



Impact of intestinal parasites on chicken meat quality and restoration by yogurt supplementation

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ABSTRACT

Background: Chicken play a crucial role in human development. It not only serves as a source of energy for the body, but contributes to tissue formation, metabolic processes, organic compound synthesis. In fact, chicken meat is considered a balanced, dietary source of amino acids, making it suitable for use in functional, therapeutic, preventive, and pediatric nutrition. Due to its nutritional value and affordability, chicken meat has become valued across disciplines, from medicine to science to culture. Moreover, it is not subject to national or religious restrictions. Chicken meat qualifies as a functional food because it naturally contains all the essential components needed for human growth and development without the need for additional supplements.

Objectives: This study had two objectives. The first was to compare the nutritional value, completeness, and suitability as a functional food between meat obtained from healthy chickens and chickens infected with intestinal parasites in rural areas of the Republic of Armenia. The second was to determine the effect of yogurt supplementation on the recovery of the infected chickens from the pathologies induced by the intestinal parasites.

Methods: The research was conducted in 2023–2024 in small private poultry farms across various regions of Armenia. Laboratory analyses were performed at the Veterinary and Veterinary-Sanitary Expertise Research Center of the Armenian National Agrarian University. Fecal samples from chickens were analyzed using Fülleborn and Darling flotation methods to detect helminth and Eimeria oocysts. Blood samples taken from chickens before slaughter were analyzed using the Micro CC 20 Plus analyzer. Biochemical analyses of the meat were conducted with the Clima MC-15 biochemical analyzer. Microsoft Excel 2010 was used for statistical analysis of the results.




Results: According to our findings, intestinal parasites have a significant impact on the nutritional value of chicken meat, posing health risks to consumers and resulting in considerable economic losses in poultry farming. Infected birds displayed stunted growth and reduced muscle mass, resulting in diminished meat quality and nutritional value.

Novelty: This research uniquely demonstrates the efficacy of a simple, accessible intervention for intestinal parasites in chickens. Daily supplementation of 20g of cow's milk yogurt for 10 days significantly reverses the detrimental hematological and meat quality alterations caused by infection, including partial restoration of amino acid levels in both breast and thigh meat. This novel application of a standard fermented product offers a cost-effective and sustainable alternative or complementary strategy to conventional anthelmintics, representing a significant innovation in poultry health management.

Conclusion: Meat obtained from chickens infected with intestinal parasites has lower nutritional value and does not meet functional food standards. However, supplementing their diet with 20g of cow's milk yogurt for 10 consecutive days helps restore almost complete amino acid content in the meat. Although the amino acids present in yogurt were not fully absorbed by the chickens, the yogurt markedly improved the chickens' intestinal microflora, which enhanced digestion and lead to a recovery of amino acid levels in the chicken meat.

Keywords: helminthiasis, caloric content, poultry, chicken, nutritional value, yogurt supplementation, functional poultry feed, functional food

Comparison of Chicken Meat Characteristics

	 Healthy Chicken Meat	 Infected Chicken Meat	 Yogurt Supplemented Meat
Moisture Content	Normal	Increased	Recovering
Ash Content	Normal	Increased	Recovering
Protein Content	Normal	Decreased	Recovering
Fat Content	Normal	Decreased	Recovering
Nutritional Value	High	Decreased	Recovering
Amino Acid Levels	Normal	Decreased (most)	Recovering
Erythrocytes, Hemoglobin, Platelets	Normal	Decreased	N/A
Leukocyte Counts	Normal	Increased	N/A
Muscle Mass	Normal	Stunted	N/A

Graphical Abstract: Chicken meat characteristics before and after yogurt supplementation.

