this fish type, not bulging, not sunken, not damaged, without spots.
Anus	Not swollen, without obvious redness. Closed tightly, no fluid discharge.
Muscle Tissue	Texture dense, elastic. Indentation formed under pressure recovers quickly and completely, difficult to separate from bones, cross-section appears greyish-white.
Viscera (upon autopsy)	Clearly visible, easily separable from each other, odorless.
Olfactory & Taste	Characteristic of live fish, no off-odors. After cooking, the fish's odor and taste conform to the typical characteristics of this fish type, without a pronounced fishy odor. No muddy, putrid, gasoline, acetone, or other foreign odors. The broth is clear and transparent, with a few drops of oil floating on the surface.
Color	Characteristic natural dark grey of this fish.

Source: Developed by the authors based on DSTU 2284:2010.

Data in Table 1 indicate that all indicators meet the established requirements, confirming the good quality of the raw material. Chinese grass carp has no pronounced fishy odor, making it suitable for use in various products and dishes.

From a nutritional perspective, the nutritional value of grass carp is very prominent, with its high protein content making it one of the high-quality animal protein sources. Research shows that grass carp flesh has a very high moisture content, typically around 80%, indicating it is a low-calorie,

high-moisture food. High moisture not only gives the grass carp flesh a tender and juicy texture but also makes it easier to maintain softness during cooking, resulting in a more delicate mouthfeel. More importantly, high moisture implies lower energy density; consuming the same weight of grass carp is more satiating compared to high-fat, high-protein but lower-moisture foods, while the calorie intake is relatively lower, aligning well with the "low-energy, high-nutrition" concept in modern healthy diets.

The crude protein content of grass carp is also considerable. For instance, various studies report white muscle protein content in grass carp reaching approximately 17–19% (Wang et al., 2022; Dong et al., 2022). These proteins are complete, containing all essential amino acids for humans. Short muscle fibers and low connective tissue content contribute to high digestibility and bioavailability. High-quality fish protein is crucial for tissue repair, growth, maintenance of immune function, and the synthesis of various enzymes/hormones. It is particularly suitable for children, pregnant women, athletes, and individuals in recovery or convalescence. Furthermore, the crude fat content of grass carp is very low. Some studies report crude fat levels as low as approximately 1% or less. This extremely low fat content makes it an ideal ingredient for weight management, cardiovascular disease prevention, and dietary plans for metabolic diseases such as diabetes.

More importantly, this small amount of fat is not "unhealthy fat" but possesses significant qualitative advantages: the fat of grass carp has a relatively high proportion of unsaturated fatty acids, including the health-beneficial Omega-3 series fatty acids (Wang et al., 2022). These unsaturated fatty acids have anti-inflammatory and lipid-regulating effects and are essential for brain development and vision health.

Therefore, with its nutritional structure of "low total fat, high-quality fatty acids, high protein, high moisture," as shown in Figure 1, grass carp maximizes health benefits. It is precisely these nutritional characteristics that make grass carp a very ideal animal-based food choice for people concerned about a healthy lifestyle.

