Founder, Editorial and Publisher
POLISSIA NATIONAL UNIVERSITY
e-ISSN 2709-8877
ISSN: 2663-2144

SCIENTIFIC HORIZONS

НАУКОВІ ГОРИЗОНТИ

Засновник, редакція, видавець:
Поліський національний університет

Рік заснування: 1998

Рекомендовано до друку та поширення через мережу Інтернет Вченою радою Поліського національного університету (протокол № 2 від 27 вересня 2023 року)

Свідоцтво про державну реєстрацію друкованого засобу масової інформації
серії КВ № 24997-14937 ПР

Науковий журнал включено до категорії А Переліку наукових фахових видань України, у яких можуть публікуватися результати дисертаційних робіт на здобуття наукових ступенів доктора та кандидата ветеринарних, економічних, сільськогосподарських і технічних наук зі спеціальностей: 051 – Економіка; 071 – Облік і оподаткування; 072 – Фінанси, банківська справа та страхування; 073 – Менеджмент; 075 – Маркетинг; 076 – Підприємництво, торгівля та біржова діяльність; 101 – Екологія; 133 – Галузеве машинобудування; 201 – Агрономія; 202 – Захист і карантин рослин; 203 – Садівництво та виноградарство; 204 – Технологія виробництва і переробки продукції тваринництва; 205 – Лісове господарство; 206 – Садово-паркове господарство; 208 – Агроінженерія; 211 – Ветеринарна медицина (наказ МОН України № 1166 від 23 грудня 2022 р.)

Журнал представлено у міжнародних наукометричних базах даних, репозитаріях та пошукових системах: Інституційний репозитарій Поліського національного університету, AGRICOLA, CAB Abstracts and Global Health (CABI), Open Academic Journals Index (OAJI), Scopus, Index Copernicus, Реєстр наукових видань України, Національна бібліотека України імені В. І. Вернадського, Crossref, Directory of Open Access Journals (DOAJ), ERIH PLUS, MIAR, International System for Agricultural Science and Technology (AGRIS)

Адреса редакції:
Поліський національний університет
10008, б-р Старий, 7, м. Житомир, Україна
E-mail: info@sciencehorizon.com.ua
https://sciencehorizon.com.ua/uk

© Поліський національний університет, 2023

SCIENTIFIC HORIZONS

Founder, Editorial and Publisher:
Polissia National University

Year of foundation: 1998

Recommended for printing and distribution
via the Internet by the Academic Council
of Polissia National University
(Minutes No. 2 of September 27, 2023)

Certificate of state registration
print mass media
Series KV No. 24997-14937 PR

The scientific journal is included in category A of the List of scientific professional publications of Ukraine, in which the results of dissertations for the degree of doctor and candidate of veterinary, economic, agricultural, and technical sciences can be published in the following specialties: 051 – Economy; 071 – Accounting and Taxation; 072 – Finance, Banking and Insurance; 073 – Management; 075 – Marketing; 076 – Entrepreneurship, Trade and Exchange Activities; 101 – Ecology; 133 – Sectoral Engineering; 201 – Agronomy; 202 – Plant Protection and Quarantine; 203 – Horticulture and Viticulture; 204 – Technology of Production and Processing of Livestock Products; 205 – Forestry; 206 – Park and Gardening Management; 208 – Agricultural Engineering; 211 – Veterinary Medicine (Order of the Ministry of Education and Science of Ukraine No. 1166 of December 23, 2022)

The journal is presented international scientometric databases, repositories and scientific systems: Institutional Repository of Polissia National University, AGRICOLA, CAB Abstracts and Global Health (CABI), Open Academic Journals Index (OAJI), Scopus, Index Copernicus, Register of Scientific Publications of Ukraine, Vernadsky National Library of Ukraine, Crossref, Directory of Open Access Journals (DOAJ), ERIH PLUS, MIAR, International System for Agricultural Science and Technology (AGRIS)

Editors office address:
Polissia National University
10008, 7 Staryi Bvld., Zhytomyr, Ukraine
E-mail: info@sciencehorizon.com.ua
https://sciencehorizon.com.ua/en

