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Assessment of the amino and fatty acid composition and biological value of meat of broiler chickens taken by "Subtiform" probiotic bio preparation

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Contents

Abstract

Probiotics are widely used for intensive technologies of growing broiler chickens due to their ecologically harmless properties, increasing productivity and obtaining safe and high-quality meat products. The purpose of the study was to determine the effect of the probiotic biopreparation Subtiform on the amino and fatty acid composition and biological value of chicken meat after drinking the probiotic biopreparation Subtiform in different doses. Broiler chickens from 28 to 42 days of age were given the probiotic bio preparation Subtiform, which contains Bacillus subtilis and Bacillus licheniformis at 2.5 × 10^9 CFU/g and dry milk serum per 20 birds in a cage: control - birds were not given probiotics with water; experiment 1 – 0.5 g/10 dm^3 of water; experiment 2 – 2.0 g/10 dm^3 of water; experiment 3 – 4.0 g/10 dm^3 of water. The total content of amino acids in the breast meat of broiler chickens slightly increased in experiment 1 – by 1.71 % (P < 0.01), in experiment 2 – by 3.57 % (P ≤ 0.001), in experiment 3 – by 12.35 % (P ≤ 0.001). The content of essential amino acids in breast meat was increased – 5.39 ± 0.04 mg/100 mg (P ≤ 0.001) due to an increase in the content of methionine – 1.7 times (P ≤ 0.01), leucine – by 1.3 times (P ≤ 0.001), lysine and isoleucine – 1.2 times compared to the control group; the content of substituted amino acids also increased – 9.07 ± 0.04 mg/100 mg (P ≤ 0.001) due to an increase in the content of aspartic acid – 1.2 times (P ≤ 0.01), glutamic acid – 1.13 times (P ≤ 0.01), as well as a decrease in glycine content – by 1.2 times (P≤0.01) compared to the control group. The protein-quality index in experiment 3 was higher due to the increased content of tryptophan – 0.37 ± 0.025 mg/100 mg of meat (P ≤ 0.001) and oxyproline – 0.06 ± 0.002 mg/100 mg of meat (P ≤ 0.001). A positive effect of the probiotic biological preparation of *Bacillus subtilis* and Bacillus licheniformis on the fatty acid composition of the meat of broiler chickens of the research groups was established. The highest total content of saturated fatty acids to the total content of fatty acids in percentage was in experimental group 3 – 38.39 ± 0.002 %, which accordingly increased by 8.11 % compared to the control group (35.51 ± 0.002 %), due to the increase due to the increase in palmitic, stearic, iso-stearic content. The content of monounsaturated acids was characterized by the content of myrostolenic, palmitoleic, heptadeceneic, oleic, gondoic, and erucic nervonic acids. The highest content of monounsaturated fatty acids in experimental group 3 is 43.77 ± 0.002 % (P≤0.001) due to an increase in the content of 43.77 ± 0.002 % (P ≤ 0.001) of palmitoleic, oleic and gondoic acids. The increase in the content of polyunsaturated fatty acids in the meat of broiler chickens in experimental sample 3 was the highest – 25.16 ± 0.02 % (P ≤ 0.001) due to the increase in the content (P ≤ 0.001) of linoleic, linolenic and arachidonic fatty acids. The highest total content of omega-3 was in experimental groups of broiler chicken meat 2 and 3, respectively – 1.03 ± 0.001 % (P ≤ 0.001) and 1.30 ± 0.001 % (P ≤ 0.001) and omega-6, respectively – 22.98 ± 0.014 % (P ≤ 0.001) and 23.40 ± 0.015 % (P ≤ 0.001). The ratio ∑Omega-6/∑Omega-3 was – 22.31 and 18.00 in experimental groups 2 and 3, respectively. An increase in the relative biological value of meat (103.85 %) was observed when using *Tetrachimena piriformis* in a dose of the probiotic biopreparation Subtiform – 4.0 g/10 dm^3 of water. The practical value of the research lies in the use of the probiotic biopreparation Subtiform to increase the biological value of meat and improve the amino acid and fatty acid profile.

Keywords: probiotic; poultry fattening; safety; quality; poultry meat; amino acids; fatty acids; biological value.

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1. Introduction

The poultry industry has significant development in many countries worldwide for producing meat and edible eggs (Razanova et al., 2022; Slivinska et al., 2022). Broiler chicken production technology needs to be improved concerning the use of various nutraceuticals, in particular probiotics. In the work of veterinary medicine specialists, it is mandatory to properly control the meat production chain in the poultry sector with compliance with sanitary and hygienic requirements at facilities, welfare, and health of poultry, in particular, the safety of feed (Silva et al., 2023).

The use of safe alternatives to antibiotics, in particular probiotics, in the feed of broiler chickens improves the condition of the intestines of the bird and increases productivity, improves the quality of meat due to the optimal amount of amino acids and fatty acids in the meat of broiler chickens (Salem et al., 2023). In the world, the demand for protein of animal origin in the human diet is increasing, and the meat of broiler chickens, namely high-quality, inexpensive protein, is an essential source of it during production. Solving the problems of antimicrobial resistance in poultry in the food chain through the concept of "One Health" consists of probiotic preparations (de Mesquita Souza Saraiva et al., 2022).

