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Редакцияға енуі 22.01.2025
Өңдеуден кейін түсуі 27.02.2025
Жариялауға қабылданды 28.02.2025

https://doi.org/10.53360/2788-7995-2025-2(18)-24

IRSTI: 34.35.33

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EVALUATION OF THE BIOCHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF GAMMARUS

Abstract: *Gammarus sp. is a promising resource for aquaculture due to its high protein, lipid, and carbohydrate content, along with its environmental purity. This study compared the biochemical composition of gammarus collected from five water bodies in Northern and Eastern Kazakhstan to evaluate its nutritional value and potential for feed industry applications. Protein content in the samples ranged from 40.96% to 50.3%, lipids from 6.57% to 9.20%, and carbohydrates from 13.74% to 21.69%. On average, gammarus had an energy value of 324 kcal/1355 kJ per 100 g of dry weight. In modern aquaculture, finding sustainable and cost-effective protein sources for high-quality feeds is critical. Gammarus is distinguished by its unique composition, which contains rare amino acids, vitamins, and minerals that are either absent or present in trace amounts in fishmeal. Biochemical analysis determined the content of protein, lipid, carbohydrate, ash, and moisture using standard laboratory methods, with energy values calculated based on macronutrient composition. Overall, gammarus proves to be a valuable and sustainable resource for enhancing feed quality in aquaculture, promoting more efficient and eco-friendly feed production.*

Key words: *Gammarus, nutritional value, aquaculture, biochemical composition, biomass.*

Introduction

One of the promising directions in biotechnology is the extraction of biologically active substances from aquatic organisms, which contain a wide range of unique components with valuable properties. The main objects for obtaining nutrient complexes used in food and feed products are commercially harvested and cultured marine and freshwater crustaceans, including crabs, shrimp, lobsters, crayfish, krill, and others [1]. Due to the high cost of fish meal in fish diets, utilizing more affordable protein sources can lower diet formulation costs and potentially increase profits for manufacturers [2]. Gammarus meal is known for its beneficial amino acid profile and high protein and lipid content, making it a valuable resource for aquaculture feed [3].

Aquaculture success is influenced by factors such as species, food, water quality, and their interactions. Feed costs represent a significant portion of aquaculture economics, accounting for about 50% of total expenses. When formulating mixed feeds for fish, both animal and plant raw materials are utilized, with animal-derived proteins offering essential amino acids like methionine, lysine, and tryptophan, which are lacking in plant proteins. Additionally, animal-based raw materials are rich in minerals [4]. This approach can help decrease reliance on fishmeal while ensuring the production of more economically viable and environmentally sustainable products [5, 6].

For all these reasons, gammarus is considered a promising feed supplement in aquaculture, even though its use in such industries has not yet been widely implemented [7]. Additionally, it presents a cost-effective and excellent alternative to fish meal in fish diets [2]. Gammarus has been utilized as an alternative to animal protein in the diets of various high-value fish species, including Caspian roach, African jewelfish, Siberian sturgeon, Caspian salmon, common carp, rainbow trout, and Nile tilapia [8-16].

This study aimed to perform a comparative analysis of specific biochemical characteristics of Gammarus sp., collected from five lakes in Northern and Eastern Kazakhstan. The findings may contribute to improving the use of aquatic biological resources in Kazakhstan's water bodies for the development of high-quality aquaculture feeds. Furthermore, the identified biochemical traits could serve as chemotaxonomic markers to assist in the identification and classification of species and populations.

Materials and Methods

Sampling of Gammarus sp. was conducted in 2024 at five water bodies: four located in Northern Kazakhstan (Lake Gorkoye, Lake Bolshiye Slivki, Lake Borovskoye, and Lake Prudok) and one in Eastern Kazakhstan (Lake Khomutino). Samples of gammarus were collected from three stations at each water body.

