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Research Article

# Comparative Characteristics of the Mineral Composition of the Meat of the Black Sea Grass Shrimp *Palaemon Adspersus*, Rathke, 1837 in Different Fishing Periods

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## Annotation

The nutritional value of the mineral composition of the meat of one of the species of crustaceans of the Black Sea-*Palaemon adspersus* Rathke, *1837* in the spring and autumn periods of fishing-has been studied. Essential mineral elements. Calcium (Ca) Potassium (K), Sodium (Na) Magnesium (Mg), Copper (Cu), Zinc (Zn), Iron (Fe), Manganese (Mn), Nickel (Ni), Lithium (Li), Little Studied (Silver (Ag), Aluminum (Al), Barium (Va), Boron (B), Bismuth (Bi), As Well as Toxic (Arsenic (As), Cadmium (Cd), Swine c (Pb), Mercury (Hg).. The level of most mineral elements in the meat of this crustacean is lower than the physiological needs for an adult, with the exception of Cu, Cr, Ni and Al. Their amount significantly exceeds the recommended values for humans, however substantially below the toxicity threshold. The content of heavy metal in the meat *of Palaemon adspersus* Rathke, 1837 during catch periods does not exceed the permissible norms.

## Introduction

The nutritional value of raw materials is determined by many constituent factors, among which the qualitative and quantitative composition of mineral elements [1-5], as well as their safety [6] play a significant role in ensuring the physiological needs of a person [7,8] Mineral components of nutrition are characterized by various physiological functions: play an important role in plastic processes, the formation and construction of body tissues, are necessary to maintain acid-base balance in the body, create a certain concentration of hydrogen ions in tissues and cells, interstitial and intercellular fluids, participate in enzymatic processes as activators and cofactors of enzymes [7,8].

Hydrobionts are a source of biologically valuable proteins, lipids, carbohydrates, mineral components, vitamins with health benefits for all age categories of people and their consumption is promoted as a healthy food choice [9-11].

Based on this, the World Health Organization and the Food and Agriculture Organization of the United Nations recommend regular consumption of seafood in amounts of one to two servings per week [12].

### Study of mineral components in the meat of hydrobionts, including

crustaceans, a significant number of works are devoted [13-21]. In these studies, it is shown that their meat contains all the essential, poorly studied and toxic elements. Qualitative and quantitative composition reveals significant fluctuations that are associated with their type, size, sex, degree of development of the reproductive system, season and catch area, nutritional characteristics. Thus, on the example of the Antarctic krill *Euphausia superba*, it was found that sexually mature females and males differ between themselves and immature individuals in the content of manganese, zinc, copper, nickel, strontium and cadmium [16,20]. *Pandalus borealis,* which lives in the Pacific region [17-19], reveals a number of differences in both the qualitative and quantitative content of the mineral components of meat compared with the meat of related species- *Euphausia superba* [16,20] and *Maja brachydactyla* [21].

The Black Sea *Palaemon adspersus,* Rathke, 1837 is a commercial species of crustaceans living in the Black Sea [22]. In many countries of the world, since ancient times, this type of crustacean has been used for food in boiled and boiled frozen form. Many issues relating to the features of biology, in particular, various stages of the life cycle, migration, nutrition are covered in the works [23-26].

The chemical composition and biological value of this species of crustaceans were studied only in the pre-spawning period for amino acid and fatty acid compositions [27,28]. Information on the mineral component of the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 is limited to indicating their total content [27]. This type of crustacean is in great demand in the Ukrainian market. Therefore, the study of the nutritional value of the mineral composition of meat and the assessment of its contribution to the provision of physiological needs, as well as the determination of safety, represent an urgent task.

The purpose of the work was to assess the nutritional value of the mineral composition of the meat of the Black Sea herbal shrimp *Palaemon adspersus* Rathke, 1837 during the fishing periods (spring and autumn), as well as to assess the contribution of the mineral elements of its meat to the satisfaction of human physiological needs.