The effect of probiotics and prebiotics is aimed at the regulation of the intestinal microbiota of poultry, as well as the control of some diseases associated with metabolic and inflammatory disorders. These processes lead to increased productivity of broiler chickens and improved indicators of the safety and quality of meat, in particular, biological value and content of amino acids and fatty acids. One of the alternative methods of determining the biological value of poultry meat is using biological objects, particularly the ciliate Tetrachimena piriformis (Shehata et al., 2022).

Broiler production in European countries is a valuable factor of food security in the concept of "One Health". In the rations of broiler chickens, essential components are feed energy and protein, as well as cost factors for poultry production. This affects poultry productivity, average daily growth, feed conversion ratio, meat quality, in particular, the content of amino acids and fatty acids, and biological value (Ndlebe et al., 2023).

When feeding poultry, rations should be used, which contain a sufficient amount of crude protein, which will ensure the improvement of the metabolism of the poultry and the saturation of the bird's body with amino acids, which take part in the formation of meat quality (Selle et al., 2023). Feeding poultry a diet that includes probiotics improves the quality of meat and eggs (Fluck et al., 2023).

An adequate criterion for evaluating the nutritional characteristics of poultry meat is its biological value and toxicity. Biological value is a leading indicator of quality, as it determines the degree of compliance of a food product with optimal human needs following the physiological norm (Zotsenko et al., 2001).

Therefore, ***the aim of the work*** was to find out the expediency of using the probiotic biopreparation Subtiform in different doses: 0.5 g/10 dm^3 of water, 2.0 g/10 dm^3 of water, 4.0 g/10 dm^3 of water and establishing the amino acid and fatty acid composition of meat and its biological value to meet the needs of the average consumer.

2. Materials and methods

Experimental studies were carried out on six samples of meat (breast) of broiler chickens of the Sovv-500 cross on the 42nd day of slaughter, which were grown at the LLC "Skybynetsk Poultry Factory" in the village of Skibintsi of the Kyiv region and drank the probiotic bio preparation Subtiform with water in the following doses – 0.5, 2.0, and 4.0 g/10 dm^3 of water for 20 birds in a cage. Probiotic bio preparation Subtiform consists of bacteria of the genus *Bacillus subtilis* and *Bacillus licheniformis* in the amount of 2.5×10^9 CFU/g) and dry milk serum. The control group of broiler chickens was not given a probiotic bio preparation in their water.

Research on the amino acid and fatty acid composition of broiler chicken meat was conducted at the Institute of Biochemistry, named after O. V. Palladin of the National Academy of Sciences of Ukraine, in particular, in the department of lipid biochemistry, chromatography group (certificate of testing capability recognized by SE "Ukrmetrteststandart" dated 11/15/2022, No. PT-212/10). The amino acid composition of poultry meat (breast) was determined on the TTT-339 automatic analyzer by the method of ion exchange liquid column chromatography by hydrolysis of the meat sample with hydrochloric acid and its deproteinization to obtain an extract of free amino acids and further separation of amino acids on ion exchange columns.

The fatty acid composition of poultry meat (breasts) was determined following the requirements of national standards: preparation of the examined meat sample of broiler chickens SSTC ISO 661 (2004); test by gas chromatography method of methyl esters of fatty acids – SSTC ISO 5508 (2001); preparation of methyl esters of fatty acids – SSTC ISO 5509 (2002).

The relative biological value and toxicity of the meat of broiler chickens were determined using the infusion of Tetrachimena piriformis strain WH-14 following the requirements of the Guidelines for tests on the establishment of biological value of food products and feeds using Tetrachimena piriformis strain WH–14, 2022) in the accredited research laboratory of the department of veterinary and sanitary examination, hygiene of livestock products and pathology named after J. S. Zagaevskii. The relative biological value of the meat of broiler chickens was determined by the ratio of the indicator of the biological value of the studied meat samples to the indicator of the biological value of the control sample of meat, calculated according to the formula, and the result was expressed as a percentage.

Scientific research was carried out following the provisions of the Procedure for experiments and experiments on animals by scientific institutions (2012).

The reliability of the conducted scientific research was confirmed by using certified equipment, modern test methods, and statistical processing of the obtained results. Statistical processing of research results was carried out using the Microsoft Excel computer program; significance was determined by Student's test with ($P \leq 0.05$, $P \leq 0.01$, $P \leq 0.001$).

3. Results and discussion

3.1. Results

Determining the amino acid composition of broiler chicken meat using the probiotic bio preparation Subtiform. The quality and safety of broiler chicken meat depends on its amino acid and fatty acid composition, as well as its biological value and harmlessness.

Tests of the amino acid composition, in particular essential and replaceable amino acids, of broiler chicken meat (breasts) were conducted in the control and experimental groups of poultry on the 42nd day of slaughter (Table 1).