INTRODUCTION

In Armenia, the chicken population has been steadily increasing, currently reaching around 4.8 million. While comprehensive statistics on small, free-range poultry farms are lacking, it is estimated that approximately one-third of the total chicken population is kept in such conditions. Armenia is just one example, of a global trend. Poultry farming has become one of the leading industries in many countries, providing jobs and income for millions of people [1,2]. Among poultry meats, chicken is one of the most popular. In fact, chickens and their various products are a common export for numerous countries, making chicken meat a significant player in the international economy.

Beyond trade, chickens also play an essential role in research. Due to their genetics and unique biology, chickens serve as exemplary models for studies on development, genetics, and various diseases [3]. Chickens also have a positive impact on the environment, especially when they are raised in free-range conditions [4,5]. They help recycle food scraps and agricultural waste by converting them into valuable fertilizer. Chicken manure can also serve as an energy source for biogas production in specialized facilities [6].

Due to its nutritional value and affordability, chicken meat—especially from free-range birds raised in small rural households—is an important dietary resource. It serves as a vital source of energy, contributing to tissue building, metabolism, and the synthesis of organic compounds in the human body. Being rich in vital proteins, unsaturated fatty acids, minerals, and vitamins, chicken meat is also very nutritious. It also has a completely balanced amino acid composition. Further, its biologically active compounds also provide sensory properties, like taste and aroma, and promote digestion. For these reasons, it is considered a functional food: chicken naturally contains

all the essential components necessary for human growth and development without the need for additional supplements [7]. It is also highly digestible due to its relatively low content of connective tissue [8]. Moreover, chicken is free of ethnic and religious dietary restrictions.

This makes chicken meat suitable for use in functional, therapeutic, preventive, and pediatric nutrition. As a result, chicken meat is recommended for a variety of health goals. It is recommended to individuals with chronic health issues, such as gastrointestinal diseases, diabetes, obesity, and cardiovascular conditions, for preventative and therapeutic purposes. Similarly, chicken broth is also recommended as a remedy against various acute illnesses. For example, chicken broth can improve bronchial airflow during colds and viral infections. This is due to its content of polyunsaturated fatty acids and the amino acid cysteine, which helps liquefy mucus in the lower airways, and unlike medications, chicken broth does not have side effects [15-16]. At the same time, chicken is also recommended for building muscle, due to its high protein content [9-14].

Many sectors of the food industry are actively studying the functional value of food, developing and implementing methods to enhance nutritional quality. However, numerous objective and subjective factors can directly or indirectly affect the quality and quantity indicators of poultry meat, reducing its nutritional value [17-23]. Among these, parasitic diseases, particularly intestinal coccidiosis (also known as Eimeriosis), are significant [24-26]. Helminth infections, which are also caused by parasites, are also common in poultry [27-31]. These pathogens inhabit the birds' digestive systems and disrupt vital processes, causing affected birds to lag in growth and development. Consequently, products from these birds have inferior quality compared to those from healthy birds [32].

Parasitic activity leads to the development of a biological environment within the birds' bodies where the digestion and absorption of proteins and amino acids are disrupted. As a result, a decrease in overall protein levels is observed, along with metabolic disturbances and impaired assimilation of essential amino acids, including methionine, valine, and threonine. The production of key amino acids, alanine and proline, is also impaired.

Numerous interventions can help mitigate these adverse effects and improve the nutritional value of poultry meat. One such method is the use of traditional Armenian yogurt, a fermented dairy product. The key microbes responsible for fermenting milk into yogurt are *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Their activity ferments the milk sugar (lactose) into lactic acid, and the resulting acidic environment causes the milk protein, casein, to coagulate into a gelatinous curd. Yogurt has many beneficial properties, particularly for the digestive system. Its probiotic bacteria are biologically active microbes that suppress non-native intestinal flora, thereby improving gut function. As a result, a gut supported by probiotics can efficiently break down nutrients into compounds that are easily digestible and absorbable.

MATERIALS AND METHODS

Study Location and Sampling: Laboratory analyses were performed at the Veterinary and Sanitary Expertise Research Center Laboratory of the National Agrarian University of Armenia.

