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Productivity and Quality of Broiler Chicken Meat Using New Triazolin Compounds

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Abstract. In providing the population with high-quality food products, a special place is given to poultry meat production. The purpose of this study was to investigate the effect of triazoline compounds on the productivity and haematological parameters of broiler chickens. The study was conducted in 2021-2022 at the Odesa State Agrarian University in vivarium and analytical laboratories. 1,2,4-triazole derivatives synthesised at the Zaporizhzhia State Medical University were used for the study: GKPF-109 – Morpholin-4-ium-2-((4-amino-5-(3-methyl-pyrazol-5-yl)-1,2,4-triazol-3-yl)thio)acetate; ASP-34 – sodium 2-((4-amino-5-(thiophen-2-ylmethyl)-4H-1,2,4-triazol-3-yl)thio)acetate. The dynamics of poultry growth was determined by individual weighing, followed by determination of absolute and average daily live weight gains. Poultry feeding was carried out according to species and age periods per the existing norms. Haematological, immunological, and biochemical studies were performed according to the following methods. Tasting evaluation of meat and broth was carried out according to a 5-point system. Broths were evaluated according to 4 indicators – taste, smell, colour, transparency, each of them according to a 5-point system. The analysis of total weight data in the groups indicates the highest gross gain in live weight in the group of 36-day-old chickens that received GKPF-109 from 10 days of age, which is 14,966 g in 26 days of the experiment. The preservation of broiler chickens during the experimental period was 96% in the experimental groups, and 94% in the control group. Analysing the above, it can be concluded that adding research compounds of the triazoline series to drinking water increases haematopoiesis, has anti-inflammatory and hepatoprotective effects. Evaluation of the quality of meat of broiler chickens and broth at the end of the experiment does not allow claiming a decrease in their aroma and taste qualities, which indicates the absence of a negative effect of the research compounds of the triazoline series and the methods of their application on the organoleptic parameters of the meat

Keywords: 1,2,4-triazole derivatives, meat productivity of broilers, poultry carcasses, growth, mass

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INTRODUCTION

The most important branch of animal husbandry, which provides the population with complete food products, is industrial poultry farming. The main indicators that determine the efficiency of the operation of this industry are the productivity, preservation of the poultry population, and the quality of the obtained products. Obtaining high-quality and safe poultry products directly depends on several biotic (De Boeck *et al.,* 2015; Paliy *et al.,* 2018) and abiotic (Mesquita *et al.,* 2021; Orobchenko *et al.,* 2022) environmental factors of keeping productive livestock. Therewith, preserving the health of poultry directly affects the yield of finished products, its cost price, and thus determines the economic efficiency of production (Mohammed *et al.,* 2021). It has been proven that the basis of poultry health and the successful realisation of its genetic potential is the proper functioning of the immune system (Song *et al.,* 2021). It is undeniable that vaccination is the main veterinary preventive measure necessary to prevent the occurrence and spread of infectious diseases (Hautefeuille *et al.,* 2020; Ike *et al.,* 2021). Along with vaccines, several immunomodulators and immunostimulants are used to increase viability, resistance to stress in poultry, as well as to ensure its high productivity (Krishan *et al.,* 2015; Hasted *et al.,* 2021).

Immunomodulators (IMDs) are drugs of various origins that can correct the body's immune system and increase its natural resistance. The vital property of IMDs is that they do not affect the normally functioning immune system (Al-Khalifa, 2016). The results of experimental studies and production tests allow recommending immunomodulators for introduction into the practice of industrial poultry farming, which is economically profitable and contributes to a substantial increase in the qualitative and quantitative characteristics of the resulting poultry products (Ghosh *et al.,* 2016; Rehman *et al.,* 2017). Despite the multitude of proposed immunomodulatory drugs for commercial poultry farming, their safety, impact on poultry productivity and product quality must be considered when using them (Sunder *et al.,* 2008; Arif *et al.*, 2019). It is necessary to give preference to those immunomodulatory drugs that can not only normalise the functional state of the immune system, but also stimulate the growth and development of poultry, increase its productivity indicators (Avango *et al.,* 2016). Almost any immunomodulatory drug has a maximum allowable dose and if it is exceeded, immunosuppression can be obtained instead of the expected positive effect (Bascones-Martinez *et al.,* 2014).

Currently, such immunomodulating drugs as Fosprenil and Gamavit are used in poultry farming. There is evidence that administering these drugs with water to broiler chickens can increase the productivity of poultry (Sanin *et al.,* 2011). An increase in immune protection of broiler chickens was established when copper nanoparticles were introduced into drinking water (Yang *et al.,* 2011; Ognik *et al.,* 2018). The influence of arginine on productivity and immunity of broilers was studied. Thus, with an increase in the content of arginine in the feed on Day 22, serum concentrations of antibody titres to Newcastle disease improved (Xu *et al.,* 2018). Scientific research conducted by Shyma K. Latheef *et al.* (2017) indicate the use of herbal preparations for prevention and stimulate the immune system of poultry under vaccination against infectious diseases. Among the feed additives that have gained popularity in poultry farming after the ban on antibiotic stimulants are probiotics. They are one of the most versatile feed additives and are easily combined with other additives. Probiotics have many benefits, including stimulating the development of macroorganism microflora and immunomodulating it (Krysiak *et al.,* 2021; Jha *et al.,* 2020).

