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Determination of the Nutritional Properties of Snail Meat and Its Comparative Analysis with Other Animal Species

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Abstract. In Ukraine, in today's conditions, snails, which are widely used for food in a number of European countries, are of increased interest. Over the past few years, this type of shellfish has been intensively harvested for processing and exporting abroad. However, there is not much data on the nutritional properties of snail meat, and there is practically no such information in Ukraine. The aim of this study is to determine the chemical composition (wet, dry matter, and energy value) of raw and cooked snail meat *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia* and conducting their comparative analysis among themselves with other types of meat. Indicators of nutritional properties were determined according to the following methods. The moisture and fat content was determined according to DSTU ISO 1442:2005; DSTU ISO 1443:2005, respectively. The mass fraction of dry matter, protein, ash, and caloric content of meat was determined by the methods described by P.V. Zhitenko and others. Comparative analysis of snail meat with other animal species was carried out based on literature sources. In the study, the authors found that on average in snails of the following species: *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia* it contains moisture – 72.03±0.29% and dry matter – 27.97±0.29%, of which: protein – 22.83±0.3%, fat – 0.23±0.03%, carbohydrates – 2.07±0.17%. It was determined that the indicators of moisture, dry matter, protein, fat, carbohydrates, ash and energy value in snails of all three species taken in the experiment did not differ significantly from each other. At the same time a sample of boiled snail meat *Helix pomatia* it has a higher chemical composition compared to the other two types of snails, namely: dry matter (28.5%), protein (23.4%), fat (0.3%) and energy value (103.9 kcal/100 g). Comparing the obtained data on the study of the chemical composition of raw and boiled meat of the same snail species, it was found that boiled meat is 14.2% more energetically valuable than raw, both in kcal/100 g and in kJ/100 g. We consider determining changes in organs at the cellular level, that is, conducting histological studies, taking into account different periods: hibernation, after hibernation and during the active period of their vital activity, to be a promising area of further research

Keywords: chemical composition, snail *Helix aspersa maxima*, snail *Helix aspersa muller*, snail *Helix pomatia*, heat treatment, caloric content



INTRODUCTION

The nutritional value of food products is determined by the content of proteins, fats, carbohydrates, vitamins, minerals, as well as biologically active compounds. Protein is the most valuable component of food, involved in the most important functions of the body. Their main importance lies in their indispensability with other food substances. The need to determine the amount of demand for animal protein, as the most complete and best absorbed, is not in doubt [1; 2].

The usefulness of food products is characterised by nutritional, energy, biological, physiological and organoleptic value, as well as biological efficiency, digestibility and safety. Nutritional value characterises the fullness of the useful properties of the product and its taste preferences, which are conditioned upon the nutrients contained in it. Depending on the energy value, animal meat can be divided into three groups: high-, medium- and low-calorie [3; 4].

The energy value is determined by the proportion of energy that is released from the product during biological oxidation and provides physiological functions of the body and is measured in kCal or kJ. According to modern concepts, the concept of "nutritional value" reflects the full significance of the useful properties of a product, including such more precise definitions as "biological value" (protein quality), "energy value" (the amount of energy released in the body from a food product) [5].

The value of the nutritional value of meat can be defined as the percentage of provision of each of the most important nutrients, the average values of human needs for nutrients and energy [6]. In addition, the nutritional value of a product depends on important factors: the use of individual food substances (biotransformation), the degree of grinding, heat treatment, storage conditions, and other technological factors for processing raw materials [7].

Meat of agricultural and exotic animals and poultry is a combination of muscle, connective, bone, and adipose tissues in their natural ratio. These tissues have different nutritional value, and therefore their ratio affects the nutritional properties of meat. The specific weight of tissues depends on the type, breed of animals, gender, age, fatness and part of the carcass [1; 8]. Notably, meat productivity and the qualitative composition of meat of farm animals and poultry have been studied by many scientists, but the study of these indicators of snail meat in the scientific literature is not sufficiently covered. Most publications in foreign literature in the field of productive snail farming, as a branch of Agriculture, relate to the issues of proper cultivation of shellfish and the useful properties of their meat [2; 6].