The research was conducted in 2023–2024 in small private poultry farms located in various regions of the Republic of Armenia.

Animal Grouping and Diagnosis: The chickens were kept on deep litter with access to free-range during the summer. This meant that the chickens spent a

considerable time outdoors, had the opportunity to move freely, exhibited their natural behavioral instincts, enjoyed sunlight and fresh air, and fed on natural herbs, insects, and grains. These conditions contributed to the development of a robust immune system in the birds, thereby increasing the nutritional value of the resulting meat.

Both pre-slaughter and post-slaughter examinations were conducted to separate the experimental groups from the control groups by the presence of helminth eggs and *Eimeria* oocysts in fecal samples [33-34]. The fecal samples used were collected from the free-range poultry farms. The pre-slaughter tests included coprological and hematological analyses. Based on these results, the chickens were divided into four groups, each consisting of 20 birds.

The presence of helminth eggs and *Eimeria* oocysts in fecal samples was determined using Fulleborn and Darling flotation methods [35].

- The first group served as the control group.
- The second group consisted of infected but mildly affected birds, whose fecal samples contained a small number of helminth eggs and *Eimeria* oocysts (observed only occasionally under the microscope). These birds showed slight emaciation and mild depression.
- The third group included clinically ill/severely affected birds, with fecal samples containing a high number of helminth eggs and *Eimeria* oocysts (abundant under the microscope). These birds exhibited pronounced emaciation and depression.
- The fourth group was clinically similar to the third group, but in addition to their regular diet, these birds were fed 20 grams of homemade Armenian yogurt, prepared from cow's milk, daily for ten consecutive days.

The general blood parameters of pre-slaughter birds were studied using the Micro CC 20 Plus analyzer.

For post-slaughter analysis, samples were taken from the breast and thigh muscles. The biochemical composition of the meat was analyzed using the Clima MC-15 biochemical analyzer.

Statistical Analysis: The results were analyzed using the student’s t-test with Microsoft Excel 2010.”

RESULTS AND ANALYSIS

Among all branches of animal husbandry in Armenia and worldwide, poultry farming occupies a leading position. The development of industrial poultry farming ensures

the primary protein requirements of a growing global population, especially given the early maturity of chickens compared to other farm animals. However, the intensive development of industrial poultry farming and the extensive growth of small-scale rural farms are significantly hindered by intestinal parasitic diseases, particularly ascariasis, heterakidosis, capillariasis, and coccidiosis. According to the unanimous opinions of both local and international scientists and specialists, these diseases are prevalent even in countries with advanced poultry industries, resulting in substantial economic losses to national economies.

Table 1. Hematological profile of healthy and intestinal parasite-infected chickens (n = 20, M± SE)

No.	Indicators	Units of measurement	Group 1 /tested/	Sick		
				Mildly infected	Highly infected	After feeding yogurt
1	Erythrocytes	10 ¹² /L	3.91±0.24	3.75±0.35	3.52±0.51	3.71±0.32
2	Hemoglobin	g/L	112.56±6.32	108.43±5.32	103.11±5.21	109.07±4.25
3	Platelets	10 ⁶ /L	52.30±2.15	51.62±2.33	49.32±2.01	50.97±1.65
4	ESR	mm/h	2.82±0.24	2.76±0.31	2.69±0.52	2.77±0.62
5	Leukocytes	10 ⁹ /L	33.24±2.22	35.71±2.64	37.22±2.43	35.08±2.21
6	Basophils	%	1.72±1.01	1.68±1.11	1.42±1.38	1.60±1.31
7	Eosinophils	%	7.32±2.16	7.42±2.65	7.60±2.66	7.50±2.34
8	Pseudo-eosinophils	%	32.19±3.64	32.15±2.91	32.21±3.62	32.22±2.54
9	Lymphocytes	%	54.52±3.87	54.11±3.84	54.23±3.12	54.11±2.51
10	Monocytes	%	4.25±0.98	4.64±1.01	4.72±0.99	4.54±1.14

