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Comparative assessment of meat carcass quality of healthy and fasciolosis-affected animals

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ABSTRACT

Background: Fasciolosis is a zoonotic disease that primarily affects cattle in Armenia, leading to significant economic losses. Due to the absence of an integrated plan to combat fasciolosis in the Republic of Armenia, there is a lack of statistical data, and no systematic registration or diagnostic measures are conducted for animals affected by the disease. Additionally, milk and meat from animals undergoing curative and preventive treatments are often sold without considering the appropriate waiting period or the nutritional value of the products. As a result, the population and food industry receive food and raw materials that do not meet the required nutritional standards.

Objectives: The objective of this study is to investigate the nutritional value of meat carcasses obtained from animals suffering from fasciolosis and supplied to the population of the republic. This includes analyzing caloric content, protein levels, fat, ash, and moisture content. Approximately 70% of the cattle bred in small rural farms are locally acclimatized, low-yielding meat-and-dairy crossbreeds.

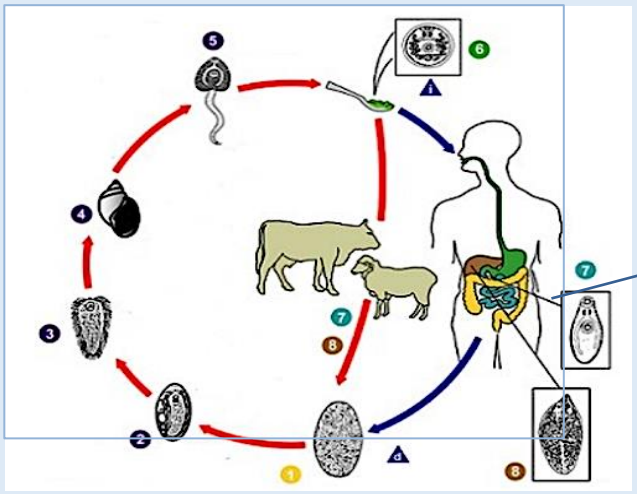
Methods: The research was conducted in the laboratory of the Research Center of Veterinary Medicine and Veterinary Sanitary Expert Examination at the Armenian National Agrarian University. Samples of meat carcasses and offal from infected animals were collected from slaughterhouses in the Ararat region.

For the formation of research groups, the presence of pathogens in the liver and the extent of bile duct damage were used as criteria. The samples were divided into three groups: The first group served as a control, consisting of muscle tissues taken from the carcasses of seven healthy cattle. The second group, labeled as slightly affected, included 16 cattle whose livers contained pathogens, though the infection of the bile ducts was not significantly pronounced. The third group, labeled as severely affected, included 15 cattle with livers whose bile ducts were severely damaged and calcified.

Results: Although no qualitative deviations were observed in the organoleptic properties of meat from animals affected by fasciolosis, the chemical composition and physicochemical properties of this valuable food product have undergone significant changes. Specifically, caloric content decreased by 1.85-3.35%, protein levels by 8.49-12.3%, and fat content by 9.71-17.11%. In contrast, ash content increased by 8.45-25.35%, and moisture content rose by 3.86-8.41%.

Conclusion: The scientific novelty of this study lies in the investigation of the decline in nutritional value observed in meat from animals with fasciolosis. The research results demonstrate that the chemical composition of meat carcasses from animals affected by fasciolosis is directly related to the degree of infection. Infected animals show a decreased nutritional value, primarily due to a reduction in the most valuable component—protein. Additionally, the ratio of protein to fat decreases, in contrast to the higher levels found in the meat of healthy animals. These changes lead to a reduction in the overall nutritional value of the meat carcass, resulting in the population consuming meat of lower nutritional quality.

Keywords: fasciolosis, calorie content, meat carcass, large cattle.



1. Eggs
2. Miracidia in eggs,
3. Miracidia,
4. Water snail,
5. Cercariae,
6. Adolescariae,
7. Fascioles

INTRODUCTION

Ensuring the availability of healthy raw materials for the food industry and providing the population with complete nutrition are among the top priorities for the agro-industry. However, achieving these goals is hindered by several challenges, including the prevalence and impact of parasitic diseases. Despite the implementation of modern antiparasitic drugs and preventive measures, the global spread of these diseases continues to rise [1].