## Material and Methods

The collection of material was carried out during the spring and autumn fishing of the Black Sea grass shrimp *Palaemon adspersus Rathke*, 1837 in the area of the northwestern coast of the Black Sea of the Odessa region. Fishing was carried out by venters with a mesh size of 2.8 to 8 mm. The total number of analyzed individuals was 650 specimens. After catching shrimp were cut, in meat was isolated, minced meat was cooked and in an average sample in an amount of 300-350g the total ash content was determined by weight after mineralization of the hanging in a muffle oven at a temperature of 500-600 ° C. By inductively coupled plasma mass spectrometry (ICP-MS) in the samples obtained, the content of the following elements was determined: silver (Ag),, aluminum (Al),boron (B), barium (Ba),bismuth (Bi),» calcium (Ca). , cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), lithium (Li), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na),nickel (Ni),lead (Pb),zinc (Zn).. The analysis was carried out on the atomic emission spectrometer IRIS Interpid II XSP (Termo Fisher Scientific, USA) equipped with a gas-filled cell of the DRC system for the removal of interference and a seven-port dosing valve FAST, as well as an autodosator ESISCDX4 (Elemental Scientific Inc., Omaha, NE 68122, USA). librated by external calibration to multi-element standards. Standards containing a full range of detectable elements (0.5, 5, 10 and 50 μg/L) were prepared prior to operation from the Universal Data Acquisition Standards Kit (#N9306225, Perkin Elmer Inc.) by dilution in distilled deionized water acidified with 1% HNO3. To account for the incomplete correspondence of sample matrices and calibration solutions for acidity and viscosity, internal standardization «online» for the isotope yttrium-89 was applied in the analysis. An internal standard containing 10 μg/l Y was prepared from the reference standard of yttrium (#N9300167, Perkin Elmer Inc.) on a matrix containing 8% 1-Butanol ((#1.00988, Merck KGaA), 0.8% TritonX-100 (Sigma #T9284 Sigma-Aldrich, Co.), 0.02% TMAH (#20932, Alfa-Aesar, Ward Hill, MA 01835, USA) and 0.02% EDT Acid (Sigma#431788 Sigma-Aldrich, Co). The detection limit was 0.1 mg/kg.

Analysis of the content of mineral elements was carried out in comparison with the literature data published on crustaceans upholstering in various seas [16-21], as well as on marine mollusks [29], fish of the Black Sea [30-32] and other seas [33].

The reliability of the results was analyzed using Microsoft Excel 365 and SPSS 16.0 at $P \leq 0.05$.

## Results and Discussion

Analysis of the results of research shows that the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 in the spring and autumn periods of fishing in terms of the total content of mineral elements does not show significant differences: 1.85 ± 0.21 and 1.92 ± 0.34%, % and on average is 1.88 ± 0.27. According to the literature, the total mineral content of other crustaceans, e.g., *Euphausia superba* ranges from 1.9 to 3.2% [16], *Pandalus borealis* from 1.76 [17] to 4.0% [19] and *Pandalus goniurus* to 3.9 ± 0.1% [19].

To assess the nutritional value of the mineral component of shrimp meat, the contribution of 100g of meat per day to meet the physiological needs of an adult, as well as its toxicity in comparison with the literature data was determined (Table 1).

## Essential mineral elements

Analysis of the research results indicates that the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 contains all essential mineral elements that are determined by mass spectrometry with inductively coupled plasma. In the spring of *the Palemon adspersus* Rathke fishery, 1837, the content in its meat of such elements as Ca, Mg, Cu, Zn, Mn, Ni and Li shows higher concentrations in comparison with the autumn period (differences are significant at P ≤ 0.05). The recommended values of the physiological needs of the daily intake of mineral elements are average indicators and reflect the estimated required amount to maintain a normal healthy state of a person [6,7]. Taking into account these recommendations, it follows that the use of 100g of Black Sea shrimp meat is not able to meet human needs for most of the essential mineral elements. Thus, the content of Ca in the spring period of fishing in the meat *of Palaemon adspersus* Rathke, 1837 was 1.89 ± 0.20, in the autumn-1.19 ± 0.10 against the recommended level per day-1200 mg, which is its deficit of more than 99% (Table 1). Sa has been identified in the meat of many hydrobionts, including fish, invertebrates and algae [12-20]. Thus, in the meat *of Pandalus borealis* [17] and *Euphausia superba* [16], the content of Ca was 125.10 and 124.00 mg/100g, respectively. In the meat of the Black Sea shark *Squalus acanthis,* Linnaeus, 1758, 13.84 ± 0.69 mg/100g were detected [32]. Ca is the determining factor for the normal formation of the skeleton and the achievement of peak, genetically predetermined mass and density [34-36]. The amount of this element both in the meat of the Black Sea *Palaemon adspersus* Rathke, 1837, and in the meat of other crustaceans [16-20] and fish [30-31] is significantly lower than the recommended daily level of its consumption [7].