One of the most effective methods of strengthening the body's immunity is balanced feeding. Lack of any nutrients adversely affects the immune system and increases the sensitivity of poultry to infectious diseases (Fritts *et al.,* 2004; Nosrati *et al.,* 2017; Schulze Brend *et al.,* 2020). Lack of substances such as linoleic acid, vitamin A, E, iron, selenium, and arginine has been proven to have a destructive effect on the immune system of poultry (Gilbert, 2018; Lin *et al.,* 2020), phosphorus and calcium (Hofmann *et al.,* 2021).

Modern crosses of productive poultry are more susceptible to various infections and metabolic diseases and show a high mortality rate. As a result, interest in the use of feed additives with immunomodulatory properties for use in commercial poultry farming has grown recently (Swiatkiewicz *et al.,* 2014). However, the effectiveness of using modern immunomodulators is still understudied. Today, the issues of establishing rational doses and modes of use of the most effective immunomodulatory drugs in poultry farming remain relevant. *The purpose of this study* was to improve technological methods for increasing the productivity of broilers with triazoline derivatives.

MATERIALS AND METHODS

The study was conducted during 2021-2022. Laboratory tests were carried out in the vivarium and analytical laboratories of the Odesa State Agrarian University, where 30 heads of broiler chickens were raised. Several 1,2,4-triazole derivatives synthesised at the Zaporizhzhia State Medical University were studied:

GKPF-109 – Morpholin-4-ium-2-((4-amino-5-(3-methyl-pyrazol-5-yl)-1,2,4-triazol-3-yl) thio) acetate (Fig. 1).

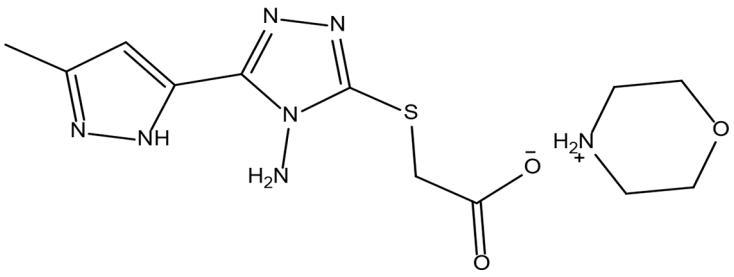

***Figure 1**. Chemical formula of GKPF-109*

***Note**: Chemical formula: $C_{12}H_{17}N_7O_3S$*
Molecular weight: 339.37
Calculated: C, 42.47%; H, 5.05%; N, 28.89%; S, 9.45%
Found: C, 42.36%; H, 5.04%; N, 28.97%; S, 9.47%

The synthesised compound is a white crystalline substance that is soluble in water, partially in alcohol, insoluble in diethyl ether, ethyl acetate.

ASP-34 – sodium 2-((4-amino-5-(thiophen-2-ylmethyl)-4H-1,2,4-triazol-3-yl)thio)acetate (Fig. 2).

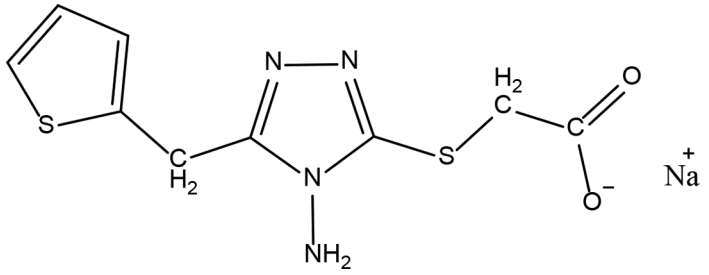

***Figure 2**. Chemical formula of ASP-34*

***Note**: Chemical Formula: $C_9H_9N_4NaO_2S_2$*
Molecular Weight: 292.31
Calculated: C, 36.98%; H, 3.10%; N, 19.17%; S, 21.94%.
Found: C, 37.14%; H, 3.11%; N, 19.15%; S, 21.90%.
The synthesised compound is a light-yellow crystalline powder

In the infrared spectrum, the test compounds have absorption bands of –C=N-groups at 1,630-1,610 cm^{-1}, –CH2-groups at 2,915-2,940 cm^{-1}, symmetric (1,388 cm^{-1}) and asymmetric (1,569 cm^{-1}) fluctuations of the –COO– group.

Administration of drugs with water is one of the most frequently used technological methods of administration of various medicinal substances and vaccines in poultry farming (Krysiak *et al.,* 2021).

The main purpose of this study was to investigate the new derivative compounds of the triazoline series on the productive qualities of broiler chickens. For this purpose, day-old birds were selected from which three experimental groups were formed: control (I) and experimental (II; III), 10 heads each. The young poultry was selected considering the following parameters: breed, age, live weight.

Triazoline compounds ASP-34 and GKPF-109 were added to the main diet of the control group every day, starting from the age of one day, in a dose of 0.5 ml per 1 liter of water. The dose of the drug ensured a water pH value of 4.5. Experimental drugs were given to experimental chickens from the 10th to the 14th day of rearing.

The experimental poultry was fed equally according to age periods (Leeson & Zubair, 1997). Protein nutritional value of starter feed of broiler chickens in 0-15 days was 21-23%, growth feed in the period of fattening from 16 to 30 days – 19-21%, finishing feed (31-38 days) – 18-20% and finisher (39-42 days) – 17-19%. The poultry was kept in standard cage equipment. Zoohygienic parameters (floor area and feeding front, lighting, ammonia level, humidity, air movement speed, etc.) corresponded to the regulations in force in poultry farming (Soliman *et al.*, 2017; Zabir *et al.,* 2021).