© Polissia National University, 2023

НАУКОВІ ГОРИЗОНТИ

Том 26, № 10 2023

НАУКОВИЙ ЖУРНАЛ
Засновано 12 березня 1998 р.
Періодичність випуску: дванадцять разів на рік

Редакційна колегія

Головний редактор
Олег Васильович Скидан ректор, д-р екон. наук, професор, Поліський національний університет, Україна

Заступник головного редактора
Людмила Романчук д-р с.-г. наук, професор, Поліський національний університет, Україна

Національні члени редколегії
Савелій Кухарець д-р техн. наук, професор, Поліський національний університет, Україна
Іван Грабар д-р техн. наук, професор, Поліський національний університет, Україна
Ярослав Ярош д-р техн. наук, професор, Поліський національний університет, Україна
Тетяна Федонюк д-р с.-г. наук, професор, Поліський національний університет, Україна
Наталія Сорока д-р вет. наук, професор, Національний університет біоресурсів і природокористування України, Україна
Руслана Ставецька д-р с.-г. наук, професор, Білоцерківський національний аграрний університет, Україна
Анастасія Зимароєва канд. біол. наук, доцент, Поліський національний університет, Україна
Людмила Чижевська д-р екон. наук, професор, Державний університет «Житомирська політехніка», Україна
Віталій Данкевич д-р екон. наук, професор, Поліський національний університет, Україна
Ельчин Алієв д-р техн. наук., професор, Дніпровський державний аграрно-економічний університет, Україна
Олександр Галатюк д-р вет. наук, професор, Поліський національний університет, Україна
Валентина Гамаюнова д-р с.-г. наук, професор, Миколаївський національний аграрний університет, Україна
Леонід Горальський д-р вет. наук, професор, Житомирський державний університет імені Івана Франка, Поліський національний університет, Україна
Дмитро Дерев'янко д-р техн. наук, професор, Поліський національний університет, Україна
Олександр Жуков д-р біол. наук, професор, Мелітопольський державний педагогічний університет імені Богдана Хмельницького, Україна
Ірина Іванова канд. с.-г. наук, доцент Таврійський державний агротехнологічний університет ім. Д. Моторного, Україна
Олександр Кочук-Ященко канд. с.-г. наук, доцент, Поліський національний університет, Україна
Дмитро Кучер канд. с.-г. наук, доцент, Поліський національний університет, Україна
Федір Марков канд. с.-г. наук, доцент, Поліський національний університет, Україна
Олена Марковська д-р с.-г. наук, старший науковий співробітник, Херсонський державний аграрно-економічний університет, Україна
Андрій Михайлов д-р екон. наук, професор, Сумський національний аграрний університет, Україна
Валентин Москалець д-р с.-г. наук, доцент, Інститут садівництва НААН, Україна
Віктор Пазич канд. с.-г. наук, доцент, Поліський національний університет, Україна
Людмила Тарасович канд. екон. наук, доцент, Поліський національний університет, Україна
Тетяна Тимощук канд. с.-г. наук, доцент, Поліський національний університет, Україна
Наталія Цивенкова канд. техн. наук, доцент, Національний університет біоресурсів і природокористування України, Поліський національний університет, Україна
Марина Швець канд. біол. наук, старший викладач Поліський національний університет, Україна

Тетяна Зінчук д-р екон. наук, професор, Поліський національний університет, Україна
Геннадій Голуб д-р техн. наук, професор, Національний університет біоресурсів і природокористування України, Україна

Міжнародні члени редколегії
Юліус Раманаускас д-р наук, професор, Клайпедський університет, Литва
Інна Левкович д-р наук, старший науковий співробітник, Лейбніцький інститут розвитку сільського господарства у країнах з перехідною економікою, Німеччина
Егідіюс Сараускіс д-р техн. наук, професор, Інститут сільськогосподарської техніки та безпеки університету Вітовта Великого, Литва
Ришард Пукала канд. екон. наук, Державний Техніко-Економічний Університет ім. кс. Броніслава Маркевича в Ярославі, Польща
Самат Танірбергенов вчений секретар, Казахський науково-дослідний інститут ґрунтознавства і агрохімії ім. У.У. Успанова, Республіка Казахстан
Саліх Ташпулатов д-р техн. наук, професор, Ташкентський інститут текстильної та легкої промисловості, Республіка Узбекистан
Шпенд Шахіні канд. наук у галузі захисту рослин, Сільськогосподарський університет Тирани, Албанія