The human digestive system is a complex ecosystem that consists of a vast array of microorganisms, collectively known as the gut microbiota, which are necessary for humans' wellbeing [2]. As research provides evidence of a relationship between food and health, it is necessary to address this new realm of understanding to be properly regulated. Functional foods are characterized by the presence of bioactive compounds, which are molecules that improve health through physiological mechanisms [3]. Functional food science can be viewed as an interdisciplinary field that is dedicated to discovering and developing food bioactive compounds for symptom management and risk reduction for chronic and viral diseases. Food bioactive compounds (FBCs) are nutritive and non-nutritive compounds naturally found in food and elicit a bioactive impact on the human body, ideally to promote health [4]. The increase in animal protein consumption, especially in developing countries, has actually led to a decrease in the per capita share of red meat. Meat is composed by a group of muscle, connective, and fatty tissue [5] .

Parasitic diseases, such as fascioliasis, represent significant socio-economic challenges for society. Fascioliasis, a zoonotic disease primarily affecting cattle in Armenia, inflicts substantial economic damage on the livestock industry. This damage is multifaceted, including reduced productivity of infected animals, decreased live weight, diminished food yield, impaired reproductive function, lower quality of products, spoilage of meat and by-products, and increased costs for medical and preventive interventions.

In the republic, the lack of a unified, planned approach to combat fascioliasis has resulted in an absence of statistical data, as well as measures for the registration and diagnosis of infected animals [6].

The government's current agrarian policy aims to satisfy the population's nutritional needs. However, the quantity and quality of meat and by-products produced do not consistently meet the intended standards.

Meat holds a prominent position in the human diet as a vital source of protein and fat. It also provides essential minerals, carbohydrates, nitrogenous and non-nitrogenous extractives, water, enzymes, and vitamins, all of which are crucial for maintaining human health.

Meat is a crucial source of essential amino acids that the body cannot synthesize on its own, including valine, leucine, isoleucine, lysine, methionine, threonine, tryptophan, and phenylalanine. Additionally, it provides important vitamins such as B1, B2, B6, PP, and B12, along with minerals like iron, selenium, and zinc. Meat is composed of protein content ranging from 18-22%. Meat also contains essential amino acids and fat-soluble vitamins, such as A, D, E, and K, as well as the B and C group of vitamins. As a consequence of customer demand or severe rivalry, the meat business is the most significant in the world [1-5].

These nutrients are vital for maintaining overall health. Extractives, another key component of meat products, are chemical compounds that enhance the taste and aroma of meat dishes and play a stimulating role in digestion [7].

In the Republic of Armenia, limited resources, widespread poverty, and a lack of awareness among the population about disease transmission contribute to the spread and persistence of various diseases. Furthermore, milk and meat obtained from animals undergoing curative and preventive treatments are often sold

without observing the appropriate waiting period or considering the nutritional value of these products. Consequently, the food industry and the population are often supplied with food and raw materials that do not meet nutritional standards and may sometimes be unsafe [8].

Purpose: This study aims to investigate the nutritional value of meat from animals affected by fascioliasis that are supplied to the population. The analysis will focus on key nutritional parameters, including caloric content, protein, fat, ash, and moisture content.

Fascioliasis is a prevalent zoonotic disease in many countries worldwide [9].

While several dozen species of animals are susceptible to fascioliasis, the infection rate in cattle is 1.47 times higher than in other animals.

Human fasciolosis is a significant public health issue in many countries worldwide. This disease is prevalent across Europe, Africa, Asia, the Americas, and Oceania, with over 17 million people currently infected [9-10].

The causative agents of fasciolosis are the trematodes *Fasciola hepatica* and *Fasciola gigantica*, which reside in the bile ducts of the liver during their adult stage. The biological activity of these pathogens within the host leads to damage to the hepatobiliary system in both animals and humans [11-12].