Table 1 – Location of the studied water bodies

Lake	District	Date	Latitude Coordinates	Longitude Coordinates
Gorkoye	Kyzylzharsky	October, 2024	54°56'55.70" N	68°57'20.23" E
Bolshiye Slivki	Zhambylsky	October, 2024	54°41'58.77" N	67°48'07.10" E
Prudok	Uzyunkolsky	October, 2024	54°33'33.29" N	65°47'33.02" E
Borovskoye	Mendykarynsky	October, 2024	53°47'47.44" N	64°08'33.53" E
Khomutino	Akkuly	October, 2024	51°40'16.1" N	77°28'02.1" E

Methodology for Sample Collection. Gammarus specimens were collected using a conical net 2.0 m in length with an entrance ring diameter of 0.5 m, made of mesh material with mesh sizes No. 10-12. All collected samples were preserved for subsequent laboratory analysis to assess the population characteristics of gammarus in the studied water bodies, as well as to determine the biomass and productivity parameters of this species. The nutritional value of gammarus from the water bodies was evaluated using standardized biochemical methods in the accredited laboratory of LLP «Erkin Talgam» (Almaty).

The content of nutrients in gammarus was determined according to the following GOST standards: moisture content – GOST R 54705-2011 [17], ash content – GOST 32933-2014 [18], nitrogen and crude protein content – GOST 13496.4-2019 [19], crude fat content – GOST 13496.15-2016 [20], cesium Cs-137 content – GOST 32161-2013 [21], strontium Sr-90 content – GOST 32163-2013 [22]. Carbohydrate content was determined using a calculation method by subtracting the total content of proteins, fats, ash, and moisture from the dry matter weight, while the energy value was

calculated based on the content of proteins, fats, and carbohydrates using standard caloric coefficients [23].

Results and Discussion

Analysis of the collected data revealed that the biomass of gammarus populations in the studied water bodies ranged from 4.66 ± 2.18 g/m2 (Lake Borovskoye) to 10.45 ± 3.12 g/m2 (Lake Khomutino). The corresponding productivity values varied from 93.2 ± 43.55 kg/ha to 209.0 ± 56.12 kg/ha. The results of biomass and productivity assessments for gammarus populations are presented in Figure 1.

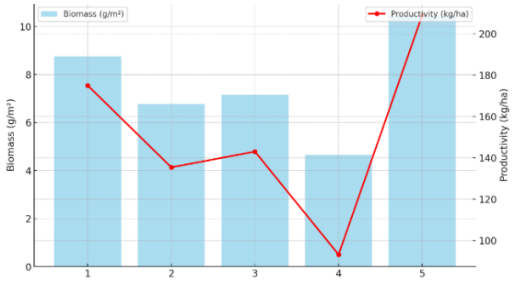

Figure 1. Biomass and productivity of gammarus populations in the studied Lakes
1 – Gorkoye, 2 – Bolshie Slivki, 3 – Prudok, 4 – Borovskoye, 5 – Khomutino

Characterization of the biochemical composition of gammarus from different populations. The determination of moisture content and organic matter composition is a crucial step in the biochemical analysis of gammarus individuals from various populations. The results of selected biochemical characteristics of gammarus, calculated per 100 g of dry weight, are presented in Figure 2.

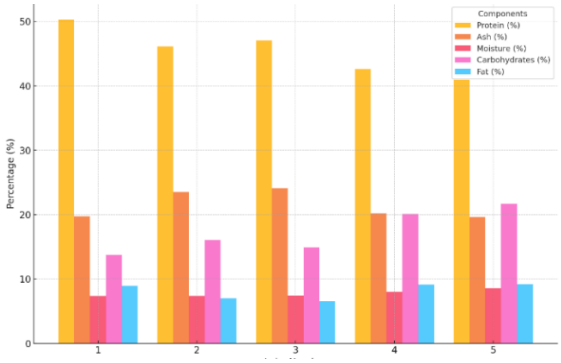

Figure 2 Comparison of general chemical composition between lakes
1 – Khomutino, 2 – Gorkoye, 3 – Bolshie Slivki, 4 – Borovskoye, 5 – Prudok

A comparative analysis of the average protein content in 100 g of dry mass of gammarus from five populations revealed that the highest protein levels were observed in samples from Lake Khomutino (50,3±1,46%), while the lowest protein content was recorded in samples from Lake Prudok (40,96±1,20%). The average protein content across all five populations indicated a high overall protein level of 45,4±1,2%.