Table 1
Amino acid composition of meat of broiler chickens (breasts) of the control and experimental groups after drinking the probiotic bio preparation Subtiform, mg/100 mg (M ± m, n = 6)

The name of the amino acid	Control group of broiler chicken meat	Experimental group 1 meat (0.5 g/10 dm^3 of water)	Experimental group 2 meat (2.0 g/10 dm^3 of water)	Experimental group 3 meat (4.0 g/10 dm^3 of water)
Essential amino acids				
Lysine	0.66 ± 0.09	0.70 ± 0.05	0.77 ± 0.05	0.82 ± 0.04
Phenylalanine	0.62 ± 0.12	0.66 ± 0.05	0.75 ± 0.05	0.76 ± 0.04
Valin	0.51 ± 0.07	0.56 ± 0.06	0.56 ± 0.03	0.60 ± 0.04
Methionine	0.14 ± 0.03	0.12 ± 0.02	0.21 ± 0.03	0.24 ± 0.02**
Isoleucine	0.70 ± 0.05	0.74 ± 0.06	0.94 ± 0.05**	0.82 ± 0.05
Leucine	1.35 ± 0.06	1.38 ± 0.08	1.49 ± 0.06	1.69 ± 0.05***
Threonine	0.43 ± 0.07	0.50 ± 0.06	0.38 ± 0.03	0.46 ± 0.05
In total	4.41 ± 0.07	4.66 ± 0.05**	5.10 ± 0.04***	5.39 ± 0.04***
Substitute amino acids				
Histidine	0.26 ± 0.03	0.29 ± 0.04	0.30 ± 0.04	0.31 ± 0.04
Arginine	1.04 ± 0.05	1.03 ± 0.04	1.10 ± 0.05	1.11 ± 0.05
Aspartic acid	1.01 ± 0.04	1.05 ± 0.04	1.06 ± 0.04	1.20 ± 0.05**
Glutamic acid	2.48 ± 0.08	2.51 ± 0.06	2.49 ± 0.08	2.81 ± 0.04**
Proline	0.62 ± 0.06	0.56 ± 0.05	0.48 ± 0.04	0.54 ± 0.04
Glycine	0.85 ± 0.04	0.73 ± 0.06	0.71 ± 0.06	0.72 ± 0.04**
Alanine	0.96 ± 0.05	0.94 ± 0.06	0.95 ± 0.05	1.04 ± 0.04
Cystine	0.19 ± 0.03	0.22 ± 0.03	0.18 ± 0.02	0.24 ± 0.03
Tyrosine	0.57 ± 0.04	0.58 ± 0.04	0.55 ± 0.04	0.55 ± 0.03
Serin	0.48 ± 0.03	0.52 ± 0.04	0.41 ± 0.04	0.55 ± 0.04
In total	8.46 ± 0.05	8.43 ± 0.05**	8.23 ± 0.05***	9.07 ± 0.04***
Total content of amino acids	12.87 ± 0.06	13.09 ± 0.05**	13.33 ± 0.05***	14.46 ± 0.04***

Note: * – $P \leq 0.05$; ** – $P \leq 0.01$; *** – $P \leq 0.001$ compared to control indicators

The content of essential amino acids slightly increased in experimental groups of meat of broiler chickens when the amount of probiotic preparation was given, respectively – experiment 1–0.5 g/10 dm^3 of water by 5.67 %; experiment 2 – 2.0 g/10 dm^3 of water by 15.64 %; experiment 3 – 4.0 g/10dm^3 of water by 22.2 % due to a slight increase in the content of such essential amino acids in the meat of broiler chickens in experimental group 3 as lysine, isoleucine, phenylalanine – by 1.2 times, leucine – by 1.3 times ($P \leq 0.001$), methionine – 1.5 times ($P \leq 0.01$) compared to the indicators of the control group.

The content of substitute amino acids in experiment 1 was on the border of the indicators of the control group – 8.43 ± 0.05 mg/100 g of poultry meat and slightly decreased by 0.4 % ($P \leq 0.01$); in experimental group 2 – also slightly decreased by 2.72 % ($P \leq 0.001$), and in experimental group 3 – slightly increased by 7.21 % ($P \leq 0.001$) due to a probable increase in the content of aspartic acid by 18.8 % ($P \leq 0.01$) and glutamic acid – by 13.3 % ($P \leq 0.01$).

However, it should be noted that the total content of amino acids in the meat of broiler chickens slightly increased in experiment 1 – by 1.71 % ($P \leq 0.01$), in experiment 2 – by 3.57 % ($P \leq 0.001$), in experiment 3 – by 12.35 % ($P \leq 0.001$).

The protein-quality index of breast meat was determined in the control and experimental groups. The study was conducted to establish the ratio of an essential amino acid (tryptophan) to a replaceable amino acid (oxyproline) (Table 2).

Table 2
The ratio of tryptophan to oxyproline and the determination of the protein-quality index of the meat of broiler chickens (breasts) in the control and experimental groups after drinking the probiotic preparation Subtiform in different doses, mg/100 mg (M ± m, n = 6)

The name of the amino acid	Control group of broiler chicken meat	Experimental group 1 meat (0.5 g/10 dm^3 of water)	Experimental group 2 meat (2.0 g/10 dm^3 of water)	Experimental group 3 meat (4.0 g/10 dm^3 of water)
Tryptophan	0.21 ± 0.015	0.22 ± 0.017	0.27 ± 0.023	0.37 ± 0.025***
Oxyproline	0.04 ± 0.002	0.04 ± 0.002	0.05 ± 0.002**	0.06 ± 0.002***
Protein-quality indicator	5.25	5.50	5.80	6.20

Note: ** – $P \leq 0.01$; *** – $P \leq 0.001$ compared to control indicators

From the data in the table, it was established that the significance of the indicators of the content of tryptophan and oxyproline ($P \leq 0.001$) was noted in experimental group 3 after drinking the probiotic preparation Subtiform in a dose of 4.0 g/10 dm^3 of water to broiler chickens. The protein-quality index of breast meat of broiler chickens was the highest in experimental group 3 – 6.20, which led to an increase in the content of tryptophan – by 1.8 times ($P \leq 0.001$) and oxyproline – by 1.5 times ($P \leq 0.001$) compared to the indicators of the control group.