These trematodes parasitize the liver bile ducts of humans and a wide range of herbivorous animals, including cattle, sheep, goats, and, less commonly, pigs, horses, dogs, and other animals. Fascioliasis has been documented in more than 50 countries, causing substantial economic losses to national economies. The global economic impact is estimated to be approximately $3 billion annually, primarily due to liver degradation and the subsequent decline in food production. In Switzerland, the economic loss per infected animal is approximately 299 euros, while in some regions of Tanzania, the livers of infected animals are entirely compromised [13-14].

The presence of multiple animal species on a farm increases the risk of fasciolosis infection [15].

To improve the diagnosis of this disease, advanced methods and equipment have been introduced. Currently, the PCR diagnostic test is more effective than immunoenzymatic and coprological tests [16].

Fasciolosis causes irreversible organic changes in the bodies of infected animals, leading to a decrease in both the quantity and quality of food products derived from them. Meat from diseased animals is characterized by a dark reddish color, higher moisture content, and less flavor compared to meat from healthy animals. These pathological changes result in the development of dystrophic processes in organs and tissues, significantly reducing the nutritional value of the products [17-19].

In the Republic of Armenia, the issues related to the nutritional completeness and safety of meat obtained from animals affected by fasciolosis have been infrequently studied.

MATERIALS AND METHODS

The research was conducted in the laboratory of the Research Center of Veterinary Medicine and Veterinary Sanitary Expertise at the National Agrarian University of Armenia. Meat and offal samples from affected animals were collected from slaughterhouses in the Ararat Marz region.

From a sanitary evaluation perspective, the suitability of healthy meat an important source of functional food is crucial. The shelf-life index of the meat is assessed based on the level of bacterial contamination. Research on the microbial contamination of skeletal muscles and internal organs of cattle was conducted in accordance with the GOST 21375-75 standard. For microbiological examinations, two smear impressions were prepared: one from the surface of organs and tissues, and another from deeper layers.

These smears were air-dried, stained using the Gram method, and then observed under a microscope. Microbe counts were conducted across five fields of view, with the arithmetic mean calculated.

To evaluate the epidemiological situation of fasciolosis, the study utilized results from coprological analysis of fecal samples taken before slaughter, along with data from post-slaughter examinations of meat and liver.

Post-mortem meat sampling was conducted on 38 animals, with stool samples individually collected from the rectum in separate plastic bags for coprological methods. A total of 63 stool samples were analyzed using sequential washing methods.

Histological studies and veterinary-sanitary assessments of the quality of livestock products were performed following standard methodologies. Veterinary-sanitary examinations of carcasses and internal organs were conducted by inspecting slaughterhouse animals and evaluating the quality of meat and meat products.

GROUP CLASSIFICATION

Control Group: The first group served as the control, consisting of 7 healthy cattle. No pathogen eggs were found in their feces, and there was no liver damage detected. Muscle tissue samples from these animals were used for the study.

- **Second Group (Weakly Affected):** This group included 16 cattle that had detectable particles and occasional eggs of the pathogen in their feces. While pathogens were present in the liver, the bile duct lesions were not pronounced.
- **Third Group (Severely Affected):** The third group comprised 15 cattle with a high number of eggs in their feces. The bile ducts of their livers were heavily infected with pathogens, resulting in significant damage to the bile duct walls (as depicted in Graphical Abstract).

Figure 1. Liver affected by fascioliasis.

Figure 2. Liver affected by fascioliasis.

Laboratory Methods: For meat sampling and laboratory analysis, internationally approved methods and GOST standards were followed. The caloric content of the meat was calculated using the following formula:

$$K=4.1C+5.2F-4.1Z$$

Where:

- K is the caloric content of the meat, expressed in kilocalories (kcal).
- C is the amount of dry matter, in grams.
- F is the amount of fat, in grams.
- Z is the amount of ash, in grams.

Statistical analysis: A systematic search of research articles was conducted in databases of PubMed, Web of Science, Scopus, Google Scholar, and ResearchGate, as well as other websites, as well as several traditional books.

The data were exported to STATA software version 14 for analysis after all pertinent findings had been extracted and placed in Microsoft Excel 2021. The research groups were formed based on the presence of pathogens in the liver and the extent of bile duct damage, with samples categorized into three groups according to the degree of contamination.

RESULTS AND DISCUSSION

The research findings indicate that in the Republic of Armenia, meat from animals affected by fasciolosis is of lower quality compared to meat from healthy animals. This is demonstrated in Table 1 below.

