Analysis of technical and chemical characteristics as well as the nutritional value of clams from the Sea of Azov

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Abstract. Clams as a group of burrowing molluscs hold high positions in the world fishery and aquaculture of bivalve molluscs. The paper presents the results of studies of the technical and chemical composition, functional and technological properties as well as the nutritional value of meat of three types of clams harvested in the Kerch Strait towards the Sea of Azov: Anadarakagoshimensis Tokunaga, 1906, Chameleagallina Linne, 1758, Donaxtrunculus Linnaeus, 1758. Shellfish meat is rich in protein substances, being (in % of absolutely dry matter) 77.4, 74.1, 74.8, respectively, for A. kagoshimensis, Ch. gallina and D. trunculus. However, the availability of limiting essential amino acids affects their balance and biological value (%), namely A. kagoshimensis – 48.6, Ch. gallina – 58.8, D. trunculus – 80.0. High iodine content in clams’ tissues was noted. It suggests the possibility of introducing mollusc meat into diets for preventive dietary nutrition. In terms of food saturation, these types of molluscs can be attributed to low-saturated food raw materials, and according to their calorific value, to low-calorie ones. Further investigations in this sphere, the popularization of clam meat as a gourmet product, and world experience in the mollusc farming can ensure the progressive development of clam aquaculture in the Azov-Black Sea basin.

1. Introduction
The commercial value of bivalve molluscs is due to the peculiarities of their structure, lifestyle, and high nutritional value. The mollusc meat is characterized by a high content of proteins and trace elements. It contains a large number of biologically active substances; the life cycle features allow many species forming sufficient concentrations in a relatively short period, which significantly facilitates their cultivation and fishing.

Groups of species such as oysters, scallops, mussels and clams are better known [1−5]. The morphological feature of the clams is the specialized outgrowths of the mantle, i.e. siphons through which water is sucked in and removed to breathe and nourish the mollusc immersed in the ground. Data on the world fishery and aquaculture of burrowing molluscs are presented in the FAO annual reports (Figure 1) [6].

The traditional and most demanded species of bivalve molluscs of the Azov-Black Sea basin are representatives of the genera Mytilus and Ostrea. Clams due to the complexity of their production and processing are practically inaccessible to a wide range of consumers. At the same time, clams’ meat
has a high organoleptic value, stimulates the digestive apparatus, facilitates the assimilation of nutrients and, as a result, forms consumers’ demand in this segment of the seafood market.

Figure 1. Total catches of clams (genera Chamelea, Anadara, Donax) in 1970 – 2016

The paper presents the results of studies of size and mass composition and nutritional value of clams of Azov sea – Donax trunculus Linnaeus, 1758; Anadara kagoshimensis Tokunaga, 1906, Chameleagallina Linne, 1758.

2. Materials and methods
The objects of research were samples of bivalve molluscs Donax trunculus Linnaeus, 1758, Anadara kagoshimensis Tokunaga, 1906, Chameleagallina Linnaeus, 1758 (Syn. Venus gallina), taken in August and September 2019. In the water area of the Kerch Strait (45°15′N, 36°25′E). Sampling and processing of samples were carried out in the field and laboratory conditions according to the generally accepted methods [7].
Studies of the chemical composition were carried out using standard methods adopted in comprehensive chemical analysis, namely: the total content of nitrogenous substances – according to the Kjeldahl method using a FOSS auto-nitrogen analyzer; mineral substances - gravimetrically, after burning at a temperature of 600-700 °C, the composition of macro-and microelements – by capillary electrophoresis, pectin substances – by the calcium-pectate method.

The protein-water coefficient of mollusc meat (%) was calculated as the quantitative ratio of protein to water. Lipid-protein ratio (%) was assessed as the ratio of lipid to protein in the muscle tissue. The coefficient is an indicator of the tenderness of the consistency of meat of aquatic organisms. The food saturation coefficient was determined by the ratio of the sum of proteins, fats and carbohydrates to the mass fraction of water in raw materials [8].