Broilers were weighed on Domotec electronic scales in the morning before feeding. Livestock conservation was determined by daily accounting. The effect of compounds of the triazoline series on the body of broiler chickens was investigated by haematological and immunological

indicators of blood. Blood collection for research was carried out in compliance with the rules of asepsis and antiseptics from the wing with heparin and trilon, and to obtain serum, blood was collected without the use of an anticoagulant.

The number of erythrocytes was measured in the Goryaev chamber. A drop of diluted blood was taken to fill the Goryaev counting chamber and after sedimentation in the chamber the cells were counted under a microscope. Number of red blood cells in 1 mm^3 of blood was calculated according to the following formula (1) (Sadovnikov *et al.,* 2009):

$$X = a \times 4{,}000 \times c \div b \quad (1)$$

where X is the number of red blood cells in 1 mm^3 blood; a is the number of red blood cells counted in 80 squares; b is the number of squares counted; c is the degree of blood dilution.

The number of platelets was counted in counting chambers on glass slides stained according to the Romanovsky-Giemse method. White blood cells were counted in 100 large squares with a total area of 4 mm^2. White blood cells and platelets were counted using a microscope. Platelet and white blood cell counts were calculated using the following formula (2) (Sadovnikov *et al.,* 2009):

$$X = \frac{A\text{x}4{,}000\text{x}20}{C} \quad (2)$$

where X is the total amount of blood per 1 mm^3; A are the counted cells; *1/4,000* is the capacity of one square; *20* is the breeding; C is the number of small squares counted.

To find the leukocyte formula, it was determined on blood smears stained according to the Romanovsky-Giems method. T and B lymphocytes were produced using a rosette formation reaction with ram erythrocytes (Sadovnikov *et al.,* 2009; Kanda *et al.,* 2020).

Erythrocyte sedimentation rate (ESR) was determined according to the Panchenkov micromethod. In a capillary pipette, pre-washed with a solution of sodium citrate, this solution is drawn up to the mark "P" and introduced into test tubes measuring 10x1 cm. Then, with the same capillary, blood was collected 2 times to the "K" mark, and it was introduced into the same test tube each time. After mixing, it was sucked into the capillary to the "O" mark and then placed in the tripod. After 1 hour, the value of the remaining plasma column was calculated according to the distribution of the capillary pipette. The sedimentation rate was determined in 1 hour. (Burton *et al.,* 1966).

Circulating immune complexes were performed in the selective precipitation of antigen-antibody complexes in a 3.75% solution of polyethylene glycol (PEG) with subsequent photometric determination of the optical density of the precipitate. The phagocytic activity of neutrophils was expressed as a percentage of leukocytes involved in phagocytosis to the total number of neutrophil leukocytes counted. To find the opsonophagocytic reaction, the method of V.M. Berman and E.M. Slavskyi (1982) was applied, which included the following methodological techniques: 1) the phagocytic function of chicken blood cells was investigated in relation to the gram-positive St. Aureus test microbe. The phagocytic index characterised the intensity of phagocytosis. The average number of phagocytosed microbes was found per active leukocyte. The phagocytic index was calculated by dividing the number of phagocytosed bacteria by the number of active leukocytes (Wansbrough-Jones, 1979).

Slaughter yield is the ratio of slaughter mass to live weight, expressed as a percentage. It was determined by which parts of the body are included in the slaughter mass. In poultry, the slaughter weight depends on the features of the post-slaughter processing of the carcass: it is the highest in uneviscerated poultry, as it includes the mass of the bloodless and plucked carcass with fat, head, limbs, and internal organs; a half-eviscerated bird has a mass of carcass with fat, but no intestines; with complete evisceration, blood, feathers, fluff, and intestines are removed, as well as all internal organs, and even the head up to the second cervical vertebra, limbs up to the metatarsals and wings up to the elbow joint. In control slaughter, the slaughter and meat qualities of the bird were determined: mass of eviscerated carcasses; pectoral muscle, fat, slaughter output.

Appearance (smell, consistency, state of fat, quality of broth upon cooking meat) was evaluated visually. The pectoral and hip muscles were cut across the direction of the muscle fibres, and their condition was determined on the cut. Filter paper was used to determine muscle moisture. Muscle colour was determined visually. Organoleptic assessment of poultry meat was carried out. To determine the flavour of the broth, 70 g of muscle was cut out, crushed. To determine the transparency and smell of the broth, 20 g of the crushed sample was weighed, poured with distilled water to about 60 ml, mixed, covered with a watch glass, and then placed in a water bath. During heating, the smell of the broth was determined at the moment of the appearance of steam. Transparency was determined visually in a cylinder with a diameter of 20 mm. The aroma of the broth was determined in hot broth at 80-85°C. The degree of transparency was determined visually by pouring 20 ml of broth. Comparing the results of the organoleptic examination of the samples with the requirements of the standard, the results of the study were described, and a conclusion was drawn about the quality of the meat. Tasting evaluation of meat and broth was carried out according to a 5-point system, evaluating each of the indicators according to the scale of the degree of quality, expressed in points: 5 – excellent; 4 – good; 3 – satisfactory quality; 2 – poor quality; 1 – unsatisfactory quality. Tasting indicators of meat and broth were determined according to modern methods (Jung *et al.,* 2014; Liu *et al.,* 2021).