Table 1. Chemical Composition of Meat from Animals with fasciolosis.

Indicators	1st Group (Control) n=7	2nd Group (Slightly Affected) n=16	3rd Group (Severely Affected) n=15
Caloric content (kcal)	112.23 ± 6.21	110.16 ± 5.92/1.85%	107.35 ± 5.48 / 3.35%
Proteins (%)	18.7 ± 0.62	17.3 ± 0.55 / 8.49%	16.4 ± 0.72 / 12.3%
Fats (%)	3.8 ± 0.12	3.44 ± 0.21 / 9.71%	3.15 ± 0.29 / 17.11%
Ash (%)	1.42 ± 0.2	1.54 ± 0.18 / 8.45%	1.78 ± 0.15 / 25.35%
Moisture (%)	72.5 ± 0.75	75.3 ± 0.68 / 3.86%	78.6 ± 0.45 / 8.41%

*P<0.05

Animals affected by fasciolosis, although there were no violations in meat quality based on organoleptic indicators, the chemical composition and physico-chemical properties of this valuable product were altered. Specifically, caloric content decreased by 1.85-3.35%, protein levels dropped by 8.49-12.3%, fat content was reduced by 9.71-17.11%, ash content increased by 8.45-25.35%, and moisture levels rose by 3.86-8.41%.

Additionally, as part of evaluating meat as a functional food source, a qualitative analysis of microbes was performed simultaneously in the butchery. The analysis included the following indicators: the number of mesophilic aerobic and facultative anaerobic bacteria, bacteria from the group of intestinal fungi, bacteria of the genus Proteus and Salmonella, as well as the presence of Listeria monocytogenes pathogens.

To assess the quality and sanitary conditions of the meat from cattle with fasciolosis, bacterial contamination was determined using the bacterioscopy method, as detailed in Table 2.

Table 2. Bacterial contamination of skeletal muscle and viscera of bovine animals with fasciolosis (number of bacteria per field of view)

Group	Muscles	Liver	Lymph Nodes	Lungs	Spleen
Control Group	1.18 ± 0.23	0.44 ± 0.32	1.47 ± 0.51	1.51 ± 0.39	0.62 ± 0.35
Weakly Infected	1.32 ± 0.48	1.02 ± 0.54	1.88 ± 0.33	2.14 ± 0.26	1.05 ± 0.42
Heavily Infected	3.12 ± 0.74	2.36 ± 0.82	2.91 ± 0.47	4.65 ± 0.98	2.11 ± 0.57

Gram-positive bacteria, including micrococci, streptococci, and staphylococci, were identified in the smears. During the sanitary microbiological examination, no bacteria from the group of intestinal fungi, the genus Proteus, the genus Salmonella, or Listeria monocytogenes pathogens were detected in any of the examined samples, indicating the safety of the meat. The results of the general bacterial examination reveal that non-pathogenic bacteria are present on both the surface and in the deep layers of the meat from animals affected by fasciolosis. Notably, the bacterial count in smears taken from the organ tissues of animals with fasciolosis is approximately three times higher than in the meat of healthy animals.

The research findings indicate that bacterial contamination of organ tissues increases with the severity of the fasciolosis infection. Consequently, the quality of meat from cattle heavily infected with fasciolosis is inferior to that of healthy cattle. Therefore, it is essential to minimize its inclusion in the human diet and direct it towards industrial processing.

To further explore the effects of consuming such meat, five employees from the research center, who were informed of the fasciolosis infection and agreed to participate in a non-life-threatening scientific experiment, incorporated a dish made from the affected meat into their daily diet. Within 24 hours, some participants reported symptoms such as difficult digestion, diarrhea, bloating, and gas.

These clinical signs underscore the necessity of properly identifying, separating, labeling, and processing meat from animals infected with parasites to ensure it is not consumed in its raw form.

Based on the findings, it is concluded that meat from animals infected with fasciolosis is not suitable as a source of functional food. Compared to meat from healthy animals, it possesses lower sanitary and nutritional properties, making it unsuitable for functional food purposes.