SCIENTIFIC HORIZONS

Vol. 26, No. 10 2023

SCIENTIFIC JOURNAL
Year of establishment: Since March 1998.
Publication frequency: Twelve times a year

Editorial Board

Editor-in-Chief
Oleh V. Skydan — Rector, Doctor of Economic Sciences, Professor, Polissia National University, Ukraine

Deputy Editor-in-Chief
Ludmila Romantschuk — Doctor of Agricultural Sciences, Professor, Polissia National University, Ukraine

National Members of the Editorial Board

Savelli Kukharets	Doctor of Technical Sciences, Professor, Polissia National University, Ukraine
Ivan Grabar	Doctor of Technical Sciences, Professor, Polissia National University, Ukraine
Yaroslav Yarosh	Doctor of Technical Sciences, Professor, Polissia National University, Ukraine
Tatiana Fedoniuk	Doctor of Agricultural Sciences, Professor, Polissia National University, Ukraine
Natalia Soroka	Doctor of Veterinary Sciences, Professor, National University of Life and Environmental Sciences of Ukraine, Ukraine
Ruslana Stavetska	Doctor of Agricultural Sciences, Professor, Bila Tserkva National Agrarian University, Ukraine
Anastasiia Zymaroieva	PhD in Biological Sciences, Associate Professor, Polissia National University, Ukraine
Lyudmyla Chyzhevska	Doctor of Economic Sciences, Professor, Zhytomyr Polytechnic State University, Ukraine
Vitalii Dankevych	Doctor of Economic Sciences, Professor, Polissia National University, Ukraine
Elchin Aliiev	Doctor of Technical Sciences, Professor, Dnipro State Agrarian and Economic University, Ukraine
Olexandr Galatiuk	Doctor of Veterinary Sciences, Professor, Polissia National University, Ukraine
Valentina Hamaiunova	Doctor of Agricultural Sciences, Professor, Mykolaiv National Agrarian University, Ukraine
Leonid Goralskiy	Doctor of Veterinary Sciences, Professor, Zhytomyr Ivan Franko State University, Polissia National University, Ukraine
Dmytro Derevjanko	Doctor of Technical Sciences, Professor, Polissia National University, Ukraine
Olexander Zhukov	Doctor of Biological Sciences, Professor, Bogdan Khmelnitsky Melitopol State Pedagogical University, Ukraine
Iryna Ivanova	PhD in Agricultural Sciences, Associate Professor, Dmytro Motornyi Tavria State Agrotechnological University, Ukraine
Oleksandr Kochuk-Yashchenko	PhD in Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
Dmytro Kucher	PhD in Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
Fedir Markov	PhD in Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
Olena Markovska	Doctor of Agricultural Sciences, Senior Research Scientist, Kherson State Agrarian and Economic University, Ukraine
Andrii Mykhailov	Doctor of Economic Sciences, Professor, Sumy National Agrarian University, Ukraine
Valentyn Moskalets	Doctor of Agricultural Sciences, Associate Professor, Institute of Horticulture of the National Academy of Agrarian Sciences, Ukraine
Viktor Pazych	PhD in Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
Ludmyla Tarasovych	PhD in Economic Sciences, Associate Professor, Polissia National University, Ukraine

Tetiana Tymoshchuk	PhD in Agricultural Sciences, Associate Professor, Polissia National University, Ukraine
Natalia Tsyvenkova	PhD in Technical Sciences, Associate Professor, National University of Life and Environmental Sciences of Ukraine, Polissia National University, Ukraine
Marina Shvets	PhD in Biological Sciences, Senior Teacher, Polissia National University, Ukraine
Tetyana Zinchuk	Doctor of Economic Sciences, Professor, Polissia National University, Ukraine
Gennadii Golub	Doctor of Technical Sciences, Professor, National University of Life and Environmental Sciences of Ukraine, Ukraine
International members of the Editorial Board	
Julius Ramanauskas	Dr. Habil., Professor, Klaipeda University, Lithuania
Inna Levkovych	Dr. Habil., Senior Research Scientist, Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Germany
Egidijus Sarauskis	Doctor of Technical Sciences, Professor, Institute of Agricultural Engineering and Safety of Vytautas Magnus university (VMU), Lithuania
Ryszard Pukala	PhD in Economic Sciences, The Bronisław Markiewicz State University of Technology and Economics in Jarosław, Poland
Samat Tanirbergenov	Scientific Secretary, U.U. Uspanov Kazakh Research Institute of Soil Science and Agrochemistrydis, Republic of Kazakhstan
Salikh Tashpulatov	Doctor of Technical Sciences, Professor, Tashkent Institute of Textile and Light Industry, Republic of Uzbekistan
Shpend Shahini	PhD in Plant Protection, Agricultural University of Tirana, Albania