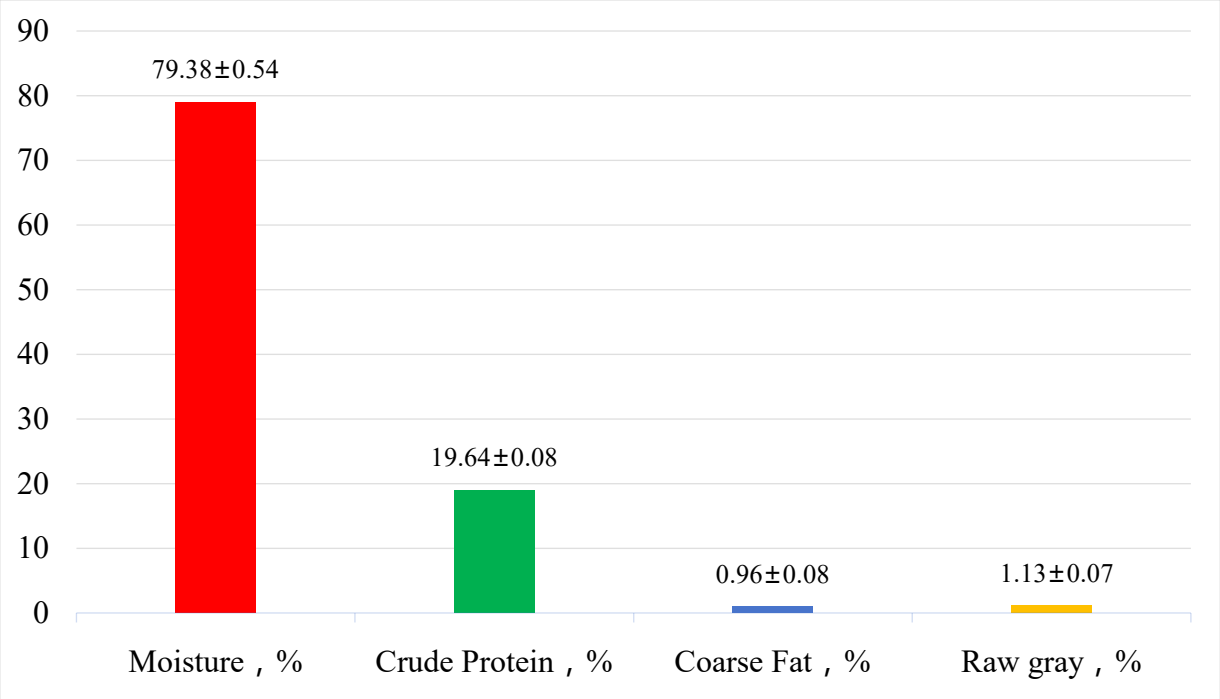

Figure 1. Chemical composition of grass carp

Source: Developed by the authors.

Grass carp protein is not only complete in type but also has an amino acid composition close to the ideal pattern required by the human body, being rich in various essential amino acids (EAAs). As shown in Figure 2, lysine, valine, and histidine are among the higher-content amino acids in multiple

compositional analyses. Multiple comparative studies indicate that grass carp ranks among the top common edible fish species in terms of total essential amino acids and individual EAA content, demonstrating excellent protein quality and nutritional supplementation value (Lise et al., 2021; Öztekin et al., 2024). Lysine is an essential amino acid that the body cannot synthesize; it is crucial for child growth and development, protein synthesis, and immune function. Clinical and nutritional studies also show that lysine can promote intestinal calcium absorption and help maintain calcium balance in the body, thereby having potential positive effects on bone health. Lysine deficiency can impair immune response and affect tissue repair; therefore, foods rich in lysine are particularly beneficial for individuals in growth, development, and recovery phases. Valine, as one of the branched-chain amino acids (BCAAs), plays an important role in maintaining nitrogen balance, participating in protein synthesis, and muscle repair; studies also show that valine has physiological significance in providing muscle energy, improving mitochondrial function, and reducing post-exercise fatigue, thus benefiting athletic populations and individuals requiring rapid recovery (Kaspy et al., 2024).

Histidine is both a precursor for histamine synthesis and involved in the construction of hemoglobin and other important proteins; modern research indicates that histidine has functions such as scavenging reactive oxygen/nitrogen species, metal ion chelation, and anti-inflammatory properties, holding potential value for maintaining antioxidant defense and reducing inflammatory responses, especially important for tissue development and immune support in growing children (Holeček et al., 2020).