Determination of the fatty acid composition of meat of broiler chickens using the probiotic bio preparation Subtiform. Our research determined the fatty acid composition of broiler chicken meat in the control sample and experimental meat samples (breasts) 1, 2, 3. Such saturated fatty acids as: lauric (C12:0), myristic (C14:0), pentadecanoic

(C15:0), palmitic (C16:0), iso-palmitic (C iso-16:0), margarine (C17:0), stearic (C18:0), iso-stearic (C iso-18:0), geneicosan (C21:0), behenov (C 22: 0) and lignocerine (C24:0).

The total content of saturated fatty acids to the total content of fatty acids in percentage was 35.89 ± 0.002 % ($P \leq 0.001$) in experimental group 1, 36.09 ± 0.002 % ($P \leq 0.001$) in experimental group 2 and in experimental group 3 – 38.39 ± 0.002 % ($P \leq 0.001$), which respectively increased by 1.10 %, 1.63 % and 8.11 % compared to the control group (35.51 ± 0.002 %).

Figure 1 shows the significant indicators of the content of saturated fatty acids in experimental groups of broiler chicken meat.

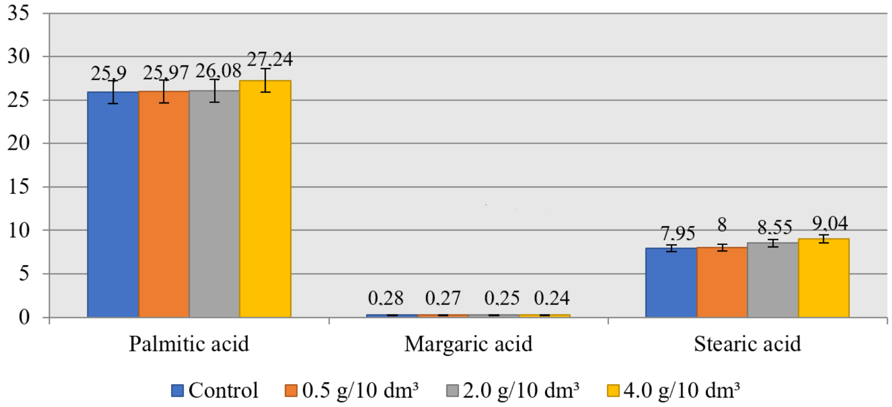

Fig. 1. The content of saturated fatty acids in the meat of broiler chickens (breast), %

By analyzing Figure 1, it was established that the increase in the content of saturated fatty acids in experimental samples 1, 2 and 3 was due to palmitic acid, respectively, – by 0.30 % ($P \leq 0.001$), by 0.62 % ($P \leq 0.001$) and by 5.20 % ($P \leq 0.001$); of stearic acid, respectively, by 0.63 % ($P \leq 0.001$), by 7.55 % ($P \leq 0.001$) and by 13.70 % ($P \leq 0.001$) compared to the control indicators. However, the content of margaric acid decreased in experimental meat samples 1, 2, and 3, respectively, – by 3.60 % ($P \leq 0.01$), by 10.7 % ($P \leq 0.001$), and 14.30 % ($P \leq 0.001$) compared to control indicators.

Monounsaturated fatty acids were detected in the meat of broiler chickens of the control and experimental groups, namely myrostolenic (C14:1), palmitoleic (C16:1), heptadeceneic (C17:1), oleic (C18:1n9c), gondoic (C20:1), erukova (C22:1), nervonova (C24:1). The total content of monounsaturated fatty acids was 39.75 ± 0.002 % ($P \leq 0.001$) in experimental group 1, 40.05 ± 0.002 % ($P \leq 0.001$) in experimental group 2, and 43.77 ± 0.002 % in experimental group 3 ($P \leq 0.001$), which was increased, respectively, by 9.80 % ($P \leq 0.001$), by 13.70 % ($P \leq 0.001$) and by 20.90 % ($P \leq 0.001$) compared to control indicators (36.20 ± 0.002 %).

Figure 2 shows significant indicators of the content of monounsaturated fatty acids.

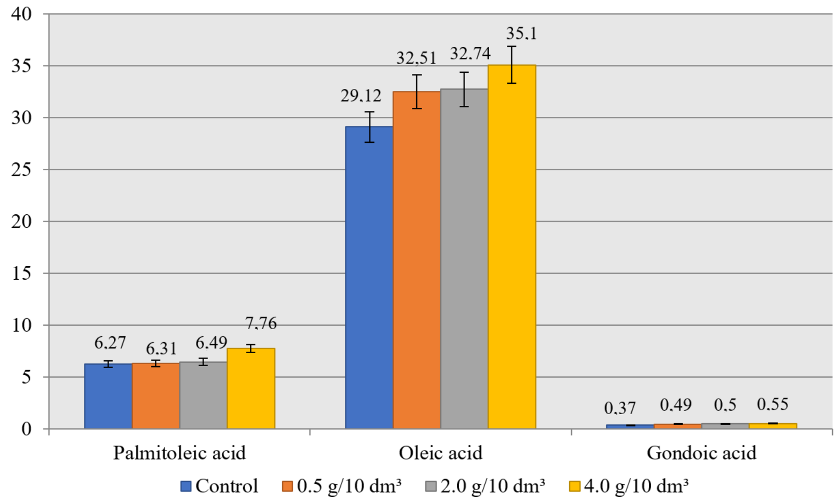

Fig. 2. The content of monounsaturated fatty acids in the meat of broiler chickens (breast), %.