| Item Name | Black Sea *Palaemon adspersus* Rathke, 1837, fishing periods | | *Pandalus borealis* [17] | *Euphausia superba* [16] | Daily level for an adult | |
|---|---|---|---|---|---|---|
| | spring | autumn | | | The 20th [7] | Toxicity [5] |
| Essential mineral elements, mg/100g | | | | | | |
| *Are | 1,89 ± 0,20 | 1,19 ± 0,10 | 125,10 | 124,00 | 1200 | - |
| K | 0,33 ± 0,01 | 0,34 ± 0,03 | 281,50 | 253,00 | 2500 | 6000 |
| On | 0,33 ± 0,07 | 0,27 ± 0,01 | 118,90 | 313,00 | 1300 | - |
| *Mg | 90,10 ± 7,78 | 66,10 ± 0,06 | 125,10 | 430,00 | 400 | - |
| *With | 2,95 ± 0,51 | 1,96 ± 0,24 | 0,35 | 2,60 | 1,00 | 200 |
| *Zn | 2,51 ± 0,28 | 1,93 ± 0,14 | 2,12 | - | 12,00 | 600 |
| Fe | 0,92 ± 0,90 | 0,86 ± 0,06 | 4,69 | 4,10 | 15 | 200 |
| *Mn | 0,62 ± 0,03 | 0,32 ± 0,01 | 0,06 | - | 2,00 | 40 |
| Cr | 0,07 ± 0,003 | 0,06 ± 0,008 | - | 0,36 | 0,005 | 5 |
| *Nor | 0,04 ± 0,001 | 0,02 ± 0,002 | 0,03 | 2,00 | 0,01 | 20 |
| *Li | 0,12 ± 0,05 | 0,04 ± 0,003 | - | 4,50 | - | 146 |
| With | ≤ 0,01 | ≤ 0,01 | - | 0,06 | - | 0,9 |

**Table 1:** Nutritional value of the mineral composition of the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 during fishing periods.

Note: *- statistically significant differences at P ≤ 0.05.

Essential mineral elements such as K, Na are also found in *palaemon adspersus rathke*, 1837 in low concentrations (0.33 ± 0.01; 0.34 ± 0.03; and 0.33 ± 0.07; 0.27 ± 0.01, respectively) against a higher number in the meat of other crustaceans-*Pandalus borealis* (K-281.50; Na-118,90 mg/100g) [17], *Euphausia superba* (K-253,00; Na-313,00 mg/100g [16]. K is an important dietary mineral and electrolyte that is necessary for the regulation of the body's electrical signals (maintaining cellular polarity, neuronal signaling, transmission of cardiac impulses and muscle contraction), in the transport of nutrients and metabolites, as well as in the activation of enzymes [5,6]. However, its amount in the meat of crustaceans, as well as in the meat of some Black Sea fish (*Squalus acanthis, Linnaeus,* 1758-166.60 ± 8.33 [32] is significantly lower than the recommended daily intake level of 2500 mg/day [7]. Na is important for the effective functioning of the kidneys, nervous and digestive system, for vascular tone, for normal muscle contraction; Together with K, it takes part in maintaining the normal water-salt balance in cells, regulating the volume of fluid in the body, is an integral part of the ferment, which is responsible for the biosynthesis of energy and the transport of valuable amino acids and glucose to the cells of the body [6,35,36]. The deficiency of these elements in the meat of the Black Sea shrimp is more than 99%.