In several studies, gammarus has been utilized as a feed additive to improve growth rates and biochemical parameters in aquatic organisms. For instance, Kovalev et al. (2021) investigated the effects of experimental feed formulations containing gammarus on the growth and biochemical characteristics of the Far Eastern sea cucumber (*Apostichopus japonicus*). The study demonstrated that feed supplemented with gammarus (50 g per 1 kg) resulted in a maximum weight gain of juvenile sea cucumbers, achieving a 775% increase over three months of the experiment, which was 2.7–3.3 times higher compared to control groups [24].

A comparative analysis of lipid content in 100 g of dry mass of gammarus from five populations revealed that the highest lipid level was observed in samples from Lake Prudok (9,20±0,83%), while the lowest was recorded in Lake Bolshiye Slivki (6,57±0,70%). The average lipid content across the samples was 7,75±0,81%.

Gammarus is recognized as a valuable source of polyunsaturated fatty acids (PUFAs) and carotenoids, making it a promising resource for the feed industry. According to studies, its chemical composition varies significantly depending on habitat conditions. For instance, the study by

Makhutova et al. (2016) demonstrated that in predator-free water bodies, the DHA content in gammarus was 1.5 times higher compared to water bodies with fish, a difference attributed to dietary shifts and changes in the organism's energy expenditures [25].

The ash content, reflecting the mineral composition of gammarus, was highest in samples from Lake Bolshiye Slivki (24,09±0,01%) and lowest in samples from Lake Prudok (19,58±0,01%). The average ash content across all populations was 21,82±0,01%.

The highest carbohydrate content was observed in samples from Lake Prudok (21,69±1,08%), while the lowest value was recorded in Lake Khomutino (13,74±0,69%). The average carbohydrate content among the samples was 17,30±0,86%.

The analysis of moisture content in 100 g of dry mass of gammarus collected from five different populations demonstrated moderate variation among the samples. The highest moisture content was observed in samples from Lake Prudok (8,57±0,86%), whereas the lowest was recorded in samples from Lake Khomutino (7,32±0,73%). The average moisture content across the studied populations was 7,93±0,78%, indicating a characteristically low hydration level of gammarus, consistent with its biological traits under dry mass analysis conditions.

The energy value of gammarus, calculated per 100 g of dry mass and presented in Figure 3, showed variability among populations, likely influenced by ecological and biochemical habitat characteristics. The highest energy value was recorded in samples from Lake Khomutino (336 kcal/1406 kJ), reflecting a high content of energy-dense components. The lowest value was observed in samples from Lake Bolshiye Slivki (307 kcal/1284 kJ), potentially attributed to local abiotic factors. Samples from Lakes Borovskoye and Prudok exhibited identical values (333 kcal/1393 kJ), suggesting similar environmental conditions in these habitats. Samples from Lake Gorkoye displayed intermediate values (311 kcal/1301 kJ). The average energy value across all studied populations was 324 kcal/1355 kJ, confirming the high nutritional potential of gammarus.

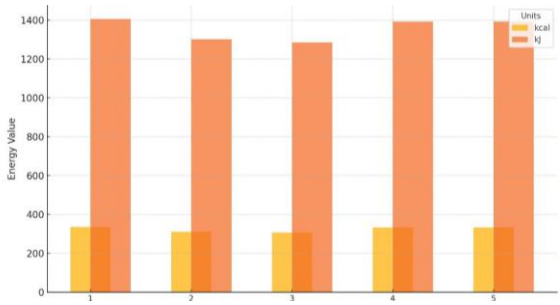

Figure 3 – Energy value of gammarus from various lakes
1 – Khomutino, 2 – Gorkoye, 3 – Bolshie Slivki, 4 – Borovskoye, 5 – Prudok

Previous studies, such as those by Barrento et al. (2009), demonstrated that marine crustaceans, including *Homarus gammarus* and *Homarus americanus*, contain significant amounts of protein (up to 18% in muscle tissue) and lipids (up to 25,5% in the hepatopancreas). These findings emphasize the importance of crustaceans as sources of protein and energy. However, gammarus, with its higher protein content (up to 58%) and lower lipid levels (approximately 12%), offers distinct advantages for applications in the feed industry [26].