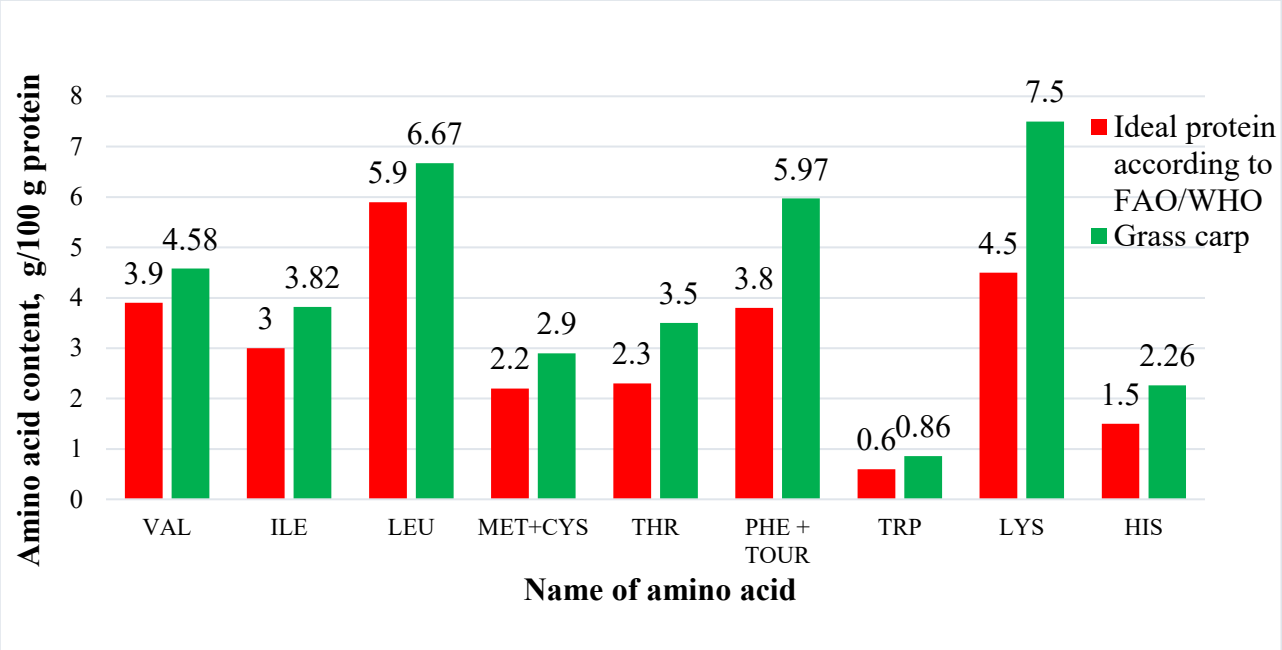

Figure 2. Compliance of the amino acid composition with meat protein of grass carp, g/100 g of protein

Source: Developed by the authors.

Furthermore, the overall fat content of grass carp is low, and its fat composition has a relatively high proportion of unsaturated fatty acids (especially in freshwater fish, often manifested as a favorable UFA/SFA ratio). This type of fat structure is beneficial for cardiovascular health, helping to regulate blood lipids, lower cholesterol, and prevent the risk of chronic diseases such as atherosclerosis. Compared to typical red meat, grass carp exhibits the nutritional advantages of being "low-fat, high-protein" and naturally free of industrial trans fats, making it a healthier animal protein source suitable for a wide range of populations (including children, pregnant women, the elderly, and those managing weight/lipids) (Pyz Łukasik et al., 2020).

In addition to protein and unsaturated fatty acids, grass carp also contains various vitamins, especially vitamin A, B vitamins, and vitamin E. Vitamin A is a key element for protecting vision, helping to maintain normal eyesight, prevent night blindness, and benefiting skin health and immune function. B vitamins participate in human metabolic processes, helping cells obtain needed energy, reduce fatigue, and improve work and life efficiency. Researchers (Liu & Hua, 2024) determined the content of vitamin B1 and vitamin B12 in grass carp flesh using High-Performance Liquid Chromatography with Diode-Array Detection (HPLC-DAD). Vitamin E, as an antioxidant, can neutralize the oxidative effects of free radicals, delay aging, and protect cell health.