The nutritional value of mollusc meat was assessed under the requirements of the technical regulation of the Customs Union TR CU 022/2011 “Food products in terms of its labelling,” approved by the decision of the Commission of the Customs Union of December 9, 2011 No. 881 [9, p. 15].

Assessment of the biological value of the proteins of mollusc meat was carried out according to the method of H. H. Mitchell & R. J. Block [10], following which the index of a protein to water coefficient of mollusc meat (%) was calculated as the quantitative ratio of the sum of proteins, fats and carbohydrates to the mass fraction of water in raw materials [8].

The results for length and the weight composition of three molluscs species are given in Table 1.

### Table 1. Average data for length and the weight composition of clams from the Sea of Azov.

| Sample weight, g | Weight with shells, g | Length of shells, mm | Meat weight, g | Shell weight, g | Intervalvular liquid, g |
|------------------|-----------------------|----------------------|----------------|----------------|-----------------------|
| **Anadara kagoshimensis**, (\(\bar{x}\pm S_x, n = 29\)), August, 2019 |
| 857              | 29.55 ± 0.86          | 45.4 ± 0.6           | 4.62 ± 0.30    | 22.47 ± 0.68    | 2.47 ± 0.20           |
| 861              | 29.69 ± 0.85          | 45.2 ± 0.7           | 4.68 ± 0.32    | 22.55 ± 0.75    | 2.46 ± 0.22           |
| 854              | 29.45 ± 0.93          | 45.1 ± 0.9           | 4.62 ± 0.27    | 22.28 ± 0.84    | 2.55 ± 0.21           |
| 856              | 29.96 ± 1.10          | 45.2 ± 0.9           | 4.69 ± 0.24    | 22.70 ± 0.85    | 2.57 ± 0.23           |
| **Anadara kagoshimensis**, (\(\bar{x}\pm S_x, n = 29\)), September, 2019 |
| 859              | 29.62±0.88            | 45.6±0.5             | 4.70±0.20      | 22.42±0.73      | 2.51±0.17             |
| 863              | 29.76±0.86            | 45.6±0.5             | 4.72±0.16      | 22.48±0.78      | 2.55±0.20             |
| **Chamelea gallina**, (\(\bar{x}\pm S_x, n = 30\)), August, 2019 |
| 152.4            | 5.08 ± 0.01           | 28.6 ± 1.7           | 0.60 ± 0.02    | 3.33 ± 0.02     | 1.15 ± 0.03           |
| 152.6            | 5.09±0.02             | 28.6 ± 0.7           | 0.61 ± 0.02    | 3.33 ± 0.02     | 1.15 ± 0.03           |
| 152.5            | 5.08 ± 0.01           | 28.7 ± 0.7           | 0.69 ± 0.02    | 3.33 ± 0.01     | 1.14 ± 0.03           |
| 152.6            | 5.08 ± 0.02           | 28.6 ± 0.8           | 0.69 ± 0.01    | 3.32 ± 0.01     | 1.06 ± 0.02           |
| **Chamelea gallina**, (\(\bar{x}\pm S_x, n = 30\)), September, 2019 |
| 152.6            | 5.08 ± 0.01           | 28.5 ± 0.7           | 0.70 ± 0.01    | 3.33 ± 0.02     | 1.06 ± 0.02           |
| **Donax trunculus**, (\(\bar{x}\pm S_x, n = 30\)), August, 2019 |
| 717              | 5.09 ± 0.01           | 28.4 ± 0.7           | 0.68 ± 0.01    | 3.36 ± 0.01     | 1.05 ± 0.02           |
| **Donax trunculus**, (\(\bar{x}\pm S_x, n = 30\)), September, 2019 |
| 718              | 5.09±0.02             | 28.6±1.1             | 0.68±0.01      | 3.35±0.02       | 1.06±0.02             |
| 720              | 5.10±0.02             | 28.7±1.2             | 0.69±0.01      | 3.32±0.04       | 1.09±0.04             |
The studies of length and mass composition made it possible to establish the following characteristics of molluscs:

- for *A. kagoshimensis*: the largest length of the mollusc was 46 mm at the weight of 31.4 g; the average weight of the mollusk was \((29.7 \pm 1.8) \text{ g (} \bar{X} \pm \Delta X \text{ with} \ p = 0.95, n = 174)\), the meat output is 15.7%, the shells made up 75.7% of the total weight of the mollusk.

*Anadara* intervalvar unit liquid (hemolymph) \( (2.5 \pm 0.4) \text{ g}\) is a molluse processing waste and is used in the production of dietary supplements. Due to the hem-containing protein, hemolymph is coloured red. Frozen hemolymph is defrosted, centrifuged, filtered, concentrated and purified with water in an ultrafiltration unit with a membrane passing through globular proteins with a molecular weight of 300 kDa. According to x-ray fluorescence and optical spectroscopy, the produced preparation contains 0.2% iron, being scattered oxyhemoglobin [11];

- *Ch. gallina*: the largest length of the mollusc was 30 mm at the weight of 0.69 g; the average weight of the mollusk was \((5.08 \pm 0.02) \text{ g (} \bar{X} \pm \Delta X \text{ with} \ p = 0.95, n = 180)\), the meat output is 12.8%, the shells made up 65.5% of the total weight of the mollusk;

- *D. trunculus*: the largest length of the mollusc was 32 mm at the weight of 0.74 g; the average weight of the mollusk was \((5.09 \pm 0.04) \text{ g (} \bar{X} \pm \Delta X \text{ with} \ p = 0.95, n = 90)\), the meat output is 13.4%, the shells made up 65.7% of the total weight of the mollusk.

It should be noted the small sizes of molluscs and their one-dimensionality in samples, especially characteristic of species *Ch. gallina* and *D. trunculus*.

There search results for chemical composition and calorific value are given in Table 2.

### Table 2. Chemical composition of clams.

| Target species | Moisture content, % | Mass percentage, % | Calorific value, kJ/100 g |
|----------------|---------------------|--------------------|--------------------------|
|                | protein | ash | fat | carbohydrates |
| *A. kagoshimensis* | 82.4 | 14.4 | 1.9 | 0.7 | 1.3 | 288.8 |
| *Ch. gallina* | 78.7 | 15.7 | 1.2 | 0.9 | 3.4 | 353.2 |
| *D. trunculus* | 80.2 | 11 | 0.9 | 0.8 | 1.8 | 244.1 |

The meat of the molluscs is waterlogged, the content of protein substances is (in % absolute dry matter) 77.4, 74.1, 74.8 respectively for *A. kagoshimensis*, *Ch. gallina*, and *D. trunculus*, carbohydrates \(-7.0, 16.0, 12.2\). Protein-water coefficient (PWC) of *A. kagoshimensis* meat is 17.4%, PWC of *Ch. gallina* meat is 19.9 %, PWC for *Ch. gallina* is 13.4 %. For comparison: PWC of commercial mollusc species meat averages for *Mytilus galloprovincialis* Lam., 1819 as 13.4 %, *Rapana venoza* Valenciennes, 1846 as 17.4 – 26.4 % [7]. The lipid-protein ratio is an indicator of the tenderness of the meat of aquatic organisms: the denser, drier texture of muscle tissue corresponds to low values. For the meat of clams, of clams, it is respectively (%): 0.05, 0.06, 0.07, and *R. venoza* meat is stiffer \(-0.02\).