The concentration of Mg in the meat *of Palaemon adspersus* Rathke, 1837 in the spring fishing period is higher compared to the autumn-90.10 ± 7.78 and 66.10 ± 0.06 ($P \leq 0.05$) and significantly less than the level of this element in other crustaceans (*Pandalus borealis* -125.10 mg/100g [16]; *Euphausia superba*-430 mg/100g [16]. The amount of Mg in *Euphausia superba* meat exceeds the recommended daily requirement level for this element (400 vs. 430 mg/day) [7,8]. Low concentrations of Mg have been identified in the meat of the Black Sea shark *Squalus acanthis,* Linnaeus, 1758-15.69 ± 0.78 mg/100g [32]. In the meat of such species of commercial fish as *Merluccius bilinearys* from the Gulf of Oman, the mg level was 137. 5-150, 4 mg/g [33]. This element is essential, which is necessary for cell adhesion and migration, energy metabolism, DNA transcription, stability RNA takes part in the synthesis and degradation of numerous neurotransmitters, in particular, catecholamines [38,39].

The level of Cu in the meat *palaemon adspersus* rathke*,* 1837 during fishing periods exceeds the recommended amount of daily consumption: 2.95 ± 0.5; 1.96 ± 0.24 mg/100g against 1.00-1.50 mg [7] (Table 1). *Euphausia superba* meat also showed high concentrations of this element-2.60 mg/100g [16], which is consistent with the results of our studies. At the same time, *Pandalus borealis* has an amount of Cu ranging from 0.19 [17] to 0.35 mg/100g [19]. In the meat *of Rapana venosa* in various regions of the Black Sea, from 1.39 ± 0.004 to 16.72 ± 2.33 mg/100g were detected [29], in the tissues of *Mytilus galloprovincialis* up to 3% of the total content of mineral elements [40].

Cu is an important micronutrient necessary for electron transfer processes, is a central component of many enzymes, is involved in energy metabolism and in the cross-linking of collagen and elastin [41-48]. Studies of the balance of consumption of this element have shown that its absorption from the diet is about 50% for all age groups and groups of all stages of human life [5]. The literature on the recommended level of Consumption of Cu is contradictory. The authors A.V. Skalny [5,49], V.I. Tsipriyan [7], A.V. Pogozheva [8] have instructions to limit the level of daily consumption of Cu. However, at present, sufficiently reliable, sensitive and specific biomarkers of Cu have not been identified., therefore, it is not possible to limit the daily level of consumption of this element [45]. The content of Cu in the meat *of Palaemon adspersus Rathke,* 1837 during fishing periods does not emit the level of toxicity [5] and is safe in the content of this element.

The presence of the trace element Zn in the meat *palaemon adspersus* rathke, 1837 in different periods of fishing does not show significant differences (2.51 ± 0.28 and 1.93 ± 0.14 mg/100g, in spring and autumn, respectively) and is consistent with data on its content in *meat Pandalus borealis* (2.12 mg/100g) living in the Sea of Okhotsk [17] (Table 1). According to other researchers of the mineral component*, Pandalus borealis* meat from the same region contains Zn up to 0.9 mg/100g [19]. In the Black Sea *Rapana venosa*, higher amounts of this element were detected-up to 9.12 ± 2.15 mg/100g. [29]. The meat of the Black Sea shark *Squalus acanthis,* Linnaeus, 1758 is characterized by the presence of Zn in concentrations: from 2.94 ± 0.03 mg/100g [30], in 14 species of fish from the Gulf of Oman-from 4,512 to 6,421 mg/g [33]. The importance of zinc for human health and life is due to the fact that this element is a cofactor of more than 300 enzymes and more than 100 variants of transcription factors [49-50]. However, this element exhibits toxicity in certain concentrations [51].