ЗМІСТ

CONTENTS

SCIENTIFIC HORIZONS

Journal homepage: https://sciencehorizon.com.ua
Scientific Horizons, 26(10), 68-77

UDC 636.08
DOI: 10.48077/scihor10.2023.68

Effect of additives with chelated forms of trace minerals on growth performance of broiler chickens, feed nutrient digestibility, and carcass characteristics

Olena Razanova*
PhD in Agricultural Sciences, Associate Professor
Vinnytsia National Agrarian University
21008, 3 Sonyachna Str., Vinnytsia, Ukraine
https://orcid.org/0000-0001-5552-9356
Halyna Ohorodnichuk
PhD in Agricultural Sciences, Associate Professor
Vinnytsia National Agrarian University
21008, 3 Sonyachna Str., Vinnytsia, Ukraine
https://orcid.org/0000-0002-9008-4927
Taras Farionik
PhD in Veterinary Sciences, Associate Professor
Vinnytsia National Agrarian University
21008, 3 Sonyachna Str., Vinnytsia, Ukraine
https://orcid.org/0000-0002-0706-2445
Oksana Skoromna
PhD in Agricultural Sciences, Associate Professor
Vinnytsia National Agrarian University
21008, 3 Sonyachna Str., Vinnytsia, Ukraine
https://orcid.org/0000-0003-1332-5579
Vita Glavatchuk
PhD in Agricultural Sciences
Vinnytsia National Agrarian University
21008, 3 Sonyachna Str., Vinnytsia, Ukraine
https://orcid.org/0000-0002-9794-319X

Article's History:
Received: 7.05.2023
Revised: 22.08.2023
Accepted: 27.09.2023

Abstract. Demand for chicken meat has been growing in recent years, requiring prominent production levels and efficient feed conversion. The purpose of this study was to determine the productivity, preservation, and slaughter performance of broiler chickens, feed conversion on the background of feeding with additives with chelated forms of trace minerals. Poultry growth intensity was determined according to zootechnical methods, slaughter indicators – according to morphological methods, and statistical analysis of the results was used. By the end of the rearing period, the

Suggested Citation:
Razanova, O., Ohorodnichuk, H., Farionik, T., Skoromna, O., & Glavatchuk, V. (2023). Effect of additives with chelated forms of trace minerals on growth performance of broiler chickens, feed nutrient digestibility, and carcass characteristics. *Scientific Horizons*, 26(10), 68-77. doi: 10.48077/scihor10.2023.68.

Copyright © The Author(s). This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/)

*Corresponding author

live weight of broiler chickens in the groups where the dietary supplement with chelated trace minerals (second group) and copper chelate complex (third group) was significantly higher than in the control group – by 6.9 and 13.8%, and the relative increase was 4.5 percentage points and 8.5 percentage points, respectively. The growth rate of broilers in terms of average daily weight gain is higher in these groups by 6.8% and 14.2%, respectively. The safety of poultry in the experimental groups is 4% better than in the control group. The feed conversion of a diet with chelated trace element additives is higher. Feed consumption in the experimental groups was reduced by 2.8% when feeding the selected additive and by 9.7% when feeding the copper chelate complex. The results of balance studies revealed an increase in the digestibility of nutrients in the diet of broiler chickens. Additives with micronutrient chelates are effective in increasing slaughter yield, meatiness of the thighs and shins, and pectoral muscles by 5.3-6.2 percentage points. The broilers of the experimental groups had a higher meatiness of the thighs and shins. The highest growth rate was found in broilers fed a copper chelate complex in their diet. The lower feed conversion in the control group is due to the lower body weight of these chickens. Based on the research data obtained, the possibility of effective introduction of additives with chelated microminerals into the diet of broiler chickens was established, which helped to increase the growth rate and meat yield. The results can be used in farm poultry farms to produce more products and reduce the cost of chicken production