Experiments conducted on animals do not contradict the current legislation of Ukraine (Article 26 of the Law of Ukraine No. 5456-VI "On the Protection of Animals from Ill-Treatment" dated 10/16/2012) and "General Ethical Principles of Animal Experiments", adopted by the First National Congress on Bioethics (Kyiv, 2001) and International Bioethical Standards (materials of the IV European Convention for the protection of vertebrates used for experimental and other purposes, Strasbourg, 1985).

The obtained digital material was processed using variational statistics (Plokhinsky, 1970) using the Statsoft Statistica 7.0 software package (StatSoft Inc., USA). In this paper, the values under study were presented as a sample mean and standard error of the mean (M±m). The Student's t-test was used to determine the average values. During the statistical analysis, the achieved level of confidence (P) was calculated. In this case, the critical confidence level was assumed to be 0.05.

RESULTS AND DISCUSSION

Administering triazoline compounds from day 10 to day 14 increased the average daily gain of live weight in the group receiving ACP-34 by 2.6% and GKPF-109 – by 6.2% compared to the control. In the period from the 15th to the 22nd day of rearing, the highest average daily growth was recorded in the group receiving GKPF-109. Thus, the average daily increase in this group was higher than in the control group by 18%, and from the group that received TSA-34 – by 15.4%. A similar trend was observed in the period from 22 to 26 days of raising chickens.

A decrease in the average daily weight gain in chickens was registered in the period from 26 to 31 days in all experimental groups, while in the rearing period from 31 to 36 days, an increase in the average daily weight gain was detected in the group that received GKPF-109. In the group with GKPF-109, this indicator was higher by 30.8% compared to the control, and by 11.4% compared to the group receiving ASP-34 (Table 1).

Table 1. *The dynamics of the increase in live weight of broiler chickens with the introduction of compounds of the triazoline series (M±m; n=10)*

Indicator	Age of chickens, days					
	10	15	22	26	31	36
			Control			
Total weight, g	2,120	4,201	7,330	9,796	12,504	14,821
Average sample weight, g	212.0±13.1	420.0±29.9	733.0±52.8	979.0±65.2	1,250.0±85.7	1,482.1±105.22
Average daily growth, g	–	41.6±4.6	52.1±0.5	58.75±12.8	54.16±6.01	46.34±7.39
			ASP-34			
Total weight, g	2,103	4,240	7,372	10,024	13,016	15,737
Average sample weight, g	210.0±6.4	424.0±7.7	737.0±21.8	1,002.0±28.9	1,301.0±33.1	1,573.7±40.1
Average daily growth, g	–	42.7±1.8	53.3±4.4	66.3±6.1	59.8±8.4	54.42±8.55
			GKPF-109			
Total weight, g	2,389	4,430	8,120	11,240	14,140	17,355
Average sample weight, g	238.0±12.2	443.0±18.09	812.0±25.1	1,124.0±28.9	1,414.0±33.3	1,735.5±33.23
Average daily growth, g	–	40.2±3.9	61.5±5.9	73.3±5.0	58.2±7.4	60.6±2.75

Note: *there is no probability in relation to the control*

The analysis of the total weight data in the experimental groups indicates the highest gross increase in live weight in the group of chickens of 36 days of age, which received GKPF-109 from the age of 10 days, which is 17,355 g for 36 days of the experiment. In the research group that received ASP-34, the increase in live weight during the same period amounted to 15,737 g. In the control group of chickens, the gross increase in live weight was 14,821 g. In the group with ASP-34, the total live weight of chickens at 36 days was lower than the group of chickens that received GKPF-109 by 1,618 g (9.4%). The total live weight of chickens from the group with ASP-34, compared to the control group, was higher by 916 g (6.2%), and in the group with GKPF-109 – by 2,534 g (17.1%). The increase in the average live weight of chickens in the groups after drinking the drugs at the age of 15 days was unreliable.

The average weight of 22-day-old chickens differed from the control group and from the group with ASP-34. Thus, chickens that received GKPF-109 had the highest average live weight of 812.0±25.1 g, which is 16 g (2.0%) higher than their peers that received ASP-34. The difference between the group of chickens receiving GKPF-109 and the control group during this period was 79 g (8.5%).

At the age of 26 days, the average daily increase in live weight in chickens of the experimental groups, compared to the control group, was also higher by

2.3% – in the group with ASP-34, and by 14.8% – in the group with GKPF-109. Therewith, in the group of chickens treated with GKPF-109, this indicator was higher than in the groups of their peers.

Therefore, the use of compounds of the triazoline series under study during the fattening period of broiler chickens stimulated the increase in their live weight.

The preservation of broiler chickens during the experimental period was 96–100% in the experimental groups, and 94% in the control group (Table 2).

***Table 2**. Preservation of chickens in experimental and control groups, %*

Group	Number of chickens, heads	Number of dead, heads	Preservation, %
Control	10	3	94
ASP-34	10	2	96
GKPF-109	10	0	100

During the experiment, the death of broiler chickens was observed in the second week of keeping. When conducting a pathological autopsy, it was found that in both groups they had a lower body weight compared to their peers, and changes in the effect of compressive influence. When obtaining the research results, it is possible to say that adding compounds of the triazoline series to the diet of broiler chickens has a positive effect on their growth and development.