The concentration of Fe in the meat *of Palaemon adspersus* Rathke, 1837 during fishing periods does not show statistically significant differences at $P \leq 0.05$ and averages 0.88 ± 0.04 mg/100g against the recommended amount of 15 mg per day [7] (Table 1). [7], *Euphausia superba* has 4.10 mg/100g [16]. *Rapana venosa* meat has a content of 0.128 to 0.332 mg/100g [29]. Fe is an important element for ensuring the vital activity of all living organisms, the physiological functions of which are due to the entry into the composition of enzymes to ensure the transport of oxygen, electrons for the synthesis of ATP and DNA [7,8,50].

The concentration of Mn in the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 in the spring fishing period is twice as high as in the autumn: 0.62 ± 0.03 against 0.32 mg/100g (Table 1). The level of Mn in the meat of the Ochotomorian *Pandalus borealis* was 0.063 mg/100g [17], in the meat of the Black Sea *Rapana venosa*-

from 0.34 ± 0.012 to 0.76 ± 0.032 mg/100g [29]. This element is involved in the normal development of bone tissue, helps to strengthen the immune system, the proper course of digestive processes, as well as fat and insulin metabolism and brain function [8]. The need for this element for different sources ranges from 2.00 [5] to 4.00 mg/100g [7].

The content of Cr in the meat *of Palaemon adspersus* Rathke, 1837 exceeds 14 and 12 times in the spring and autumn fishing periods, respectively, compared with the recommended values of the daily consumption of this element: 0.07 ± 0.003; 0.06 ± 0.008 against 0.005 mg/day (Table 1). High concentrations of Cr were observed in *Euphausia superba*-0.36 mg/100g [16], as well as in *Rapana venosa* meat-from 0.03 ± 0.002 to 0.42 ± 0.016 mg/100g [29], as well as in many species of commercial fish-at the level of 0.066-0.099 mg /g [31-33]. The daily requirement for this element is 0.005 mg/100g [7,8] with a level of toxicity of 5 mg [5]. Cr is considered an important essential trace element, because it contributes to the structural integrity of nucleic acid molecules; participates in the regulation of the heart muscle and the functioning of blood vessels; promotes the removal of toxins, salts of heavy metals, radionuclides from the body [53,54]. However, to date, the mechanisms of these Cr functions in metabolism have not been conclusively substantiated. The bioavailability of chromium from inorganic compounds in the gastrointestinal tract is low, only 0.5-1%, and increases to 20-25% with the intake of chromium in the form of complex compounds (picolinates, asparaginates) [52]. Taking into account these data, the identified content of Cr in the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 does not pose a danger to human health.

The level of Ni in the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 in the spring fishing period is twice as much as in the autumn: 0.04 ± 0.001 and 0.02 ± 0.002 mg/100g, respectively, and exceeds the recommended values-0.01 mg [7], but not toxicity [5,55]. According to the literaturn data, Ni, coming from food, is absorbed mainly in the small intestine and its bioavailability is 1–10% [5,56].

It is known that one of the main functions of Ni is an indirect participation in the process of hematopoiesis through the mechanism of penetration of iron into the blood [57]. It has also been shown that Ni is a cofactor (activator) of bioligand, capable of binding iron and transferring it from the insoluble form of $Fe^{3+}$ to easily digestible $Fe^{2+}$, is also included in the composition of blood cells-erythrocytes, participates in the activation of certain enzymes and in redox processes organism [58,59]. Its role in ensuring the necessary conformation and shape of molecules in the structural organization and functioning of DNA, RNA, proteins is shown [56]. A toxic dose of nickel with a single dose is 50 mg, and with a daily dose-20 mg/day; data on the lethal dose are not available [60]. The negative effect of Ni can be manifested in a decrease in immunity, the manifestation of allergic [59], stress reactions and depression of the cardiovascular system [61]. In the human gastrointestinal tract, from 1 to 10% of the received Ni is absorbed. According to our data, when Ni enters the body with an average of 0.33 mg/100g of shrimp and the absorption of 10% in the human body, 0.03 mg will be absorbed (Table 1), which is significantly lower than the toxicity threshold for this element [5].