Keywords: growth intensity; poultry; meat productivity; slaughter performance; feed conversion; feed consumption; live weight gain

INTRODUCTION

To ensure high growth and development of broiler chickens, it is important to provide trace elements that play an essential role in poultry metabolism, health, and bone mineralisation. During periods of intensive growth, a low supply of essential micronutrients leads to the development of micronutrient deficiencies. The bioavailability and assimilation of trace elements by the poultry body is important, depending on the feed composition, chemical form of the element, age, and physiological state of the bird. In poultry farming, trace elements are used to supplement the composition of feed, which allows poultry to reach their genetic growth potential and prevents various diseases.

The genetic base of broilers is constantly changing in the poultry industry, and poultry farmers are working to develop new diets to provide micronutrients to birds that grow intensively and are highly productive for meat. S. Zamany *et al.* (2023) confirm that broilers fed with micronutrient supplements have a higher average daily live weight gain and a lower feed conversion rate.

Most often, trace elements are added to poultry diets in the form of inorganic salts, which have low availability, although Z. Zhu *et al.* (2019) found that supplemental feeding of inorganic micronutrients ensures that poultry diets have sufficient amounts of each mineral to support normal growth, health, and reproduction. M. Kwiecień *et al.* (2017) argue that poor poultry housing conditions combined with high levels of mineral additives and low bioavailability of inorganic trace elements lead to an excess of them in poultry manure, and eventually they accumulate in the soil, which leads to environmental pollution. R. Vieira *et al.* (2020) recommend that to reduce the excretion of trace elements in the manure, it is necessary, first of all, to make them more accessible to the poultry body. Better availability of micronutrients can be achieved by feeding poultry and animals minerals in chelated form so that they can be fed in smaller doses. J. Chen *et al.* (2023) note that coccidiosis reduces poultry growth rate, and the addition of chelated trace elements can overcome this problem.

Trace elements based on organic acids have a higher bioavailability, which has been confirmed in studies using trace elements (manganese, zinc, selenium, iron, and copper). A study by J. Kong *et al.* (2022) investigated the feasibility of reducing the addition of copper, iron, zinc, and manganese in the form of glycine metal chelate hydrate or amino acid, which does not have a negative impact on poultry growth. A mineral chelate supplement based on organic acid that improves not only broiler performance but also bone structure and blood parameters. F. Faghih-Mohammadi *et al.* (2022), using copper, iron, zinc, manganese, and selenium chelates in the feeding of broiler chickens, found that blood chemistry did not change, but cholesterol and triglyceride levels decreased, as well as the bird's immune system increased and egg quality improved. Due to the antioxidant effect of copper, zinc, iron, and feeding these trace elements in a chelated, easily digestible form, the antioxidant status of broiler thigh meat changes.

The addition of methionine chelates, yeast protein forms of copper, iron, manganese, and zinc to broilers increases poultry growth, feed conversion, and reduces the release of trace elements into the environment. A. Winiarska-Mieczan *et al.* (2021) recommend that to increase the antioxidant resistance of chicken meat, glycine chelated copper should be added to the diet in an amount of 25% of the requirement for this element. Copper is widely used in poultry farming as a growth stimulant, antimicrobial agent and to support the immune system. A. Forouzandeh *et al.* (2021) argue that the addition of copper oxide and sulphate to the diet

results in changes in the gut microbiota by regulating the bacterial population in the ileum, which had a positive effect on the growth rate of broilers. Copper plays an important role in the antioxidant system and lipid peroxidation.

Thus, the realisation of the genetic growth potential is possible through the provision of trace elements to broiler chickens, especially chelated amino acids, which will improve metabolic processes in the body and increase live weight gain and slaughter yield. That is why the purpose of this study was to find out the impact of chelated micronutrient supplements on the growth rate of broiler chickens, feed conversion, and meat productivity of poultry.