Mineral elements are indispensable nutritional factors for maintaining normal physiological functions in the human body, playing important roles in bone metabolism, immune function, antioxidant balance, blood formation, and enzyme system activation. As a representative freshwater fish, the mineral composition of grass carp, as shown in Figure 3, exhibits the characteristics of being "comprehensive in variety, moderate in content, and high in bioavailability," making it one of the high-quality sources of mineral supplementation in the Chinese diet. Among them, calcium and phosphorus are important nutrients for maintaining bone health, helping to prevent osteoporosis and fractures; iron is a key component of hemoglobin and can improve anemia symptoms; zinc helps enhance immune system function and improve the body's ability to resist infections. Therefore, while meeting daily nutritional needs, grass carp also provides reliable nutritional support for health and vitality.

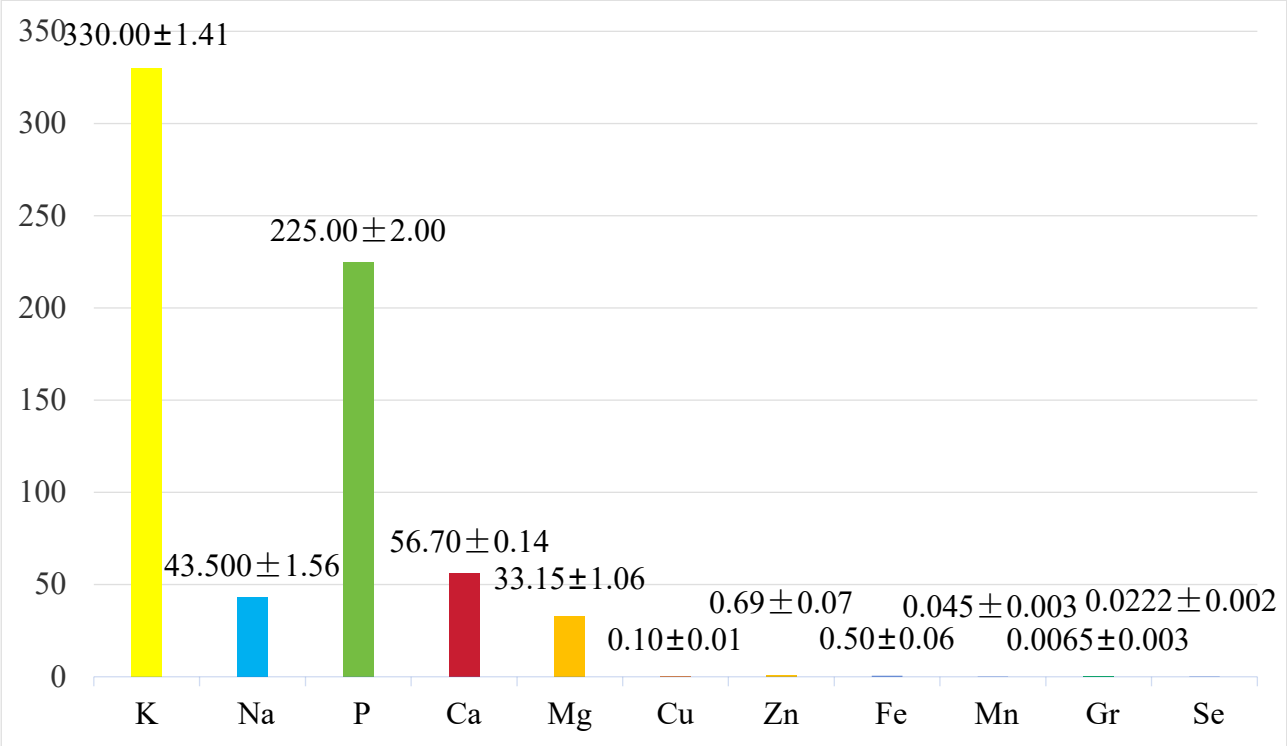

Figure 3. Mineral composition of grass carp

Source: Developed by the authors.

The results of our studies on the nutritional and biological value of grass carp are consistent with the data of other scientists (Zhou et al., 2020; Bal, 2024; Qiu & Lin, 2024).