It should be noted that the content of palmitoleic fatty acid in the experimental meat groups of broiler chickens 1, 2, and 3 slightly increased, respectively, by 0.64 %, by 3.51 % ($P \leq 0.001$) and 23.76 % ($P \leq 0.001$) compared to control indicators. In addition, the content of oleic and gondoic fatty acids in experimental groups of broiler chicken meat increased, respectively, – by 11.64 % ($P \leq 0.001$) and by 40.0 % ($P \leq 0.001$); by 12.43 % ($P \leq 0.001$) and by 42.86 %, 43.77 ± 0.002 % ($P \leq 0.001$), and 20.54 % ($P \leq 0.001$) and 57.14 % ($P \leq 0.001$) compared to control indicators.

Studies have established polyunsaturated fatty acids in the control and experimental groups of broiler chicken meat: linoleic, linolenic, eicosatriene, arachidonic, hexadecadeic, octadecatetraeic, and docosadiene. The total content of polyunsaturated fatty acids was 24.28 ± 0.02 % (P ≤ 0.001) in experimental group 1, 24.45 ± 0.02 % (P ≤ 0.001) in experimental group 2, and 25 % in experimental group 3,16 ± 0.02 % (P ≤ 0.001), which was increased, respectively, by 11.22 % (P ≤ 0.001), by 12.00 % (P ≤ 0.001) and by 15.25 % (P ≤ 0.001) compared to control indicators (21.82 ± 0.02 %).

Figure 3 shows significant indicators of the content of polyunsaturated fatty acids.

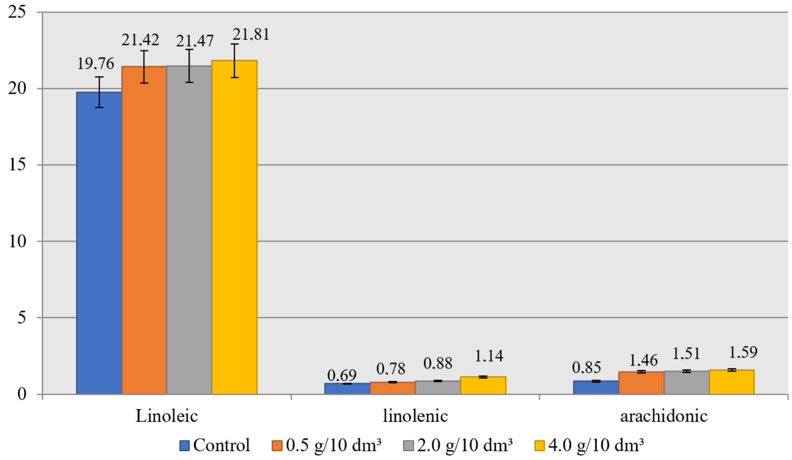

Fig. 3. The content of polyunsaturated fatty acids in the meat of broiler chickens (breast), %.

From the results of Figure 3, it was established that the content of linoleic polyunsaturated fatty acid (omega-6) in experimental groups of meat of broiler chickens 1, 2 and 3 increased, respectively, by – 8.40 % (P≤0.001), by 8, 65% (P ≤ 0.001) and 10.37 % (P ≤ 0.001) compared to the indicators of the control group, the content of arachidonic fatty polyunsaturated fatty acid (omega-6) also increased, respectively, by 71.76 % (P ≤ 0.001), by 77.65 % (P ≤ 0.001) and 76.47 % (P ≤ 0.001) compared to control indicators. The content of linolenic fatty polyunsaturated acid (omega-3) in the experimental groups of broiler chicken meat increased, respectively, by – 13.04 % (P ≤ 0.001), by 27.54 % (P ≤ 0.001) and 65.22 % (P ≤ 0.001) compared to the indicators of the control group.

It should be noted that the total content of unsaturated (monounsaturated and polyunsaturated) fatty acids in experimental meat samples of broiler chickens 1, 2 and 3 was 64.03 ± 0.02 %, 64.50 ± 0.02 and 68 %, respectively, 93 ± 0.02, which indicated their increase, respectively, by 10.36 % (P ≤ 0.001), by 11.17 % (P ≤ 0.001) and 18.80 % (P ≤ 0.001) compared to the indicators control The NFA/FA ratio was 1.63 in the control group of broiler chicken meat, 1.78 in experimental group 1, 1.79 in experimental group 2, and 1.80 in experimental group 3.