Radiological evaluation confirmed the absence of strontium – 90 and cesium – 137, indicating favorable radiation conditions in its habitats. These results validate the safety of gammarus regarding radioactive contamination, enabling its use as raw material for feed and supplements without the risk of radionuclide accumulation. The environmental purity of gammarus makes it an appealing product for international trade, where compliance with radiation safety standards is a mandatory requirement.

Conclusion

The findings of this study substantiate the significant potential of *Gammarus sp.* as a natural component for feed production in aquaculture. Biochemical analysis revealed high concentrations of essential nutrients, including proteins, lipids, carbohydrates, and mineral compounds. The highest energy value of gammarus, recorded in samples from Lake Khomutino (336 kcal/1406 kJ per 100 g dry weight), underscores its promising role as an energy source for aquatic organisms. Furthermore, the environmental purity of gammarus, evidenced by the absence of radionuclides such as strontium – 90 and cesium – 137, ensures its safety and ecological sustainability.These results broaden the

potential applications of gammarus not only within the domestic market of Kazakhstan but also as a competitive product in the international arena. Its high caloric content and comprehensive nutritional profile position gammarus as a valuable bioresource for both agriculture and aquaculture, facilitating the development of high-quality and competitive feed products. The consistency of gammarus chemical composition across various ecological habitats indicates its adaptive potential and stable quality. In conclusion, gammarus has the capacity to serve as a critical dietary component for valuable fish species, thus reducing aquaculture's reliance on conventional feed sources. The integration of gammarus into aquaculture feed chains not only offers economic benefits but also promotes the transition to more ecologically sustainable production methods. Further research is recommended to optimize the collection and processing technologies for gammarus, which could further enhance its viability as a key resource in feed production.

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Research funding

The research is being conducted within the framework of the scientific and technical program for 2024-2026: «Comprehensive studies of reservoirs for conservation, sustainable use of aquatic resources by evaluating their potential and modelling of stock dynamics» (IRN: BR23591095).

Acknowledgements

We would like to express our sincere gratitude to the staff of the Altai and Northern branches of LLP «Fisheries Research and Production Center» for their invaluable assistance in organizing and conducting the material collection for this study.

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ОЦЕНКА БИОХИМИЧЕСКОГО СОСТАВА И ПИЩЕВОЙ ЦЕННОСТИ ГАММАРУСА.

Гаммарус является перспективным ресурсом для аквакультуры благодаря высокому содержанию белков, липидов и углеводов, а также экологической чистоте. В этом исследовании сравнивался биохимический состав гаммаруса, собранного в пяти водоемах Северного и Восточного Казахстана, чтобы оценить его питательную ценность и потенциал для применения в комбикормовой промышленности. Содержание белка в образцах варьировалось от 40,96% до 50,3%, липидов – от 6,57% до 9,20%, углеводов – от 13,74% до 21,69%. В среднем энергетическая ценность гаммаруса составляла 324 ккал/1355 кДж на 100 г сухого веса. В современной аквакультуре поиск устойчивых и экономически эффективных источников белка для высококачественных кормов имеет решающее значение. Гаммарус отличается своим уникальным составом, содержащим редкие аминокислоты, витамины и минералы, которые не встречаются или

присутствуют в минимальных количествах в рыбной муке.. Включение гаммаруса в состав кормов может значительно повысить их питательную ценность, что делает его незаменимым источником белка и других жизненно важных питательных веществ. Целью исследования было оценить питательную и энергетическую ценность гаммаруса в различных экологических условиях. В ходе биохимического анализа было определено содержание белков, липидов, углеводов, золы и влаги стандартными лабораторными методами, а энергетическая ценность была рассчитана на основе состава макроэлементов. В целом, гаммарус зарекомендовал себя как ценный и устойчивый ресурс для повышения качества кормов в аквакультуре, способствующий более эффективному и экологичному производству кормов.