During the daily clinical examination of broiler chickens, it was observed that in the first weeks of the experiment, the body of the chickens was covered with yellow down in both experimental and control groups. Starting from the 8th day, the growth of feathers around the wings was noted, the broiler chickens were mobile and consumed food well, the down and feather cover was clean. During the examination of the excrements, it was noted that it had a soft grey-brown consistency with white streaks. On the 14th day, the growth of wing and tail feathers was noted. Examining the mucous membranes of the conjunctiva, it was established that it was shiny, smooth, light pink, the excrement was soft in consistency, grey-brown with a green tint.

On the 22nd day of the experiment, the body of the chickens was covered with feathers, except for the areas of the wings and abdomen. A decrease in appetite and thinning of faecal masses were noted in the chickens of the control group. The excrements were grey-green with gas bubbles. The feather cover in the cloaca area was contaminated with excrements.

Starting from the 29th day of the experiment, the chickens of the experimental groups, which were given compounds of the triazole series, were active and mobile. The feather cover covered the entire body, except for the chest area. A decrease in appetite was noted in the chickens of the control group. The feather cover around the cloaca was contaminated with thin grey-green excrements. On Day 36 of the experiment, the body of chickens of the experimental and control groups was completely covered with feathers. In some poultry of the control group, the feather cover in the cloaca area was contaminated with grey-brown excrements. Visible mucous membranes were smooth, moist, shiny, and grey-pink. A decrease in the motor activity of chickens was noted in the control and experimental groups that were given the compound of the triazoline series APS-34, in the group that was given GKPF-109, the survival of broiler chickens was observed at 100%. By the end of the experiment, the body of both intact and experimental chickens was evenly covered with feathers. The chickens of the experimental groups actively consumed feed and water. In some chickens of the control group, a decrease in appetite was observed, their feather cover around the cloaca was contaminated with thin grey-green faecal masses with gas bubbles. From the research, it can be concluded that when triazole compounds are added to the diet, they have a positive effect on the clinical condition of the chickens in the experimental groups compared to the control group. The chickens of the experimental groups were more mobile, with satisfactory feed intake and formed excrements. This indicates the beneficial effect of compounds of the triazoline series on digestive processes, especially in critical phases of development starting from the first week of life, transition from one diet to another and during the period of juvenile moulting.

Haematological analysis belongs to the methods that can contribute to the detection of some changes in the state of health and can be useful for the diagnosis of poultry diseases (Tables 3, 4). Haemoglobin is an essential component of blood. Its function is to transfer oxygen and nutrients from cells to tissues, ensuring the normal flow of energy processes in the body. An increase in the level of hAemoglobin was found, namely in the group of broilers that were given the ASP-34 compound. In the GKPF-109 group, according to the table data, a decrease in haemoglobin was observed. The results of the colour index of broilers observed in all experimental and control groups were less than one. An increase in erythrocytes and haemoglobin in the broilers of the research groups may indicate that triazole compounds stimulate the processes of erythropoiesis, do not have a harmful effect on the stability of hematopoiesis and constancy in the composition and total amount of blood.

***Table 3**. Haematological parameters of broiler blood (M±m; n=10)*

Indicators	Chicken groups			Norm (according to M. P. Babina)
	Control	ASP-34	GKPF-109	
Haemoglobin, h/l	100±3.3	95.0±1.89	104±2.3	92.71–101.5
Red blood cells, t/l	3.99±0.045	3.9±0.03***	4.06±0.034	2.2–2.3
White blood cells, g/l	22.7±0.02	24.6±0.02	28.4±0.7	29.2–32.6
Colour index	0.84±0.02	0.81±0.012	0.84±0.015	1–3
ESR, mm/h.	3.0±0.36	2.4±0.37 **	2.2±0.25***	1.0–3.0
Lymphocytes, %	60.6±1.08	62.71±0.64	60.8±1.44	58.7–60.84
Monocytes, %	4.0±0.37	3.71±0.42	4.1±0.35	6.28–8.52
Eosinophils, %	3.7±0.39	2.57±0.37***	2.8±0.33**	2.83–5.17
Basophils, %	0.7±0.26	1.0±0.31	1.0±0.26	0.24–0.96
Pseudoeosinophils, %	31.0±0.78	31.4±1.19	31.4±1.17	28.5–32.2
Platelets, thous./ml	37.5±0.91	38.0±0.93	38.4±0.79	50.7–62.6

***Note**: ** – P<0.01 probability in relation to the control, *** – P<0.001 probability in relation to the control*

***Table 4**. Immunological parameters of broiler chickens (m±m; n=10)*

Indicators, units of measurement		Chicken groups		
		control	ASP-34	GKPF-109
T-lymphocytes, %		35.7±0.94	36.2±0.41	35.5±0.36
T-helpers, %		24.1±0.66	24.2±0.38	23.1±0.59
T-suppressors, %		11.6±0.65	11.7±0.36	12.4±0.37
T active, %		2.2±0.32	2.9±0.18	2.14±0.26
T-resistant, %		5.5±0.31	5.8±0.29	4.71±0.56
T-0, %		49.7±0.90	49.2±0.53	51.54±0.69
IRI-insulin resistance		2.13±0.13	2.12±0.07	1.87±0.10
Phagocytic activity of neutrophils, %		60.0±1.30	62.5±1.12	60.0±1.90
Phagocytic number, units		3.6±0.22	3.2±0.20	2.86±0.26
Circulating immune complexes, units of optical density				
small molecular weight		17.1±3.63	30.9±5.07	15.3±1.72
medium molecular weight		11.5±3.42	21.8±2.60	11.43±1.17
large molecular weight		7.9±3.20	11.3±0.60	7.14±0.98
NST-test	+	14.2±0.42	14.2±0.47	11.28±0.60
	++	6.1±0.46	6.3±0.30	6.0±0.44
	+++	2.8±0.25	3.0±0.33	3.0±0.31