Analysis of amino acid composition of proteinin tissues of mollusks made possible to detect the availability of all essential amino acid sin species *Ch. gallina*, and *D. trunculus*. The limiting amino acids are as follows: methionine (*Chamelea*); valine, lysine, methionine, threonine (*Donax*) (Table 3, 4). The essential amino acid lysine is not found in *A. kagoshimensis* meat protein. The availability of limiting essential amino acids affects the balance and biological value (BV) of the protein substances of molluscs (%): for *A. kagoshimensis* 48.6 %, *Ch. gallina* as 58.8 %, *D. trunculus* 80.0 %.

Potassium, calcium, magnesium, sodium and phosphorus were detecte damong macrolelements in the mineral composition of mollusc meat (Table 5). Consumption of 100 g of shellfish meat compensates a person for 40-60% of the daily requirement for calcium. *Ch. gallina* meat contains up to 75% of the physiological needs of the body in phosphorus and 25% in magnesium.
An analysis of the results of studies of the technical and chemical composition, functional and technological properties of the shellfish meat, assessment of the biological value of the protein component and calorific value allows talking about their nutritional value and the possibility of using this meat in the preventive dietary nutrition.

4. Conclusion

High iodine content in molluske meat, namely in *D. trunculus* and *Ch. gallina* as 0.042 %, *A. kagoshimensis* as 0.053 % (the physiological norm for an adult 130–200 mcg/day), allows recommending the use of shellfish meat for iodine deficiency diseases of the thyroid gland.
Further activities in this direction, world experience in the cultivation of molluscs, the popularization of clam meat as a delicious product can ensure the progressive development of the clam aquaculture in the Azov-Black Sea basin.

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References
[1] Kim Y G and Kang Y J 1987 Culturing Density and Production of Ark Shell, Anadarabroughtoni Bull. Fish. Res. Dev. Agency 36 81–88
[2] Padella M and Finco A 2009 Governance and bioeconomy in Adriatic clam fishery (Chameleagallina) New Medit N. 3/2009
[3] Boussoufa D, Ghazali N, Rabeh I, Soudani N, Navarro J C and Cafsi M EL 2011 Seasonal variation in condition and fatty acid composition of coquina clam, Donax trunculus (Linnaeus 1758) (Mollusca: Bivalvia) from the Tunisian coast Cahiers de Biologie Marine 52 (1) 47–56
[4] Revkov N K 2011 Quantitative development of macrozoobenthos and its long-term dynamics Commercial bioresources of the Black and Azov Seas (Sevastopol: ECOSI-Hydrophysics) 144–152(Perm Russian)
[5] Revkov N K and Shcherban S A 2017 Features of the biology of the bivalve mollusk Anadara goshimensis in the Black Sea Ecosystems 9 47–56 (In Russian)
[6] FAO – Fishery and Aquaculture Statistics – Antarctic krill global capture production 1950–2017 FishstatJ, available at: www.fao.org/fishery/statistics/software/fishstatj/en
[7] Ed. Abakumova V A 1983 Guidance on methods for hydrobiological analysis of surface waters and bottom sediments (L.: Hydrometeoizdat) (In Russian)
[8] Levandinov I P 1980 Interrelation of the main components and chemical composition of meat of aquatic organisms Fisheries 8 62–64 (In Russian)
[9] 2011 Technical regulation of the Customs Union TR CU 022/2011 “Food products in terms of their labelling” No 881 29, available at: http://docs.cntd.ru/document/902320347
[10] Mitchell H H and Block R J 1946 J. biol. Chm. 163 599
[11] Rutskova T A, Kofanova N N, Kozlovskaya EP, Glazunov V P and Artyukov A A 2006 Patent No. 2286685 Method for producing iron-containing biologically active food additives (11 November 2006)
[12] Bityutskaya O E, Lyubchik V N and Ovsyannikova T N 2012 Use of molluscs in the technology of dietary products Products and market s2 (14) 111–121(In Russian)
[13] Pokrovsky A A 1975 On the biological and nutritional value of food products Nutrition Issues 3 pp 25–40