Among the traditional types of meat available on the Ukrainian market, such as pork, beef, poultry meat, non-traditional ones also appear. Non-traditional types

of meat include snail meat. Snail meat gained popularity abroad at the end of the last century, as one of the products of delicatessen food. Now farms are being created to grow snails as a source of protein substances. Snail meat is considered only muscle, connective and adipose tissue. The edible part of the snail is its "leg" with which it moves. It is the most important and valuable muscle tissue and is used to make various dishes [9].

Based on the results of the analysis of literature sources, it was found that there are no publications on the nutritional value of snail meat. In particular, there is no information on the chemical composition of food snail meat in terms of moisture, dry matter and energy value, and these indicators after its cooking. Since in the modern world the use of snails in the restaurant industry is mostly gaining momentum, and there are no data on the chemical composition of frozen and boiled meat of these shellfish, the need to determine these indicators is not in doubt.

Purpose of the study it consists in determining the chemical composition: moisture, dry matter and energy value of raw and boiled meat of food snails *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia*, comparative analysis of them among themselves and with other types of meat.

MATERIALS AND METHODS

At the beginning of the experiment, average samples of snail meat of each species were formed, which were selected in early summer – 100 shellfish. To prevent the meat from spoiling, it was frozen for delivery to the laboratory in proper condition. At the second stage of research, an average sample of snail meat of each species was formed – 200 shellfish (based on the boiling coefficient). It was boiled for 90 minutes. Snails were selected during their active use (in mid-summer). At the third stage, an average sample of snail meat of each species was taken, which was taken at the end of the season of their use (in autumn) – 100 shellfish. The research was conducted based on a testing laboratory accredited according to the international standard during 2017-2018.

Before forming an average sample of snail meat, attention was paid primarily to their condition: behaviour, reaction to external stimuli, mobility, that is, only live ones were selected. For research, snails were taken that moved in a calm state, and in a stressful state they hid in a shell. Snails were removed from the shell using a spiral-shaped dental probe (Fig. 1) and only the "leg" of the snail was selected. At the same time, the snail was held in the left hand, and the snail's leg was hooked on the right side of the mouth with the right hand. The shell was placed at an angle of 90 degrees and with a sharp movement of the right hand, the snail was completely removed. Further, only the "leg" of the snail was separated.



Figure 1. Spiral-shaped dental probe

The chemical composition of meat was studied by the moisture content according to DSTU ISO 1442:2005 "Meat and meat products. Method for determining the moisture content" [10], fat – according to DSTU ISO 1443:2005 "Meat and meat products. Method for determining the total fat content" [11]. The mass fraction of dry matter, protein, ash, and caloric content of meat was determined by the methods described by P.V. Zhitenko

and others [12]. Snails of the species *Helix pomatia* collected after rain or early in the morning, *Helix aspersa maxima* and *Helix aspersa muller* they were obtained from the farm "snail 2016" (Ukraine). To calculate the caloric content of meat, you need to know the quantitative content of fats, proteins and carbohydrates in it. The authors of the article used the coefficients of energy value of food substances, which are provided in Table 1.

Table 1. Coefficients of energy value of food substances

Food substances	Coefficient, kcal/g
Proteins	4.0
Fats	9.0
Carbohydrates "by difference"	4.0

To determine carbohydrates "by difference", the amount of moisture, protein, fat and ash is subtracted from 100% of the product. The energy value (X , kcal) is equal to the sum of these components, i.e.:

$$X = 4.0 \times B + 4.0 \times C + 9.0 \times D$$

where 4.0; 4.0; 9.0 are the coefficients of energy value, respectively: proteins, carbohydrates and fats, kcal/g; B is the amount of protein, g, C is the amount of fat, g, D is the amount of carbohydrates, g.