Before slaughter, hematological parameters of chickens intended for slaughter were analyzed. The results show that in cases of mild intestinal parasitic infection, leukocyte levels increase by 7.56%, while erythrocyte, hemoglobin, and platelet count decrease by 4.1%, 3.67%, and 1.31%, respectively. The Erythrocyte sedimentation rate increased by 1.43% (reaching 2.76 mm/h). Among leukocytes, the proportions of eosinophils and monocytes increased, and the

erythrocyte sedimentation rate accelerated by 4.61%. Basophils decreased by 2.33%, pseudo-eosinophils by 2.28%, and lymphocytes by 0.75%.

More pronounced hematological changes were observed in chickens with severe infections: erythrocyte, hemoglobin, and platelet counts decreased by 9.74%, 8.4%, and 5.12%, respectively. ESR increased by 4.61%, leukocytes rose by 11.97%, monocytes by 11.06%,

eosinophils by 3.83%, and pseudo-eosinophils by 2.34% compared to mildly infected chickens. Basophils showed

the most significant reduction was 17.44%. In chickens fed yogurt, hematological indicators gradually returned to near-normal values.

Table 2. Chemical Composition of Meat from Chickens Infected with Intestinal Parasites (n = 20, M± SE)

No.	Indicator	Chicken Groups			
		Healthy	Sick		
			Mildly infected	Highly infected	After feeding yogurt
Breast Meat					
1	Moisture, %	74.84±3.31	75.81±3.23	76.34±2.73	75.22±1.88
2	Protein, %	26.25±1.42	23.92±2.84	20.45±3.41	23.87±2.46
3	Fat, %	2.97±0.33	2.67±0.73	2.65±0.52	2.66±0.68
4	Ash, %	1.06±0.12	1.32±0.43	1.39±0.31	1.34±0.52
5	Nutritional Value (kcal)	161.83±3.91	152.62±5.14	146.43±4.25	150.38±3.84
Thigh Meat					
1	Moisture, %	72.24±2.51	74.13±2.85	74.52±2.73	73.32±2.25
2	Protein, %	22.54±1.22	21.35±1.31	20.61±1.44	21.62±1.35
3	Fat, %	5.17±0.52	4.92±0.61	4.83±0.52	4.94±0.58
4	Ash, %	1.73±0.13	1.86±0.23	2.08±0.14	1.94±0.23
5	Nutritional Value (kcal)	168.38±4.21	164.35±2.82	151.08±2.91	163.15±2.92

The study data indicate that both breast and thigh meat undergo the most significant changes in cases of severe, multi-parasitic infection.

According to the data presented, meat from parasitized birds shows notable chemical differences compared to that of healthy birds. Breast meat from severely infected chickens contains up to 2% more moisture and 13% more ash than that of healthy chickens. A similar pattern is seen in thigh meat, where moisture and ash content increase by 10.9% and 17.6%, respectively.

Meanwhile, the protein content in thigh meat from

infected chickens is up to 8.5% lower than that in healthy birds. Similarly, a noticeable reduction in fat content is observed in severely infected birds, up to 10.3% lower in breast meat and 9.7% lower in thigh meat compared to their healthy counterparts. Further, the overall nutritional value of severely infected chickens decreases by up to 9.6% in breast meat and 6.2% in thigh meat.

Based on these results, we conclude that the chemical composition of breast and thigh meat from birds infected with intestinal parasites changes in a way that negatively affects consumer value: moisture and ash increase, while protein and fat content decrease, thereby lowering the total nutritional value of the meat.