The content of Li in the meat of the spring shrimp catch exceeds its amount in the autumn by 3 times: 0.12 ± 0.05 against 0.04 ± 0.003 mg/100g (Table 1). In other crustaceans, this element is present in higher concentrations-4.50 mg/100g [16] or is not detected [17-20]. In the meat of many species of commercial fish, this element has not been determined [28-32].

Li is important for the proper functioning of a number of enzymes, hormones, vitamins, growth factors, the immune system, and the nervous system [62]. This mineral also has a wide range of neuroprotective effects [63-65]. The recommended level of daily intake of Li has not yet been established, but there is data on the level of toxicity-146 mg per day [5].

The content of Co in *the meat of Palaemon adspersus* Rathke, 1837 does not show differences depending on the catch season and is ≤ 0.01 mg/100g (Table 1). In the meat of other crustaceans, for example, *Pandalus borealis*, this element was not detected [17], while in *Euphausia superba* its content is established at 0.90 mg/100g [16]. This element is a vital and indispensable component of many enzymes and coenzymes [66-68]. In the middle, the intake of Co ions into the human body with food is 0.012 mg/day and the expression of the physiological level of Co consumption can cause toxic effects: activation of inflammatory processes, mutagenesis, carcinogenesis, tissue necrosis [69].

### Toxic and little-studied elements

One of the groups related to toxic elements are heavy metals: Pb, Cd, As and Hg, which in certain concentrations can have harmful effects on the human body, capable of accumulate in the tissues, causing a number of diseases [70,71]. These elements enter the ocean through the atmosphere and with the burial of multi-faceted waste in the oceans [72,73].

The assessment of the content of heavy metals in the meat of the Black Sea *Palaemon adspersus* Rathke, 1837 during fishing periods and their compliance with permissible levels [70] is presented in table 2.

Pb is found in the meat *of Palaemon adspersus* Rathke 1837 in amounts ≤ 0.01 mg/100g (Table 2). These data are consistent with

| **Name of the element** | **Heavy metals, mg/kg** | | | | | **Acceptable levels, not more than [70]** |
|---|---|---|---|---|---|---|
| | ***Palaemon adspersus* Rathke 1837, fishing period** | | ***Pandalus borealis* [17]** | ***Pandalus goniurus* [19]** | ***Euphausia superba* [16]** | |
| | **spring** | **autumn** | | | | |
| Pb | < 0.01 | < 0.01 | 0,15 | 0,01 | 0,10 | 2,0 |
| Cd | 0,17 ± 0,01 | < 0.01 | 0,50 | 0,02 | 0,01 | 0,5 |
| As | 0,24 ± 0,02 | 0,24 ± 0,02 | 2,03 | 2,57 | 0,50 | 0,5 |
| Hg | < 0.01 | < 0.01 | 0,17 | 0,11 | 0,01 | 0,1 |

**Table 2:** Assessment of the compliance of the heavy metals Pb, Cd, As and Hg (mg/kg) in *Palaemon adspersus* Rathke *1837* meat with their permissible levels [70].

the Pb content of *Pandalus goniurus* meat [19], while in the meat of other crustaceans (*Euphausia superba* and *Pandalus borealis* [16,17] this element is present 15 and 10 times, respectively. High concentrations of lead (from 0.03 to 0.10 mg/100g) are found in the meat of many commercial Black Sea Fish [30-32] and crustaceans [74]. However, the level of this element in the meat of hydrobionts is significantly lower than its permissible concentrations: 0.003-0.005 mg/100g [70]. The toxic effect of Pb is manifested in a negative effect on human mental abilities [7,8]. It is excreted from the body by 90% [5].

The content of Cd in the meat *of Palaemon adspersus* Rathke 1837 in the spring fishing period is higher compared to the autumn period-0.017 ± 0.001 against < 0.001 mg/100g (the differences are significant at P ≤ 0.05). In *Pandalus borealis* meat, 0.0063 mg/100g were detected [17], in *Euphausia superba*-from 0.4 ± 0.04 to 1.3 ± 0.1 mg/100g [16]. Significant accumulations of this element in the human body lead to increased pressure, renal failure and chronic poisoning [5,75,76]. This element is found in the meat of many crustaceans [13-21] and fish [30-33], however, in most cases, as for the Black Sea *Palaemon adspersus* Rathke 1837 its level is lower than toxicity [5].