To determine the energy value in kilojoules, the resulting number of kilocalories is multiplied by 4.184. Determination of fat in meat was carried out by extraction, according to the method described in DSTU ISO 1443:2005 "meat and meat products. Method for determining the total fat content" [11]. The mass fraction of fat (X) was determined as a percentage by the formula (1):

$$X_2 = \frac{(m_2 - m_1) \times 100}{m} \quad (1)$$

where m – mass of the sample taken for analysis, g; m_1 – weight of the extraction flask with pieces of porcelain, g; m_2 – mass of the extraction flask with pieces of porcelain with fat after drying, g.

Calculations were performed with errors of $\pm 0.1\%$. The final test result was taken as the arithmetic mean value of the results of two parallel definitions, the permissible difference between which should not exceed 0.5% when performing analyses in the same laboratory.

The study of moisture content was carried out by drying according to DSTU ISO 1442:2005 "Meat and meat products. Method for determining the moisture content" [10]. The mass fraction of moisture (X) as a percentage was determined by the formula (2):

$$X = \frac{(m_1 - m_2) \times 100}{m_1 \times m_0} \quad (2)$$

where m_0 – weight of box with sand and stick, g; m_1 – weight of box with sand, stick and suspension, g; m_2 – weight of box with sand, stick and suspension after drying, g.

The final result was taken as the arithmetic mean of two parallel definitions. The difference between the results of parallel definitions should not exceed 0.5%. The final result was calculated with an error of up to 0.1%.

RESULTS AND DISCUSSION

Chemical composition of frozen and boiled meat of various types of snails

At the first stage, it was frozen meat of snails that were selected in early summer was studied. The results of the

chemical composition of frozen meat of various snail species are presented in Table 2. The results of Table 2 show that the average sample of frozen snail meat *H. pomatia* contains a higher amount of dry matter, namely protein, fat and carbohydrates, and is more energetically valuable compared to the other two samples.

At the second stage of research, after cooking meat and forming an average sample of each snail species from it, the chemical composition of snail meat was determined, which is shown in Table 3.

Table 2. Chemical composition of frozen meat of different types of snails

Indicator	Samples			M±m
	1 (<i>H. pomatia</i>)	2 (<i>H. aspersa maxima</i>)	3 (<i>H. aspersa muller</i>)	
1. Moisture, %	78.2	79.7	80.1	79.33±0.58
2. Dry substance, % of which:	21.8	20.3	19.9	20.67±0.58
– protein	13.3	12.7	12.3	12.77±0.29
– fat	0.2	0.1	0.1	0.13±0.03
– carbohydrates	6.3	5.6	5.2	5.7±0.32
– ash	2.0	1.9	2.3	2.07±0.12
3. Energy value, in: kcal/100 g	80.2	74.1	70.9	75.07±2.73
kJ/100 g	335.3	309.7	296.3	313.77±11.44

Table 3. Chemical composition of boiled meat of different types of snails

Indicator	Samples			M±m
	1 (<i>H. pomatia</i>)	2 (<i>H. aspersa maxima</i>)	3 (<i>H. aspersa muller</i>)	
1. Moisture, %	71.5	72.1	72.5	72.03±0.29
2. Dry substance, including % of which:	28.5	27.9	27.5	27.97±0.29
– protein	23.4	22.7	22.4	22.83±0.3
– fat	0.3	0.2	0.2	0.23±0.03
– carbohydrates	1.9	2.4	1.9	2.07±0.17
– ash	2.9	2.6	3.0	2.83±0.12
3. Energy value, in: kcal/100 g	103.9	102.2	99.0	101.7±1.44
kJ/100 g	434.3	427.2	413.8	425.1±6.01

Analysis of the results obtained in Table 3 showed that the chemical composition, namely: moisture content, protein, fat, carbohydrates, ash and energy value (in kcal/100 g) in snail meat of three species – *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia* don't differ significantly from each other. If we take into account the indicator of energy value in kJ/100 g, then the most nutritious was the meat of grape snails and amounted to 434.3 kJ/100 g, and the least – the meat of snails of the species *Helix aspersa muller* – 413.8 kJ/100 g.