The total content of omega-3 in experimental groups of meat of broiler chickens 1, 2, and 3, respectively, was – 0.93 ± 0.001 % (P ≤ 0.001), 1.03 ± 0.001 % (P ≤ 0.001) and 1.30 ± 0.001 % (P ≤ 0.001) compared to the control group (0.78 ± 0.001 %). The total content of omega-6 in experimental groups of poultry meat 1, 2, and 3, respectively, was – 22.88 ± 0.012 % (P ≤ 0.001), 22.98 ± 0.014 % (P ≤ 0.001) and 23.40 ± 0.015 % (P ≤ 0.001) compared to the control group (20.61 ± 0.012 %). The ratio ∑Omega-6/∑Omega-3 in the control and experimental groups 1, 2, and 3, respectively, was – 26.40, 24.60, 22.31, and 18.00.

Determination of the relative biological value and harmlessness of meat of broiler chickens after drinking the probiotic bio preparation Subtiform when using Tetrachimena piriformis. Research has established the relative biological value and harmlessness of the meat of broiler chickens in the control and experimental groups.

The relative biological value of the studied carcasses of broiler chickens was determined by the intensity of reproduction of Tetrachimena piriformis ciliates on the nutrient medium using meat samples (breasts) of birds of the control and experimental groups. The criterion of relative biological value was the number of cells of Tetrachimena piriformis ciliates that grew in 3 days on experimental meat samples (breasts) of broiler chickens concerning the number of cells in the control meat sample.

The test results are shown in Table 3.

Table 3
The relative biological value of meat of broiler chickens (breasts) of the control and experimental groups after drinking the probiotic bio preparation Subtiform (M ± m, n = 6)

Meat samples	Number of cells, in 1 cm^3 of medium, $\times 10^4$	Relative biological value, % of control (100 %)
Control group of broiler chicken meat	18.70 ± 0.51	100,00
The experimental group of meat 1 (0.5 g/10 dm^3 of water)	18.80 ± 0.41	100.53
The experimental group of meat 2 (0.5 g/10 dm^3 of water)	19.05 ± 0.29	101.87
The experimental group of meat 3 (0.5 g/10 dm^3 of water)	19.42 ± 0.25	103.85

Note: * – P ≤ 0.05; ** – P ≤ 0.01; *** – P ≤ 0.001 compared to control indicators

Therefore, it can be seen from Table 3 that the highest relative biological value of the studied samples was in the third experimental group of meat (breasts) of broiler chickens after drinking the probiotic biopreparation Subtiform in a dose of 4.0 g/10 dm^3 of water and was 103.85 %, which is 3.85 % higher compared to the indicators of the control group.

To establish the relative biological value of poultry meat, the essential functional indicators of the cells of the ciliate Tetrahymena pyriformis are their mobility, in particular, the nature of movement, morphological changes, and the presence of an abnormal shape. *Tetrahymena pyriformis* ciliate cells in control and experimental groups of meat (breasts) of broiler chickens moved actively in a straight line. During the tests, no deviations in growth, development, or morphological deviations were detected, which indicates the absence of toxic substances in the examined meat of broiler chickens. Therefore, it can be noted that the samples of meat (breast) obtained from experimental groups of broiler chickens after drinking the probiotic bio preparation Subtiform are harmless to *Tetrahymena pyriformis* ciliates and, therefore, also to ordinary consumers.

3.2. Discussion

The content of lysine in the breast meat of broiler chickens increased in experimental groups 1, 2, and 3, respectively, by 6.1 %, 16.7 and 24.2 % compared to the indicators of the control group. Also, the content of methionine slightly increased in experimental groups 2 and 3, respectively, by 1.5 times and 1.7 times ($P \leq 0.01$) compared to control indicators. These data are supported by the results of scientists (Bahaddad et al., 2023), who claimed that supplements containing.

B. subtilis in the diet of broiler chickens has a positive effect on increasing the quality of breast meat, particularly improving the quality of protein and nutritional value of meat. The amino acid composition of poultry meat contributes to a better assessment of the quality and taste of meat; in particular, essential amino acids determine the quality of muscle tissue protein, and replaceable amino acids significantly affect the taste properties of poultry meat, in particular, alanine, glycine, glutamic acid, aspartic acid, serine (Alagawany et al., 2018).

In our studies, the content of aspartic acid in the meat of broiler chickens in experiment 3 increased by 18.8% ($P \leq 0.01$), glutamic acid – by 13.3 % ($P \leq 0.01$), alanine – by 8.3 %, serine – by 14.6 %, and glycine content decreased – by 15.3 % ($P \leq 0.01$). These indicators are confirmed by the results of scientists in that the use of probiotics in poultry feed increases the productivity of broiler chickens, improves the profile of the amino acid and fatty acid composition of meat, as well as its chemical indicators (Elleithy et al., 2023).

According to scientists, the content of fatty acids in the breast muscles was characterized by an increased content of palmitoleic acid – 3.228 %, oleic acid – 36.671 %, and the total amount of monounsaturated fatty acids – 41.190 ($P \leq 0.05$) was higher after adding food additives to poultry feed *B. subtilis* DSM 32315. In addition, dietary supplements with *B. subtilis* DSM 32315 tended to increase total polyunsaturated fatty acids – linoleic, linoleic, and arachidonic, which is consistent with our research results (Tang et al., 2021).

Probiotic preparations containing *B. subtilis* and *Bacillus licheniformis* have a positive effect on the characteristics of poultry carcasses, improve the quality and taste of meat, meat broth of broiler chickens, increase the biological value of meat due to the increased content of amino acids and fatty acids (Xu et al., 2021).