***Note**: there is no probability in relation to the control*

According to the results of the analysis of the haematological indicators of the blood of broilers, an increase in the number of haemoglobin and erythrocytes and the colour index was found, but there was a slight decrease in ESR. Analysing the data of immunological indicators of broilers revealed an increase in T-total lymphocytes.

No significant changes were registered in relation to T-helpers to T-suppressors compared to the control group. In the GKPF-109 group, the percentage of phagocytosing neutrophils increased by 2.5% compared to the control and to chickens from the ASP-34 group. The phagocytic number of the test compounds was also slightly lower than the control.

The biochemical parameters of the blood serum of the poultry were determined (Table 5). Thus, in broiler chickens in all experimental groups, the ALT level was higher than physiological norms. Cholesterol and total bilirubin levels in chickens in all experimental groups were within the normal range.

***Table 5**. Biochemical parameters of broiler chickens (M±m; n=10)*

Indicators	Units of measurement	Chicken groups		
		control	ASP-34	GKPF-109
ALT	mmol/l	0.71±0.09	0.77±0.20	0.73±0.04
AST	mmol/l	2.63±0.13	2.63±0.13	2.66±0.12
Cholesterol	mmol/l	4.0±0.21	4.07±0.22	4.26±0.18
Total protein	g/l	32.0±2.00	33.3±3.53	32.0±1.15
Albumin	g/l	16.43±0,17	16.8±1.04	16.8±3.08
Urea	mmol/l	2.2±0.20	2.23±0.20	2.3±0.12
Bilirubin	mmol/l	1.0±0.03	0.96±0.03	0.83±0.23
Glucose	μmol/l	12.3±0.15	14.2±0.58	10.2±0.10

***Note**: there is no probability in relation to the control*

The highest level of glucose was noted in the group with ASP-34, which was 14.2±0.58 mmol/l with a norm of 12.3 mmol, while in the group with GKPF-109 this indicator was lower than the control group and the norm. The amount of total protein, the level of which in broiler chickens ranges from 32 to 33 g/l, had some fluctuations in all experimental groups. The value of albumin in chickens was below the norm (44.5 g/l), the value was especially low in the group with ASP-34.

Analysing the above, it can be concluded that adding research compounds of the triazoline series to drinking water increases haematopoiesis, has anti-inflammatory and hepatoprotective effects. The next stage was organoleptic assessment of broiler chicken meat and broth (Figs. 3, 4).

Tasting evaluation of meat products and broth was carried out according to the generally expressed methodology described above (Table 6).