MATERIALS AND METHODS

The study was conducted in the vivarium of Vinnytsia National Agrarian University (Ukraine) during 2023 on broiler chickens of the Cobb-500 cross. The study used day-old chickens that were evenly distributed between the groups. For this purpose, three groups of poultry were formed using the analogue group method, with 25 birds in each group. The studies followed the requirements for the care and maintenance of poultry. Broiler chickens were kept in three-tiered cages. Each cage had a water drinker and a hanging feeder. Water was supplied to each cage through a nipple drinker system. The vivarium room where the birds were kept was preheated to 27°C 2 days before the study. The room temperature at the beginning of the experiment was 32°C, and during the experiment it was lowered by 2°C every week. The temperature was lowered to 26°C on day 14, to 24°C on day 21 and to 21°C on day 24, and then maintained at 21°C until the end of the fattening period. Throughout the research period, the authors of this study also monitored compliance with the light regime in the vivarium. During the first week, the broilers were provided with lighting for 23 hours. From day 8 to day 39, the light period was gradually reduced to 20 hours, and from day 40 to the end of the experiment it was increased again to 23 hours per day.

During the rearing of broiler chickens, a three-phase feeding programme was used, depending on the age of the birds: the initial phase lasted from day 1 to 15, the growth phase began from day 16 and lasted until day 35, and the final phase from day 36 to 42. During the scientific, economic and physiological experiments, the broiler chickens were fed with dry, nutrient-balanced feed. The feed used for poultry feeding was based on the age of the broiler chickens, and therefore the appropriate feed was used for each phase. At the beginning of the experiment, up to 15 days of age, the starter feed "Starter PK5-1" was fed, from 16 days to 35 days – growth feed "Grover", from 36 to 42 days – finishing feed "Finisher". The feeds met the current age-specific nutrient requirements for growing broilers and were free of antibiotics and growth stimulants.

According to the task of this study, broiler chickens in the control group were fed the basic diet without mineral additives, the second experimental group was fed an additional supplement "Kronocid-L" at the rate of 2.5 ml per 10 litres of water, and the third experimental group was fed a copper-glycine chelate complex at the rate of 3.0 ml per 10 litres of water. Copper chelate complex contains 5% copper and 20% glycine. The Kronocid-L additive contains chelates of copper, iron, zinc, manganese, and 19% acids. The test additives were administered to the poultry diet by watering with water. Throughout the experiment, broiler chickens had free access to feed and water.

To analyse the effect of the copper chelate complex and the additive under study on the growth rate of broiler chickens, the birds were weighed every 7 days, from 3-day-old age until the end of the experimental period (42 days). Broilers were paid for feed gain by the amount of feed consumed, which was recorded during the periods from days 1 to 15, 16 to 35, 36 to 42, by the periods of feeding the respective feed. Daily live weight gain and daily feed intake per bird were calculated for each week, for the periods: days 1-7, 8-14, 15-21, 22-28, 29-35, 3-42. The average daily weight gain and average daily feed intake were calculated at the end of each phase and on a weekly basis. Chicken mortality was also recorded to determine the percentage of poultry survival. Poultry mortality was checked twice a day, and the weight of dead chickens was used to adjust the feed conversion rate. Each bird was weighed separately on an electronic scale.

On day 42, 5 birds from each group were selected close to the average weight of the group for slaughter to take tissue samples and investigate the effect of additives on meat performance. Control slaughter of broiler chickens was conducted following the DSTU 3136-2017 (2019). Based on the results of poultry slaughter, the live weight of uneviscerated, eviscerated, half-eviscerated poultry, the weight of breast, thigh, and leg muscles, the weight of internal organs were determined, and the percentage of carcass yield, percentage of breast, thigh and leg muscles were calculated. After the chickens were slaughtered, their organs and tissues were examined, and samples were taken for further research. All experimental studies were conducted per the modern methodological approaches and corresponding requirements and standards that follow DSTU ISO/IEC 17025:2005 (2006). Animal husbandry and all manipulations were performed according to the provisions of the Procedure for conducting tests and experiments on animals by scientific institutions (Law of Ukraine No. 249, 2012) of the European convention for the protection of vertebrates used for experimental and other scientific purposes (1986).