The protein-quality index of breast meat in experiment 3, when broiler chickens were given the probiotic preparation Subtiform at a dose of 4.0 g/10 dm^3 of water, exceeded the index by 1.2 times in the control group by 1.13 times in experiment 1 and in 1.07 times in experiment 2. The probiotic preparation *Bacillus subtilis* DSM 29784 also has a positive effect on indicators of the biological value of broiler chicken meat. It increases the content of amino acids and fatty acids in it (Wang et al., 2021).

The biological value and toxicity of the meat of broiler chickens characterize its nutritional value and harmlessness to the human body. The use of biological objects to determine the relative biological value of the meat of slaughtered animals is relevant in scientific research (Liniichuk & Yakubchak, 2018; Wang et al., 2021).

An alternative to preventing the use of antibiotics in feeding animals is probiotics because resistance to antibiotics is emerging, which, when studying them in the environment and animals, should be evaluated for their toxicity and the identification of potentially dangerous risks to human health and the environment (Chaturvedi et al., 2021; Ahsan et al., 2022).

Therefore, veterinary medicine specialists should carry out risk-oriented control at the facilities for growing broiler chickens by feeding them balanced feed with the inclusion of probiotic preparations that have a positive effect on the health and well-being of birds, as well as on the biological value of meat. Currently, it is essential to study the effect of probiotic preparations on the cultivation of broiler chickens to ensure the health and well-being of poultry, increase the safety and quality of poultry products by reducing the impact of pathogenic microorganisms on the poultry body, and improve the quality of raw meat (Jeni et al., 2021).

4. Conclusions

It was established that the highest indicators of the amino acid and fatty acid composition were found when drinking with water the probiotic biopreparation Subtiform, which contains bacteria of the genus Bacillus subtilis and Bacillus licheniformis (2.5×10^9 CFU/g) and dry milk serum, in a dose of 4.0 g/10 dm^3 of water (experiment 3) for 20 birds in a cage. In experimental group 3, the content of essential amino acids was 5.39 ± 0.04 mg/100 mg ($P \leq 0.001$); the content of substituted amino acids – 9.07 ± 0.04 mg/100 mg ($P \leq 0.001$); total content of saturated fatty acids – 38.39 ± 0.002 % ($P \leq 0.001$); monounsaturated fatty acids – 43.77 ± 0.002 % ($P \leq 0.001$), polyunsaturated – 25.16 ± 0.02 % ($P \leq 0.001$). The highest relative biological value and harmlessness for using *Tetrahymena pyriformis* ciliates – 103.85 % – was established in research group 3 of broiler chicken meat.

Conflict of interest

The author claims no conflict of interest.

References

Ahsan, U., Adabi, S. G., Sayın, Ö., Sevim, Ö., Tatlı, O., Kuter, E., & Cengiz, Ö. (2022). Growth performance, carcass yield and characteristics, meat quality, serum biochemistry, jejunal histomorphometry, oxidative stability of liver and breast muscle, and immune response of broiler chickens fed natural antioxidant alone or in combination with *Bacillus licheniformis*. *Archives Animal Breeding*, 65(2), 183–197.
[Crossref] [Google Scholar]

Alagawany, M., Abd El-Hack, M. E., Farag, M. R., Sachan, S., Karthik, K., & Dhama, K. (2018). The use of probiotics as eco-friendly alternatives for antibiotics in poultry nutrition. *Environmental Science and Pollution Research International*, 25(11), 10611–10618.
[Crossref] [Google Scholar]

Bahaddad, S. A., Almalki, M. H. K., Alghamdi, O. A., Sohrab, S. S., Yasir, M., Azhar, E. I., & Chouayekh, H. (2023). Bacillus species as direct-Fed microbial antibiotic alternatives for monogastric production. *Probiotics Antimicrob Proteins*, 15(1), 1–16.
[Crossref] [Google Scholar]

Chaturvedi, P., Shukla, P., Giri, B. S., Chowdhary, P., Chandra, R., Gupta, P., & Pandey, A. (2021). Prevalence and hazardous impact of pharmaceutical and personal care products and antibiotics in environment: A review on emerging contaminants. *Environ Research*, 194, 110664.
[Crossref] [Google Scholar]

de Mesquita Souza Saraiva, M., Lim, K., do Monte, D. F. M., Givisiez, P. E. N., Alves, L. B. R., de Freitas Neto, O. C., Kariuki, S., Júnior, A. B., de Oliveira, C. J. B., & Gebreyes, W. A. (2022). Antimicrobial resistance in the globalized food chain: a One Health perspective applied to the poultry industry. *Brazilian Journal Microbiology*, 53(1), 465–486.
[Crossref] [Google Scholar]

Elleithy, E. M. M., Bawish, B. M., Kamel, S., Ismael, E., Bashir, D. W., Hamza, D., & Fahmy, K. N. E. (2023). Influence of dietary Bacillus coagulans and/or Bacillus licheniformis-based probiotics on performance, gut health, gene expression, and litter quality of broiler chickens. *Trop Animal Health Products*, 55(1), 38.
[Crossref] [Google Scholar]

Fluck, A. C., Cardinal, K. M., Costa, O. A. D., Borba, L. P., & Pires P. G. (2023). Yolk and eggshell colour: are these the parameters that influence egg purchasing? A systematic review. *World's Poultry Science Journal*, 79(3), 551–562.
[Crossref] [Google Scholar]