Comparing the data of frozen and boiled meat of different types of snails, which are shown in Tables 2 and 3, it can be seen that after heat treatment, the amount of dry

matter increased by 1.35%, protein – 1.79%, fat – 1.77%, ash – 1.37% and energy value – by 1.35%.

Comparative characteristics of the nutritional value of frozen snail meat

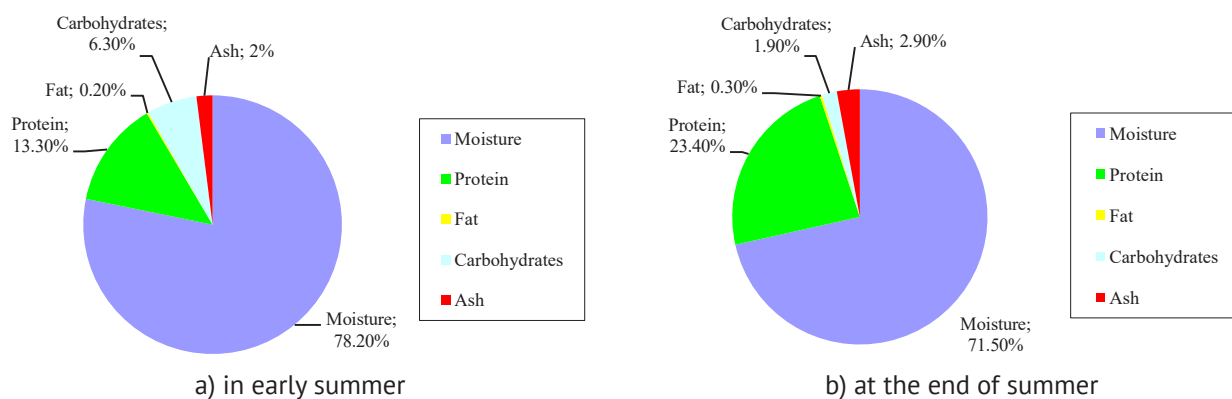
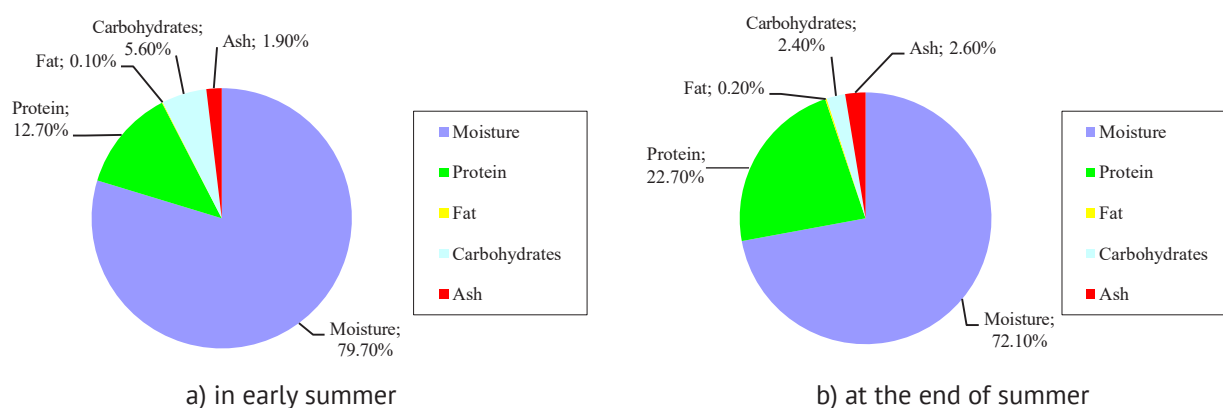
Snail meat differs in its nutritional value not only among different animal species, but also during the periods of their vital activity. Therefore, it became necessary to conduct a study to determine the nutritional value of snail meat during the period of their most active life, when products are obtained from them. For the first sample, snails were taken in early summer, and the second – at the end. The research results are presented in Table 4.