Ключевые слова: *Гаммарус, пищевая ценность, аквакультура, биохимический состав, биомасса.*

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ГАММАРУСТЫҢ БИОХИМИЯЛЫҚ ҚҰРАМЫ МЕН ҚОРЕКТІК ҚҰНДЫЛЫҒЫН БАҒАЛАУ

Гаммарус ақуыздардың, липидтердің және көмірсулардың көп мөлшері мен экологиялық тазалығының арқасында аквакультура үшін перспективалы ресурс болып табылады. Бұл зерттеу Солтүстік және Шығыс Қазақстанның бес су айдынында жиналған гаммарустың биохимиялық құрамын салыстырып, оның қоректік құндылығы мен құрама жем өнеркәсібінде қолдану әлеуетін бағалады. Үлгілердегі ақуыз мөлшері 40,96%-дан 50,3%-ға дейін, липидтер 6,57%-дан 9,20%-ға дейін, көмірсулар 13,74%-дан 21,69%-ға дейін ауытқыды. Орташа алғанда, гаммарустың энергетикалық мәні 100 г құрғақ салмаққа 324 ккал/1355 кДж құрады. Қазіргі аквакультурада жоғары сапалы азығы үшін тұрақты және үнемді ақуыз көздерін табу өте маңызды. Гаммарус сирек кездесетін аминқышқылдары, дәрумендер мен минералдардан тұратын ерекше құрамымен ерекшеленеді, олар балық ұнында кездеспейді немесе аз мөлшерде болады. Гаммаруста азыққа қосу олардың тағамдық құндылығын айтарлықтай арттыруы мүмкін, бұл оны ақуыздың және басқа да маңызды қоректік заттардың таптырмас көзі етеді. Зерттеудің мақсаты әртүрлі экологиялық жағдайларда гаммарустың қоректік және энергетикалық құндылығын бағалау болды. Биохимиялық талдау барысында ақуыздардың, липидтердің, көмірсулардың, күлділіктің және ылғалдың құрамы стандартты зертханалық әдістермен анықталды, ал энергетикалық құндылығы макроэлементтердің құрамы негізінде есептелді. Жалпы алғанда, гаммарус аквакультурадағы азық сапасын жақсарту үшін тиімді және экологиялық таза азық өндірісіне үлес қосатын құнды және тұрақты ресурс екенін дәлелдеді.

Түйін сөздер: *Гаммарус, қоректік құндылығы, аквакультура, биохимиялық құрамы, биомасса.*

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Received 22.01.2025
Accepted 26.03.2025

https://doi.org/10.53360/2788-7995-2025-2(18)-25

МРНТИ: 65.59.15

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КАЧЕСТВО ПЕРЕРАБОТАННЫХ ПРОДУКТОВ ИЗ КОЗЛЯТИНЫ

Аннотация: *Несмотря на то, что переработанные продукты из мяса козлятины менее популярны, чем конина, говядина или мясо птицы, и часто воспринимаются как второстепенные, они играют важную роль в мировом потреблении мяса. В статье представлен краткий обзор поголовья коз и состояния переработки козлятины в Казахстане. Также обобщены последние исследования, посвящённые переработке мяса козлятины, с акцентом на физико-химические характеристики, сенсорное качество, микробиологические показатели и вопросы безопасности. Рассматриваются основные выводы и перспективные направления развития производства, переработки и коммерческого потенциала продукции из козлятины. Отмечаются возможности диверсификации ассортимента и повышения рыночной привлекательности таких продуктов. Переработка мяса выбракованных животных представляет собой перспективный способ использования сырья с низкой рыночной ценностью. Некоторые виды продукции, такие как ферментированные колбасы, копчёные ноги и паштеты, обладают высоким коммерческим потенциалом и хорошей потребительской приемлемостью. Одним из перспективных направлений исследований в пищевой промышленности является разработка нового поколения продуктов из козлятины в качестве функциональных пищевых продуктов, соответствующих требованиям постоянных инноваций в мясной отрасли. Вопросы, связанные с обеспечением пищевой безопасности, остаются актуальными и требуют особого внимания в будущих научных и технологических разработках.*

Ключевые слова: *поголовье коз, козлятина, переработка продуктов, качества.*

Введение

Мясо является незаменимым продуктом питания, высоко ценимым за свою питательную ценность. Однако животноводческий сектор признан одним из значимых факторов, способствующих глобальному потеплению [1, 2]. В связи с этим возрастает необходимость перехода к более экологичным способам производства мяса.

Коза считается многофункциональным животным и стабильным источником мяса, обладающим характеристиками, идеально подходящими для устойчивого производства красного мяса. Эти животные легко адаптируются к экстремальным условиям, отличаются