The concentration of As in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 of the spring and autumn catch periods does not show any differences and is 0.002 ± 0.0001, which is more than two times less than the recommended daily intake level (0.005 mg/day) [70]. As is found in the meat of all hydrobionts, but the level of its content differs in all species. In meat*, Euphausia superba*-0.06 [16], *Pandalus borealis*-0.002 and *Pandalus goniurus*-0.002 mg/100g, respectively [19]. As refers to toxic elements, the intake of which in high concentrations can lead to acute or chronic intoxication, and in some cases to the development of malignant neoplasms [4,5,65].

The level of Hg in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 does not show differences depending on the catch period and is ≤ 0.01 mg/kg, i.e., significantly lower than the permissible level [7,8,70]. In other crustaceans, this element was detected in higher concentrations: *Pandalus goniurus*-0.11; *Pandalus borealis*-0,17 mg/kg [19]. Low Hg content (0.012-0.049 mg/g) is determined in the meat of many commercial fish species [31-33]. Hg is one of the elements constantly present in the environment and living organisms [71-74]. It is a highly toxic cumulative poison that affects the hematopoietic, enzymatic, nervous systems and kidneys [75-76]. FAO and the World Health Organization have established a weekly safe intake of total Hg-5 µg per kilogram of human body weight [70], toxic effect occurs at 0.4 mg/day [5]. Thus, the level of Hg in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 is not dangerous for human health.

## Toxic and malo-studied mineral elements

Toxic and poorly studied mineral elements include Al, Ag, Ba, Bi and B [5], data on the content of which in the meat *palaemon adspersus* rathke 1837 during fishing periods are presented in table 3.

The level of Al reveals statistically significantly large values in the spring period of the Black Sea *Fishery Palaemon adspersus* Rathke 1837 (0.41 ± 0.06 against 0.26 ± 0.03, mg/100g in autumn) (Table 3).

| Item Name | Catch periods *Palaemon adspersus* Rathke 1837 | | Permissible level, mg [5] |
|---|---|---|---|
| | Spring | Autumn | |
| To the | 0,41 ± 0,06 | 0,26 ± 0,03 | - |
| At the | 0,03 ± 0,003 | 0,02 ± 0,001 | 0,05 |
| Three | 0,63 ± 0,01 | 0,36 ± 0,04 | - |
| Would | ≤ 0,001 | ≤ 0,001 | - |
| B | ≤ 0,001 | ≤ 0,001 | - |

**Table 3:** The content of toxic and poorly studied mineral elements, mg/ 100g in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 during fishing periods.

Al refers to toxic elements, the effect of which can be manifested in the hydronephrotic transformation of the kidneys, the expansion of the urinary ducts, difficulty urinating and/or the formation of cameos, as well as in the genotoxic effect on the chromosomes of bacterial cells, cells of warm-blooded animals and neurotoxic action [78-80].

Aluminum compounds have been shown to dissolve with the release of free $Al_{3+}$ ions when released into the acidic environment of the stomach [81,82]. The absorption of various aluminum compounds in the intestine is at a level of 0.01 to 0.5% of the amount consumed [80]. The Joint FAO/WHO Expert Committee on Food Additives (JECFA) has established a new level of safe weekly consumption of aluminum PTWI, which is 0-2.0 mg/kg by weight Thus, the aluminum content in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 from the standpoint of the established level of safety is within acceptable values.

The level of Ag in the meat *of Palaemon adspersus* Rathke 1837 is higher in the spring fishing period and is 0.03 ± 0.003 mg/100g against 0.02 ± 0.001 (Table 3). In other crustaceans [16-20], mollusks [29] and fish [30,32] this element was not detected. Ag is important for the human body [7,8], but at a dose of 10g, a lethal outcome is likely [5]. According to the content of this trace element, the meat of *Palaemon adspersus* Rathke 1837 is safe during fishing periods.