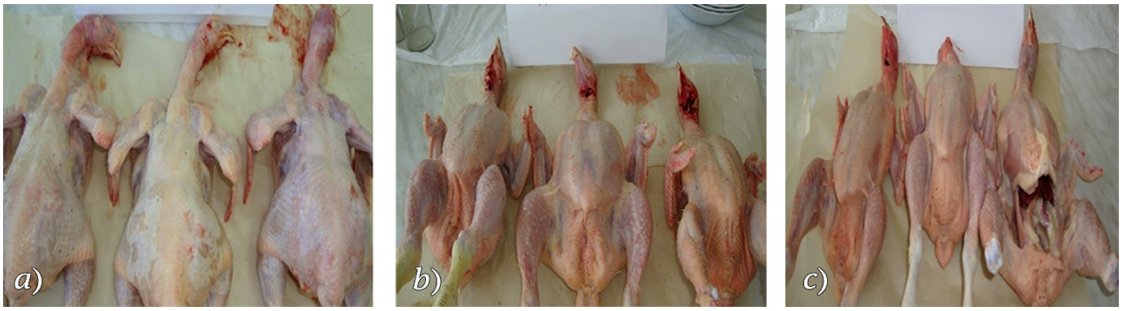

***Figure 3**. Broiler chicken carcasses*

***Note**: a) control; b) ASP-34; c) GKPF-109*

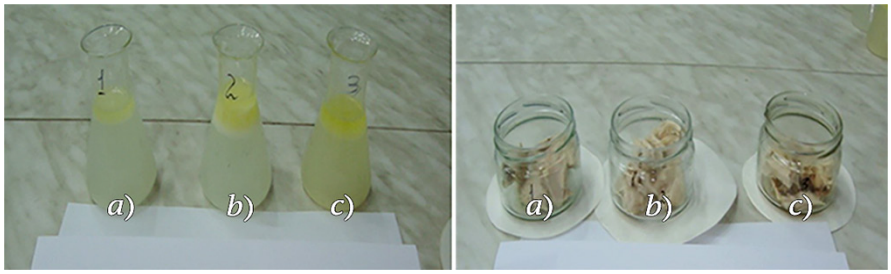

***Figure 4**. Appearance of broiler chicken broth and boiled meat*

***Note**: a) control; b) ASP-34; c) GKPF-109*

***Table 6**. Biochemical parameters of broiler chickens (M±m; n=10)*

Indicators	Group		
	control	ASP-34	GKPF-109
Arithmetic mean of the tasting assessment of meat products, score			
Colour	4.0	4.6	4.0
Smell	4.0	4.8	4.0
Fragrance	4.2	5.0	4.0
Tenderness	3.0	4.6	3.6
Taste	4.0	4.8	4.0
Juiciness	3.0	4.6	4.0
Total score	3.7	4.73	3.9
Arithmetic mean of the tasting assessment of broth quality, score			
Strength	3.6	4.8	3.8
Colour	4.0	4.8	4.4
Smell	4.0	5.0	4.0
Fragrance	3.8	4.8	4.0
Richness	3.4	4.8	3.6
Taste	4.0	4.8	3.4
Transparency	3.8	4.4	3.8
Total score	3.8	4.77	3.86

The assessment of the quality of cooked meat of broiler chickens in the ASP-34 group exceeded both the control group and the group that received GKPF-109. The total score in the ASP-34 group was 1.03 points higher than the control group, and 0.83 points higher than the GKPF-109 group. Furthermore, a higher evaluation of the broth was obtained in Group I, compared to the control by 0.97 points.

During the veterinary and sanitary evaluation of the poultry meat of the experimental and control groups, the surface of the carcasses in all samples was dry, white-yellow in colour with a pink tint; in the oral cavity, the mucous membrane was pink, moist; the beak was glossy; bulging eyeball; subcutaneous and internal adipose tissue was yellowish, the serous membrane of the chest and abdominal cavity was moist, the muscle tissue on the section was slightly moistened, pink, the smell was characteristic of fresh poultry meat. Broth in experimental samples was transparent, fragrant, in control samples – translucent, fragrant. No foreign smell was detected. No substantial differences were found in all indicators of the carcass of the experimental and control groups.

High-quality indicators of meat and broth in the experimental groups of broiler chickens indicate an improvement in the quality of meat when triazoline compounds were introduced into the diet.

Poultry farming is an essential and dynamically developing industry. In the structure of domestic poultry meat production, broiler chickens account for 97%, turkey accounts for 2%, and alternative poultry products (ducks, geese, quail) account for only 1% of the total volume. The population's need for animal proteins is met by chicken meat and eggs, the dietary properties of which are well-known. These are socially significant products that are available to the public due to their low cost.

The task of the poultry industry is to increase competitiveness by improving the quality and reducing the cost of the resulting products.

Currently, there is an active search for alternative drugs that would stimulate growth, contribute to the normalisation of the microbial composition of the digestive canal of chickens and ensure the production of high-quality and safe products. Intensive development of the poultry industry is impossible without the use of various biologically active additives. These supplements include probiotics, prebiotics, symbiotics, enzymes, organic acids, and triazoline-type compounds (Simmonds, 2017; Kabene & Baadel, 2019).

To understand the mechanism of action of individual drugs on the organs of the bird and the body as a whole, a complex morphological study of body tissues in different periods of development is necessary (Maguey-Gonzales, 2018; Mudroňová *et al.,* 2020; Arif *et al.,* 2018). Based on this, the purpose of the study was to comprehensively assess the effect of compounds of the triazoline series on haematological, immunological

indicators of blood and productive indicators of broiler chickens of the "Cobb-500" cross.

A tendency to increase the intensity of the growth rate of broiler chickens was found upon administering the compounds under study. During the same feed consumption, the growth rate of broilers in some experimental groups exceeded that of peers from the control group. The results of experiments on feeding triazoline compounds to broiler chickens indicate an increase in the stimulating effect, which implies a reduction in the time of industrial poultry rearing (Paliy & Paliy, 2022), which is relevant for industrial meat poultry farming (Disetlhe *et al.,* 2019; Jaďuttová *et al.,* 2019; Roth *et al.,* 2019).

The dynamics of the development of broiler chickens, which were in an experiment to study the effect of compounds of the triazoline series on meat productivity, showed that administering ASP-34 and GKPF-109 to broiler chickens led to a higher increase in live weight, compared to the control.

The highest average daily growth rate was observed during the rearing period from 24 to 30 days in the group with GKPF-109, which resulted in a chicken weight of 1,182.9±41.5 g, which exceeds the control by 116.7 g (10.9%) of the efficiency of using new derivatives of 1,2,4-triazole. An increase in average daily growth was found in the group that received GKPF-109 in the period from 15 to 55 days of rearing. This trend continued during the growing season from 22 to 26 days. Thus, the study established a positive effect of triazoline-series compounds and when administered at 0.1% concentration, which is economically advantageous. At the end of the 36th day of rearing, the excess live weight of chickens was found in comparison with the peers of the control group. Therewith, in 2 experimental groups that received ASP-34 and GKPF-109, live weight gain was obaserved. Administering 0.5% concentration of GKPF-109 showed an increase in stimulating activity on broiler chickens, which was 3.62% in the period from the 5th to the 10th day of cultivation.