In the context of functional food, the consumption of wholesome and healthy food is vital. Healthy meat products have a high functional value and caloric content, which is not the case for meat affected by fasciolosis.

Scientific research continues to investigate the adverse effects of consuming compromised food, aiming to prevent them. Meat from fasciolosis-infected animals can cause undesirable functional changes in the human body.

Therefore, it is crucial to emphasize further research on meat and meat products from a functional perspective, ensuring that only healthy products reach consumers.

During the veterinary and sanitary inspection, the slaughtered products were divided into three groups based on the degree of liver fasciolosis invasion: Group I

control sample – 3 heads, Group II (low degree of invasion) – 2 heads, Group III – (high degree of invasion)- 5 heads.

Quantitative assessment of carcass parts at low and medium intensity fasciolosis is important for determining the marketability of slaughter products. The invasion of F. hepatica has a negative effect on the yield of varietal carcass cuts. The results of the conducted research are presented in the Table 3. The reduction in the pre-slaughter mass of animals naturally affects the outcome of the slaughter mass. Compared to healthy animals, those with mild fascioliasis yield about 33 kg of meat, while those with severe infection yield 66 kg, and the corresponding slaughter outcomes are 59.28%, 55.46%, and 47.24%, respectively.

Table 3. Indicators of slaughter weight and slaughter yield of sick animals with fascioliasis and healthy animals.

Groups of animals	Before the murder Live weight, kg	Slaughter weight, kg	Slaughter exit, %
Control sample / Clinically healthy/	425,52±4,31	252.24±2.48	59.28±1.57
Slightly affected by fascioliasis	395,41±3.48	219.33±2.74	55.46±2.04
Severely affected by fascioliasis	387.66±2.58	186.13±2.93	47.24±2.13

Table 4. Comparative indicators of meat portions obtained from the slaughter of animals with and without fascioliasis.

Groups of animals	Slaughter weight, kg	Fragmented portions of meat, %								
		Neck	Mustaches	The back part	Taliyasbana	Hip	Marginal	Small pieces	Front shank	Rear shin
Control sample / Clinically healthy/	252.24±2.48	9.7	13.1	34.2	9.3	28.0	1.8	1.8	1.9	2.0
Slightly affected by fascioliasis	219.33±2.74	9.0	12.8	33.2	9.4	27.1	2.1	2.1	2.1	2.2
Severely affected by fascioliasis	186.13±2.93	8.5	12.5	30.5	12.7	25.3	2.3	2.8	2.6	2.8

The meat portions from the neck, shoulder, thoracic, and hip areas of animals with mild and severe fasciolosis are lower, expressed as percentages, when compared to the corresponding portions from healthy animals. In contrast, the portions from the lumbar, marginal, front, and hind limbs are higher. This indicates that the muscular and fatty tissues in the meat of healthy animals are more predominant compared to the meat obtained from those suffering from fasciolosis. The results of the conducted research on comparative indicators of meat portions obtained from the slaughter of animals with and without fascioliasis are presented in the Table 4.

CONCLUSION

The scientific novelty of this study lies in the investigation of the decline in nutritional value observed in meat from animals with fasciolosis.

The research results indicate that the chemical composition of meat from animals with fasciolosis is directly influenced by the degree of infection. Infected animals show nutritional value, primarily due to a decrease in the most valuable component—protein. The ratio of protein to fat also declines, in contrast to the higher values observed in healthy animals. These changes lead to a reduction in the overall nutritional value of the meat, resulting in the population consuming meat of lower nutritional quality.

Irreversible changes can occur in the human body as a result of consuming fasciolosis-affected meat, and it is recommended that such meat should only be used after thorough industrial processing.

Authors Contributions: VG and NH coordinated the execution of research and the design of the article. LG has developed a research methodology and organized the continuity of research work. VA, AG, GP conducted a study of the chemical composition of meat obtained from animals with fasciolosis. SY and ZM conducted a study of bacterial contamination (the number of microbes in the field of view) of skeletal muscles and internal organs of cattle with fascioliasis. SA contributed to the statistical processing. RG conducted a morphological study of the meat of healthy and fascioliasis-affected cattle.

Competing interest: The authors declared that there is no competing interest.

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