Table 4. Comparative characteristics of the nutritional value of frozen snail meat during their possible consumption

Indicator	Type of snails					
	<i>H. pomatia</i>		<i>H. aspersa maxima</i>		<i>H. aspersa muller</i>	
	1 sample	2 sample	1 sample	2 sample	1 sample	2 sample
1. Moisture, %	78.2	78.0	79.7	77.8	80.1	77.8
2. Dry matter, including % of which:	21.8	22.0	20.3	22.2	19.9	22.2
– protein	13.3	9.6	12.7	9.4	12.3	9.2
– fat	0.2	0.7	0.1	0.6	0.1	0.6
– carbohydrates	2.0	10.7	1.9	11.0	2.3	11.3
– ash	6.3	1.0	5.6	1.2	5.2	1.1
3. Energy value, in: kcal/100 g	80.2	87.5	74.1	87.0	70.9	87.4
kJ/100 g	335.3	366.3	309.7	364.2	296.3	365.8

The data shown in Table 4 indicate that the nutritional value of snail meat in early and late summer is different. Thus, the indicators of dry matter, fat, carbohydrates and energy value increased, while moisture, protein and ash – on the contrary – decreased. The increase in the content of carbohydrates and fats is obviously

conditioned upon the preparation of snails for the winter period and the use of these substances in metabolic processes in an anabiotic state. Data on the composition of snail meat at different periods of their possible consumption are shown in diagrams (Fig. 2, 3, and 4).

**Figure 2.** Composition of snail meat *H. pomatia* in different periods of life activity**Figure 3.** Composition of snail meat *H. aspersa maxima* in different periods of life activity

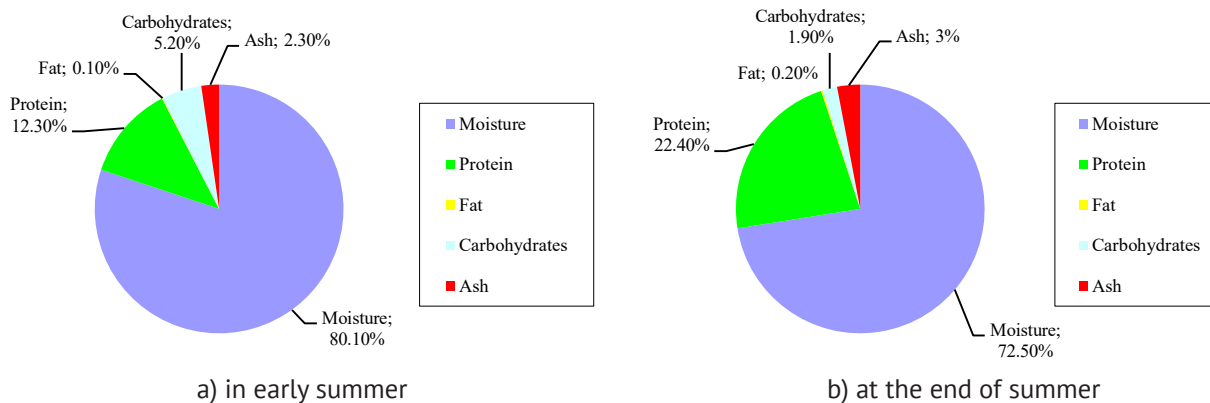


Figure 4. Composition of snail meat *H. aspersa muller* in different periods of life activity

Protein is the most valuable component of meat, which makes up 95% of all nitrogenous substances in the body. In terms of amino acid composition, they are closest to the "ideal" animal proteins, since they contain all essential amino acids in optimal amounts and ratios. After heat treatment of snail meat, it was found that out of 27.97% of dry matter, 81.6% is protein, 0.8% (on average) [13].

When determining the nutritional and biological value of snails, it is necessary to consider the conditions of their cultivation. Artificially grown snails have a lower biological value than naturally grown snails, and the differences are explained by the strength of their shells, meat yield, and chemical composition. In the meat of snails of the natural population *Helix pomatia* contains 3.0% more protein than snails *Helix aspersa maxima* and 4.27% more than snails *Helix aspersa muller*. That is, if necessary, snails of the natural population can be used as a source of protein nutrition [14].