Jeni, R. E., Dittoe, D. K., Olson, E. G., Lourenco, J., Corcionivoschi, N., Ricke, S. C., & Callaway, T. R. (2021). Probiotics and potential applications for alternative poultry production systems. *Poultry Sciences*, 100(7), 101156.
[Crossref] [Google Scholar]

Liniichuk, N. V., & Yakubchak, O. M. (2018). Toxicological and biological assessment of meat of broiler chickens after the use of the drug "Baytril 10%". *Scientific reports of NUBiP of Ukraine*, 285, 388–394 (in Ukrainian).
[Abstract] [Google Scholar]

Ndlebe, L., Tyler, N. C., & Ciacciariello, M. (2023). Effect of varying levels of dietary energy and protein on broiler performance: a review. *World's Poultry Science Journal*, 79(3), 449–465.
[Crossref] [Google Scholar]

Razanova, O., Yaremchuk, O., Gutyj, B., Farionik, T., & Novgorodska, N. (2022). Dynamics of some mineral elements content in the muscle, bone and liver of quails under the apimin influence. *Scientific Horizons*, 25(5), 22–29.
[Crossref] [Google Scholar]

Salem, H. M., Saad, A. M., Soliman, S. M., Selim, S., Mosa, W. F. A., Ahmed, A. E., Al Jaoun, S. K., Almuhayawi, M. S., Abd El-Hack, M. E., El-Tarabily, K. A., & El-Saadony, M. T. (2023). Ameliorative avian gut environment and bird productivity through the application of safe antibiotics alternatives: a comprehensive review. *Poultry Science*, 102(9), 102840.
[Crossref] [Google Scholar]

Selle, P. H., Macelline, S. P., Chrystal, P. V., & Liu, S. Y. (2023). A reappraisal of amino acids in broiler chicken nutrition. *World's Poultry Science Journal*, 79(3), 429–447.
[Crossref] [Google Scholar]

Shehata, A. A., Yalçın, S., Latorre, J. D., Basiouni, S., Attia, Y. A., Abd El-Wahab, A., Visscher, C., El-Seedi, H. R., Huber, C., Hafez, H. M., Eisenreich, W., & Tellez-Isaias, G. (2022). Probiotics, Prebiotics, and Phytogenic Substances for Optimizing Gut Health in Poultry. *Microorganisms*, 10(2), 395.
[Crossref] [Google Scholar]

Silva, V. L., Kovaleski, J. L., Pagani, R. N., & Gomes, M. F. S. (2023). Industry 4.0 implementations: a systematic review of approaches and main applicabilities in the broiler meat production chain. *World's Poultry Science Journal*, 79(3), 563–579.
[Crossref] [Google Scholar]

Slivinska, L. G., Yaremchuk, V. Y., Shcherbatyy, A. R., Gutyj, B. V., & Zinko, H. O. (2022). Efficacy of hepatoprotectors in prophylaxis of hepatosis of laying hens. *Regulatory Mechanisms in Biosystems*, 13(3), 287–293.
[Crossref] [Google Scholar]

Tang, X., Liu, X., & Liu, H. (2021). Effects of dietary probiotic (*Bacillus subtilis*) supplementation on carcass traits, meat quality, amino acid, and fatty acid profile of broiler chickens. *Front Veterinary Science*, 8, 767802.
[Crossref] [Google Scholar]

The procedure for carrying out experiments and experiments on animals by scientific institutions: Order of the Ministry of Education and Science, Youth and Sports of Ukraine from 01.03.2012 No. 249, 2012 (in Ukrainian).
[Order]

Wang, L-D., Zhang, Y., Kong, L-L., Wang, Z-X., Hao, B., Jiang, Y., Bi, Y.-L., Chang, G.-B., & Chen, G.-H. (2021). Effects of rearing system (floor vs. cage) and sex on performance, meat quality and enteric microorganism of yellow feather broilers. *Journal of Integrative Agriculture*, 20(7), 1907–1920.
[Crossref] [Google Scholar]

Wang, Y., Heng, C., Zhou, X., Cao, G., Jiang, L., Wang, J., Li, K., Wang, D., & Zhan, X. (2021). Supplemental *Bacillus subtilis* DSM 29784 and enzymes, alone or in combination, as alternatives for antibiotics to improve growth performance, digestive enzyme activity, anti-oxidative status, immune response and the intestinal barrier of broiler chickens. *The British Journal of Nutrition*, 125(5), 494–507.
[Crossref] [Google Scholar]

Xu, Y., Yu, Y., Shen, Y., Li, Q., Lan J., Wu, Y., Zhang, R., Cao, G., & Yang, C. (2021). Effects of Bacillus subtilis and Bacillus licheniformis on growth performance, immunity, short chain fatty acid production, antioxidant capacity, and cecal microflora in broilers. *Poultry Science*, 100(9), 101358.
[Crossref] [Google Scholar]

Zotsenko, V., Dzhmil, V., Ostrovskiy, D., Andriichuk, A., & Melnyk, T. (2021). Veterinary and sanitary characteristics of quail meat by feeding nanocrystalline cerium dioxide. *Scientific Bulletin of Veterinary Medicine*, 1, 27–36 (in Ukrainian).
[Crossref] [Google Scholar]