The concentration of Ba, as well as Ag and Al in the spring period of fishing is higher compared to the autumn: 0.63 ± 0.01 against 0.36 ± 0.03 (at P ≤ 0.05) (Table 3). In the meat of other crustaceans [16-20], Black Sea rapana [29] and fish [30-32] this trace element was not determined. The physiological and biochemical significance of barium for the body is not well understood [5]. Ba is a synergist of acetylcholine and in low concentrations exhibits the properties of the essential element of vertebrates, without the participation of which the correct functioning of nervous activity is impossible [83,84]. However, high concentrations of Ba are able to block potassium channels not only of neurons, but of all cellular life forms in general [84]. A day in the human body fasts 0.3-0.9 mg of Ba and in general contains 20-22 mg of this heavy metal, which enters with food and water [5]. The toxic dose for humans is 200 mg of Ba per day, the lethal dose varies between 0.8-3.7g. [6]. The content of Va in the meat of the Black Sea during fishing periods does not pose a danger to humans.

The concentration of boron B in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 does not depend on the catch season and is < 0.001g/100g (Table 3). In crustaceans [15-19] and other hydrobionts, this element was not detected [28-32]. It affects the regulation of parathyroid hormone activity and indirectly takes part in the metabolism of calcium and magnesium (prevents their loss through the kidneys), fluoride, phosphorus and vitamin D [48]. As a result, it plays a regulatory role in the formation of bone tissue, prevents the development of osteoporosis, improves the absorption of calcium by bone tissue, is necessary for the normal formation of the skeleton in children, and in older age groups it prevents diseases of the spine and joints (osteochondrosis, arthrosis, arthritis) [52,53]. It is established that healthy adults can consume 1-13 mg of boron with food [5].

Vi was detected in the meat of the Black Sea grass shrimp in the amount of ≤ 0.001 mg/100g during fishing periods (Table 3). The current level of knowledge does not allow us to speak definitively about any physiological role of bismuth in the human body [5,6]. It belongs to the category of heavy metals; it is a moderately toxic element.

Thus, studies of the mineral composition of the meat of the Black Sea *Palaemon adspersus* Rathke 1837 showed the presence of all essential, low-toxic, toxic and poorly studied mineral elements. In the spring period of the fishery, statistically significant higher concentrations of elements such as Ca, Mg, Cu, Zn, Mn, Ni were established., Li, Cd, Al, Ba (Table 1-3). This is probably due to the fact that the North-Western part of the Black Sea (NWFM), where fishing and shrimp sampling was carried out, is the most hydrologically dynamic area of the sea [85]. The Dniester, the Dnieper and the Southern Bug, the total flow of which is almost 80% of the total flow into the Black Sea and lead to high chemical pollution of water and bottom sediments in the area of the Odessa coast of the Black Sea in the spring period of the year [86]. It has also been shown that the effluents of these rivers, especially the Danube, are the most important sources of heavy metals. Nevertheless, the accumulation of toxic elements in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 is at an acceptable level and meets the safety requirements [70].

## Conclusion

The mineral composition of the meat of the Black Sea grass shrimp in the spring and autumn periods of fishing in the Black Sea has been studied. The level of essential mineral elements (Ca, K, Na, Mg, Zn, Fe, Mn) is significantly lower than the physiological needs of humans. Statistically significant higher concentrations of Mg, Cu, Mn, Ni, Cd, Al, Ba, in the spring catch period compared to the autumn catch were revealed. However, the level of toxicity of such elements as As, Cd, Pb, Hg, in the meat of the Black Sea *Palaemon adspersus* Rathke 1837 in different fishing periods is significantly lower than the permissible values. Thus, in terms of safety, the meat of the Black Sea *Palaemon adspersus Rathke* 1837 meets the safety requirements and can be used for food purposes.

There are also poorly studied elementes, such as Ag, Ba, Bi, the physiological role of which is in the research stage.

The results of the research indicate the need to monitor the mineral component of shrimp meat in the fishing periods of the year, as well as to study the effect of heat treatment regimes on the mineral status of the meat of the Black Sea grass shrimp.

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