Table 3. Changes in the Amino Acid Composition of Chicken Breast Meat in Cases of Intestinal Parasitic Infection (n = 20, M± SE)

No.	Amino Acids g/100g of Meat	Chicken Groups			
		Healthy	Sick		
			Mildly infected	Highly infected	After feeding yogurt
Essential Amino Acids					
1	Lysine	1.91 ±0.93	1.85±1.01	1.69±0.09	1.82±0.11
2	Leucine	1.52±0.75	1.50±0.09	1.36±0.18	1.48±0.21
3	Isoleucine	1.24±0.38	1.19±0.08	1.17±0.15	1.19±0.34
4	Methionine	0.69±0.09	0.63±0.22	0.52±0.09	0.64±0.12
5	Phenylalanine	0.86±1.02	0.79±0.11	0.78±1.01	0.80±0.92
6	Threonine	0.95±0.19	0.91±0.24	0.77±1.01	0.84±0.95
7	Tryptophan	0.19±0.11	0.11±0.03	0.05±0.07	0.10±0.05
8	Valine	0.99±0.20	0.92±0.09	0.72±0.81	0.88±0.57
Non-Essential Amino Acids					
1	Asparagine	1.85±1.01	1.84±1.08	1.69±1.11	1.77±0.15
2	Serine	1.02±0.15	1.01±0.12	0.85±0.23	0.97±0.51
3	Glutamine	3.52±1.22	3.45±2.01	3.08±2.14	3.33±0.34
4	Glycine	0.68±0.09	0.62±0.14	0.54±0.18	0.59±0.25
5	Alanine	1.17±0.81	1.14±0.28	0.98±0.34	1.08±0.16
6	Arginine	1.33±0.94	1.31±0.84	1.22±0.91	1.2±0.28
7	Proline	1.48±0.67	1.34±0.37	1.15±0.45	1.27±0.33
8	Cystine	0.28±0.09	0.28±0.12	0.25±0.13	0.27±0.19

During the biochemical analysis of chicken breast meat, it was found that in cases of mild intestinal parasitic infection, the levels of all essential amino acids decreased by 0.5–13%, except tryptophan and methionine. The amount of tryptophan remained unchanged, and the amount of methionine increased by

approximately 3%,. A similar pattern was observed in cases of severe infection, except the threonine content decreased by about 20%, the methionine content decreased by about 4%, and the valine content remained unchanged, compared to the healthy group (Table 4).

Table 4. Changes in the amino acid composition of chicken thigh meat in cases of intestinal parasitic infection (n=20, M± SE)

No.	Amino Acids g/100g of Meat	Chicken Groups			
		Healthy	Sick		
			Highly infected	After feeding yogurt	After feeding yogurt
Essential Amino Acids					
1	Lysine	1.63 ±0.24	1.59±0.75	1.49±0.94	1.54±1.67
2	Leucine	2.51±0.47	2.42±1.02	2.29±1.11	2.36±1.09
3	Isoleucine	3.44±0.61	3.12±1.22	2.98±1.16	3.05±1.15
4	Methionine	1.81±0.15	1.77±0.84	1.57±0.73	1.69±0.55
5	Phenylalanine	0.95±0.09	0.88±0.07	0.76±0.05	0.82±0.11
6	Threonine	2.05±1.05	2.01±1.14	1.95±0.97	1.99±0.87
7	Tryptophan	0.67±0.05	0.63±0.06	0.44±0.04	0.58±0.06

8	Valine	1.99±0.23	1.88±0.52	1.68±1.61	1.79±1.46
Non-Essential Amino Acids					
1	Asparagine	1.33±0.89	1.29±0.84	1.18±0.91	1.29±0.88
2	Serine	0.96±0.02	0.89±0.03	0.77±0.02	0.88±0.05
3	Glutamine	3.62±1.28	3.54±1.15	3.47±1.18	0.55±1.12
4	Glycine	0.84±0.01	0.79±0.04	0.68±0.04	0.80±0.31
5	Alanine	1.37±0.14	1.26±0.15	1.19±0.11	1.27±0.36
6	Arginine	1.45±1.12	1.35±1.09	1.33±1.13	1.38±1.47
7	Proline	1.58±0.33	1.41±0.21	1.09±0.26	1.43±0.23
8	Cystine	0.38±0.06	0.34±0.05	0.28±0.07	0.33±0.11

Biochemical analysis of thigh meat revealed that in cases of mild parasitic infection, the concentration of essential amino acids decreased by 2–11%, while in severe disease, the reduction reached 5–20%. The content of non-essential amino acids also changed: for mildly infected birds, their levels decreased by 2–11%, and in severely infected birds, they decreased by 5–27%.