Comparative studies of snail meat with meat of other animal species

The nutritional properties of any meat are conditioned upon the presence of proteins and fats in it. Comparative studies of snail meat with meat of other animal species showed that in terms of nutritional and energy value, they can be compared with pork, beef, lamb, horse meat, rabbit meat. These types of meat contain from 40% to 75% moisture, from 14% to 23% protein, from 2% to 22% fat. At that time, snail meat contains from 77.8% to 80.1% moisture, from 9.2% to 13.3% protein, from 0.1% to 0.7% fat. The difference in meat composition depends primarily on the type of snails and the period of their consumption [15-17]. When comparing the data on the chemical composition and caloric content of snail meat with other types of meat of farm animals and poultry, it turned out that it is closest to chicken meat. Chicken meat contains 20.4% protein and 2.3% fat, while snail meat contains 22.8% protein and 0.2% fat [1].

The nutritional value and caloric content of farm animal meat depends on the type of meat, breed, age and fatness of the animals. Young animals have a lower

caloric content of meat compared to adults, because their meat contains more moisture and protein, and less fat. Animal proteins are absorbed better by humans than vegetable proteins. And to meet the needs of the body with meat proteins and the need for them is less than vegetable. If we are talking about snail meat, then the nutritional value and caloric content, according to the authors, depends again on the period of their consumption and the type of snails.

A number of scientists have studied that the meat of farm animals contains from 1.1% to 40% fat. Pork has the highest fat content – 37%, beef – 23%, Lamb – 26%. Less fat-rich rabbit meat – 11%, etc. The digestibility of fats depends on their melting point. The most refractory is lamb fat, which is digested by 85%, then beef fat, which is digested by 94% and pork fat – by 97%. These properties of meat fats are associated with the presence of saturated and unsaturated fatty acids in the composition. Lamb fat contains more saturated fatty acids than pork or beef fat, so it is more refractory. Fat improves the taste of meat, increases its nutritional value. During our research, it was found that snail meat contains almost no fat and is only 0.7%. This indicates that this type of meat can be classified as dietary, as it contains traces of fat. The caloric content of snail meat is up to 87.5 kcal/100 g – these data also indicate that the meat of all three types of snails is dietary [8; 18; 19].

If you compare the protein indicators in the meat of different animal species, then snail meat can be compared with beef. In snails, its indicator reaches 13.3%, and in beef 14.3% [15]. The chemical composition of snail meat is determined by the quality of the environment in which they stay for the entire period of life. It is not constant, but is subject to minor fluctuations that depend on the time of year, environmental conditions, their physiological state, etc.

The use of mussel meat is also very similar in terms of promising direction of increasing the volume of non-traditional meat and in terms of nutritional indicators. Mussel meat contains: moisture – 80-81%, protein – 10-11%, fat – 1.3-1.5%, carbohydrates – 3.5-4%, while snail meat contains: moisture – 79.3%, protein – 12.8%,

fat – 0.1% and carbohydrates – 5.7% (average data for three types of snails). Thus, snail meat and mussel meat differ significantly only in terms of fat and carbohydrates. Snail meat contains less fat and more protein, compared to mussel meat – this indicates a high nutritional value of snail meat [19; 20].

In terms of their environmental friendliness, snails are considered environmentally friendly animals compared to agricultural ones. Artificial snails are kept in the field from April to October, and snails of the natural population are generally kept in natural living conditions every year. This suggests that snails do not consume hormones and antibiotics, and are not kept in cramped stalls or farms, unlike farm animals.

When justifying the general conclusion about the nutritional value of snail meat and comparing the results obtained during the experiment with the data of other scientists who studied the nutritional properties of farm animal meat, it was found that the moisture content of snail meat is close to mussel meat, and the protein content is close to beef. And in terms of fat content, it is not similar to any type of meat. The content of carbohydrates and ash in meat, today, remains a little-studied issue. If you analyse non-traditional types of meat, snail meat is similar to mussel meat, but differs in terms of fat and carbohydrates.