The positive effect of triazoline compounds is also observed in the works of other scientists. Thus, M. Krauze et al. (2006; 2007) in their studies determined the effect of adding a synthetic 1,2,4-triazole derivative to drinking water for turkeys compared to garlic extracts and the echinovit drug. An increase in the number of leukocytes, the percentage of phagocytic cells and the phagocytic index was established. Lysozyme activity exceeded the indicator of the control and other groups of turkeys twice. Adding an aqueous extract of garlic or small doses of a synthetic derivative of 1,2,4 – triazole to drinking water during turkey rearing is effective in increasing non-specific cellular immunity. According to R.C. Simmonds (2017), by day 42 of rearing, Hubbard cross chickens had a weight of 1,835.0±35.0 g, while chickens of the experimental group had an average live weight of 2,065.0±25.0 g. In the given study on triazoline series compounds, the live weight of chickens and haematological indicators in all experimental groups exceeded the control, which is consistent with the results of the researchers mentioned above.

It is known that according to the age-related increase in the live weight of broilers, there is an increase in the weight of internal organs, including the thymus, the absolute weight of which increases unevenly throughout life (Simmonds, 2017; Kabene & Baadel, 2019).

The addition of triazoline compounds to the diet affected the activity of chicken blood enzymes. Analysis of the effect of the ASP-34 derivative on blood immunological parameters indicated an increase in the level of haemoglobin, red blood cells, and white blood cells compared to the control group. Other indicators were within the limits of physiological norms.

Immunological indicators also indicated a stimulating effect of triazoline-type compounds due to an increase in the number of T-lymphocytes, as well as a significant increase in T-helpers and B-lymphocytes. Analysing the average live weight of broilers at slaughter, which received GKPF-109, was 2,061 kg, which was higher than peers of the control group by 18.58%. In the same group, a higher percentage of meat yield was recorded, which was 84.31%.

Thus, the obtained results, based on a comprehensive assessment of the influence of compounds of the triazoline series during the period of growing broiler chickens, convincingly prove that they contribute to the improvement of haematological and immunological indicators of blood, increase in live weight, average daily gains, and obtaining high-quality and safe products.

CONCLUSIONS

Low weight gain of broiler chickens is one of the reasons restraining the growth of production of poultry products. Producers lose part of the profit in raising poultry. During the conducted research, it was established that administering new compounds of the triazoline series had a positive effect on the general condition of broiler chickens compared to the control group. In addition, broiler chickens of the experimental groups were more active and consumed food well. The use of 1,2,4-triazoline derivatives had a positive effect on the gastrointestinal rhythm of broiler chickens during the transition from one diet to another. During the experiment, a positive effect on the safety of broiler chickens treated with new triazoline compounds was established relative to the control group. Furthermore, compounds of the triazoline series showed a stimulating effect on increasing the live weight of the experimental groups. The technological methods of processing broiler chickens with new compounds of the triazoline series *in ovo* used in the experiment are economically feasible for increasing the efficiency of poultry farming. Thus, they ensure an increase in average daily live weight gains, the preservation of young animals, increase the meat productivity of broiler chickens, and provide non-specific resistance of the bird's body.

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Продуктивність та якість м'яса курчат-бройлерів при використанні нових сполук триазолінового ряду

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Анотація. У забезпеченні населення якісними продуктами харчування особливе місце приділяється м'ясному птахівництву. Метою роботи було вивчення впливу сполук триазолінового ряду на продуктивність та гематологічні показники курчат-бройлерів. Дослідження проводили в період з 2021 по 2022 р. у Одеському державному аграрному університеті в віварії та аналітичних лабораторіях. Для дослідження використовували похідні 1,2,4-тріазолу, синтезованих у Запорізькому державному медичному університеті: GKPF-109 – Morpholin-4-ium-2-((4-amino-5-(3-methyl-pyrazol-5-yl)-1,2,4-triazol-3-yl)thio)acetate; АСП-34 – sodium 2-((4-amino-5-(thiophen-2-ylmethyl)-4H-1,2,4-triazol-3-yl)thio)acetate. Динаміку приросту птиці визначали шляхом індивідуального зважування із подальшим визначенням абсолютних та середньодобових приростів живої маси. Годівлю птиці здійснювали згідно з видом і віковими періодами відповідно до існуючих норм. Гематологічні, імунологічні та біохімічні дослідження проводили згідно з методиками. Дегустаційну оцінку м'яса і бульйону проводили по 5-бальній системі, Бульйони оцінюються за 4 показниками – смаком, запахом, кольором, прозорістю кожен з них за 5 бальною системою. Аналіз даних загальної маси в групах вказує на найвищий валовий приріст живої маси в групі курчат 36-денного віку, яка отримувала GKPF-109 з 10-денного віку, що становить 14966 г за 26 днів досліду. Як можна побачити, що збереження курчат-бройлерів за період досліду в дослідних групах становить 96 %, а у контрольній — 94 %. Аналізуючи викладене вище можна зробити висновок, що додавання до питної води досліджувальні сполуки триазолінового ряду посилює гемопоез, має протизапальну та гепатопротекторну дію. Оцінка якості м'яса курчат-бройлерів та бульйону в кінці досліду не дозволяють стверджувати про зниження їх аромату та смакових якостей, що свідчить про відсутність негативного впливу досліджувальних сполук триазолінового ряду та способів їх застосування на органолептичні показники м'яса

Ключові слова: похідні 1,2,4-тріазолу, м'ясна продуктивність бройлерів, тушки птиці, приріст, маса