Although grass carp is a freshwater fish with low overall fat content, its lipids are rich in polyunsaturated fatty acids (PUFAs), primarily linoleic acid (LA, 18:2 n-6) and α-linolenic acid (ALA, 18:3 n-3), along with small amounts of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) often detected. Multiple compositional analyses indicate that the PUFA/SFA ratio of grass carp is generally superior to that of many red meat sources, and it maintains a cardiovascular-beneficial fatty acid profile under different seasons and feeding conditions. Based on these compositional characteristics, grass carp intake may exert protective effects on the cardiovascular

system through multiple biological pathways (Kovacik et al., 2024/2025; Pyz Łukasik et al., 2017). A comprehensive meta-analysis indicated a significant correlation between fish intake and reduced coronary heart disease risk and stroke (Zhang et al., 2020; Bertoni et al., 2023).

Evidence at the population level (from multiple prospective cohorts and meta-analyses) shows that regular fish consumption is associated with a reduced incidence of major cardiovascular events such as coronary heart disease and stroke (Cui et al., 2022).

Cohort studies targeting the Chinese population also provide correlative evidence: among Chinese adults, moderate to high frequency of fish intake is associated with a reduced risk of ischemic stroke and total stroke, indicating that even a dietary structure based mainly on freshwater fish can bring significant cardiovascular benefits (with a dose-response relationship between intake and effect). In subgroup analyses of high-risk populations, fish intake of about 175 g per week (approximately 2 servings) was observed to significantly reduce major cardiovascular events. Combined with the widespread distribution of grass carp in the Chinese diet, these epidemiological findings provide practical basis for grass carp as a component of a cardiovascular-healthy diet (Mohan et al., 2021; Zhang et al., 2021;).

From a public health and dietary guidance perspective, it is recommended to incorporate grass carp into recommendations aiming for "fish intake 2–3 times per week," especially in non-coastal areas where freshwater fish predominate. Integrating current compositional evidence and epidemiological studies, grass carp, as a common and accessible freshwater fish, has the potential to become a component of dietary strategies for the primary prevention of cardiovascular disease (Kovacik et al., 2024).

CONCLUSION. Based on a systematic review of the nutritional composition, biological value, and health functions of grass carp, it can be unequivocally concluded that grass carp is a high-quality healthy food ingredient with significant development potential. Its core value lies in its nearly ideal nutritional profile: high moisture (79.38%) and low fat (0.96%) characteristics make it a model for low energy density foods, particularly suitable for weight management and modern healthy eating patterns. Simultaneously, its high protein content (19.64%), combined with a comprehensive essential amino acid profile and a muscle fiber structure conducive to digestion and absorption, endows it with a very high biological value, effectively supporting tissue repair, immune function maintenance, and the nutritional needs of specific populations.

The results of the amino acid composition study confirmed the completeness and balance of the proteins in grass carp meat.

Studies of mineral composition have shown that grass carp is a source of potassium, calcium, phosphorus, and selenium for the human body.

Furthermore, grass carp also possesses significant advantages in sensory and processing properties. Its tender flesh, few intermuscular bones, and lack of a pronounced fishy odor not only enhance the consumer eating experience but also open broad prospects for its application in various prepared dishes, surimi products, ready-to-eat foods, and functional foods. High edible yield and good processing adaptability are key to realizing its transformation from a primary agricultural product to a high-value-added healthy food.

In summary, with its comprehensive advantages of "high protein, low fat, superior fatty acids, rich micronutrients, and good taste," grass carp fully meets the core demands of the current market for healthy, natural, and functional foods. Against the backdrop of China's extremely abundant freshwater fish resources, vigorously promoting the research, development, and high-value utilization of grass carp in the healthy food sector will not only provide consumers with more high-quality dietary choices but also hold significant strategic importance for promoting the sustainable development of the aquaculture industry and enhancing the overall health of the population. Future research should further focus on optimizing its fatty acid composition through dietary nutritional regulation and developing deep-processed grass carp products targeting specific health needs.

Подяки. Немає.
Конфлікт інтересів. Немає.

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