CONCLUSIONS

The composition of boiled meat of snail species is determined: *Helix aspersa maxima*, *Helix aspersa muller*, *Helix*

pomatia, namely, the following indicators: moisture, dry matter (protein, fat, carbohydrates and ash), as well as its energy value. The highest rates were found in the meat of snails in the natural population – *Helix pomatia*, except for moisture, carbohydrates, and ash. The meat of the same snail species is rich in protein and reaches 82.1% of the dry matter. All three experimental snail species have the lowest fat content of all the indicators studied, and on average this indicator was $0.23 \pm 0.03\%$.

So, on average, boiled meat of the above – mentioned snail species contains moisture – $72.03 \pm 0.29\%$, and dry matter – $27.97 \pm 0.29\%$. Of the dry matter indicators, protein accounts for an average of $22.83 \pm 0.3\%$ for all three snail species, and the snail is the most enriched with this nutrient *Helix pomatia* and it is 23.4%. When studying the chemical composition of raw and boiled snail meat, we found that boiled meat is 14.2% more energetically valuable than raw meat, both in kcal/100 g and in kJ/100 g.

We consider it necessary to make histological studies of snails in different periods as a promising area of further research: hibernation, after hibernation and during the active period of their vital activity.

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Визначення поживних властивостей м'яса равликів та його порівняльний аналіз з іншими видами тварин

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Анотація. В Україні, в умовах сьогодення, підвищений інтерес викликають равлики, що широко використовуються в їжу в ряді європейських країн. Протягом кількох останніх років відбувається інтенсивна заготівля цього виду моллюсків з метою його переробки та експорту за кордон. Проте даних щодо поживних властивостей м'яса равликів не так багато, а в Україні таких відомостей практично немає. Мета цього дослідження полягає у визначенні хімічного складу (волога, суха речовина та енергетична цінність) сирого та вареного м'яса харчових равликів *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia* та проведенні їх порівняльного аналізу між собою з іншими видами м'яса. Показники поживних властивостей визначали згідно з методиками. Вміст води та жиру визначали за ДСТУ ISO 1442:2005; ДСТУ ISO 1443:2005 відповідно. Масову частку сухої речовини, білку, золи та калорійність м'яса визначали за методиками, що описані П.В. Житенко та інші. Порівняльний аналіз м'яса равликів з іншими видами тварин проводили на основі літературних джерел. При дослідженні авторами було встановлено, що в середньому у равликів видів *Helix aspersa maxima*, *Helix aspersa muller*, *Helix pomatia* міститься води – 72,03±0,29 % та сухої речовини – 27,97±0,29 %, з якої: білку – 22,83±0,3 %, жиру – 0,23±0,03 %, вуглеводів – 2,07±0,17 %. Визначено, що показники води, сухої речовини, білку, жиру, вуглеводів, золи та енергетичної цінності у равликів всіх трьох видів, що були взяті у дослід, між собою суттєво не відрізнялися. Водночас проба вареного м'яса равликів *Helix pomatia* має вищі показники хімічного складу порівняно з іншими двома видами равликів, а саме: сухої речовини (28,5 %), білку (23,4 %), жиру (0,3 %) та енергетично цінніше (103,9 кКал/100г). Порівнюючи отримані дані щодо вивчення хімічного складу сирого та вареного м'яса цих же видів равликів, було з'ясовано, що варене м'ясо на 14,2 % енергетично цінніше за сире, як у кКал/100 г, так і в кДж/100 г. Перспективним напрямом подальших досліджень вважаємо визначення змін органів на клітинному рівні, тобто проведення гістологічних досліджень, враховуючи різні періоди: сплячка, після сплячки та в активний період їх життєдіяльності

Ключові слова: хімічний склад, равлик *Helix aspersa maxima*, равлик *Helix aspersa muller*, равлик *Helix pomatia*, термічна обробка, калорійність