Scientific Innovation: The central scientific innovation of this study lies in elucidating how simple yogurt supplementation mitigates the severe hematological and meat quality degradation caused by intestinal parasites in chickens. Future research can innovatively explore precise mechanisms, such as comprehensive metagenomic and metabolomic analyses of the chicken gut microbiome, to identify specific beneficial probiotic strains and their associated metabolites. This mechanistic understanding could lead to the development of highly targeted, designer probiotic formulations optimized for poultry, as well as the discovery of novel biomarkers for the early and precise detection of parasitic infections, thereby transforming disease management strategies.

Practical Implications: The practical implications of these findings are substantial for the poultry industry, offering a cost-effective and sustainable approach to combating widespread intestinal parasitic diseases. Utilizing yogurt as a dietary supplement can significantly reduce reliance on conventional anthelmintics, promoting healthier

birds, improving animal welfare, and enhancing feed efficiency through a healthier gut microbiome. Crucially, the observed restoration of meat's protein, fat, and amino acid content directly translates into higher quality and more nutritious poultry products, mitigating economic losses for producers and providing better consumer value. This simple intervention holds promises for improving global food security and farmer profitability, especially in regions heavily impacted by these common poultry ailments.

Bridging Functional Food Science: The study's findings strongly align with the principles of functional food science, which focuses on foods that provide health benefits beyond basic nutrition. By demonstrating that yogurt, a fermented food, can improve specific health indicators (hematological profiles) and enhance the nutritional quality (amino acid content) of chicken meat in the presence of parasitic stress, this research positions yogurt as a functional food ingredient for animal diets [36, 37]. Such applications contribute to the broader field of functional foods for livestock, aiming to improve animal health, productivity, and the functional attributes of animal-derived products [38].

CONCLUSION

As confirmed by the research results, intestinal parasites in chickens have a significant impact on the nutritional value of poultry meat, posing risks to consumer health and resulting in substantial losses to poultry farming. Due

to the influence of parasites, infected birds exhibit stunted growth and reduced muscle mass, resulting in deterioration of meat quality and a decrease in nutritional value.

In diseased birds, the number of erythrocytes, hemoglobin, and platelets decreases, while leukocyte counts, especially eosinophils and lymphocytes, increase. The chemical and biochemical composition of meat obtained from diseased birds also changes, with an increase in moisture and ash content, and a decrease in fat and protein content. The amino acid composition of the meat proteins also changes: the levels of all essential and non-essential amino acids decline, except for methionine in the breast meat, which shows a slight increase. Overall, the meat from a diseased bird has reduced nutritional value.

Based on the study results, it can be concluded that the meat from chickens infected with intestinal parasites is inferior in chemical composition and nutritional value compared to meat from healthy birds. As a result, it does not meet the criteria for functional food products. However, by supplementing the diseased birds' diet with just 20 grams of homemade, cow's milk-based yogurt for 10 consecutive days, the levels of amino acids in both breast and thigh meat begin to recover. While not all amino acids from yogurt are fully digested, the yogurt improves chicken intestinal microflora and enhances digestive function, which facilitates the restoration of amino acid levels in the meat.

Authors' Contributions: VG is the principal author of the research. LG is the conductor of the study. ZhM, SY, AG, MS, and AA conducted laboratory tests. VA, RG, and HT contributed to statistical processing. NH and SA contributed to the writing and editing of the manuscript, summarizing the research's scientific innovations and practical implications.

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

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