Statistical analyses of the results were performed using Statistica software package. The arithmetic mean and standard deviation were calculated. Results are

expressed as mean ± SD (standard deviation). One-way ANOVA was used to calculate statistically significant (P<0.05) differences between the mean values for the respective groups of broilers. For comparisons, statistically significant differences between the mean values for the respective groups of broiler chickens were calculated. The results were statistically significant at (p<0.05), (p<0.01), (p<0.001).

RESULTS AND DISCUSSION

Growth parameters are usually used to assess the growth rate of poultry. The study found differences in the growth of broiler chickens treated with mineral supplements (copper chelate complex and Kronocid-L). The effect of the additives under study on the performance characteristics (live weight, absolute and relative weight gain, and survival) of chickens is presented in Table 1.

Table 1. *Growth intensity of broiler chickens after introduction of additives with chelated microminerals to the diet, x±SD, n=25*

Poultry age	Group		
	control (MD)	experimental (SK)	experimental (CC)
Live weight at the beginning of the experiment, day 3, g	72.0±1.0	72.3±1.1	71.7±0.8
Live weight on day 8, feeding of starter feed, g	230.2±3.9	235.3±4.3	239.5±3.2
Live weight at day 15, feeding of starter feed, g	508.2±5.9	557.5±6.3***	561.5±7.9***
Absolute live weight gain during the period of feeding starter feed (days 3-15), g	434.2±5.9	485.2±15.1**	489.7±7.8***
Relative live weight gain during the period of feeding starter feed (days 3-15), %	149.1±0.7	154.0±0.8***	154.6±0.6***
Live weight at day 22, feeding with Grover feed, g	987.2±26.6	1,076.5±25.5**	1,091.1±27.3**
Live weight at day 29, feeding with Grover feed, g	1,558.6±30.2	1,712.8±18.9***	1,772.3±28.7***
Live weight at day 36, feeding with Grover feed, g	2,046.8±29.0	2,147.5±22.2**	2,195.2±45.5**
Absolute live weight gain during the period of feeding "Grover" feed (days 15-36), g	1538±30.5	1590±22.3	1633±46.9
Relative gain over the period of feeding Grover feed (days 15-36), %	120.3±1.2	117.5±0.9	118.2±1.7
Live weight at day 42, feeding Finisher feed, g	2,580.1±51.9	2,752.5±25.2**	2,937.5±34.0***
Absolute live weight gain during the period of feeding starter feed (days 36-42), g	533.3±33.7	605.0±35.2*	742.3±43.4***
Relative growth during the period of feeding Finisher feed (days 36-42), %	22.9±2.6	24.7±1.4	29.1±1.8**
Absolute live weight gain during the period of feeding starter feed (days 3-42), g	2,506.2±51.4	2,680.2±25.3**	2,865.8±34.2***
Relative growth during the growing period (3-42 days), %	188.8±0.2	189.7±0.2**	190.4±0.2***
Poultry safety, %	92	96	96

Note*: * – P<0.05; ** – P<0.01; *** – P<0.001 differences between the control and experimental groups; MD – the main diet, SK – supplement Kronocid-L, CC – copper chelate*
Source: *compiled by the authors of this study*

The live weight of broiler chickens on day 8 in all three groups was almost the same at 230.2-239.5 g. Over the next week, after the introduction of the additives under study into the diet, the poultry began to grow more intensively and in the second group the live weight of chickens was 97% higher (at p<0.001), in the third group – by 10.5%. The absolute increase in live weight during the period of feeding the starter feed (days 3-15) was 11.7% higher in the second group (p<0.01), and 12.7% higher in the third group (p<0.001) compared to the data in the control group. The relative increase in live weight, which characterises the growth rate, during this period of poultry rearing with the introduction of the additive "Kronocid-L" to the diet is 3.3 p.p. higher (p<0.001), under the influence of copper chelate complex – by 3.7 p.p. (p<0.01). In the next period, the broilers of the experimental groups maintained their growth rate. At the end of the third week of rearing, live weight in chickens of the second group increased by 9.0% (p<0.01), and in the third group – by 10.5% (p<0.01). In the following period (days 29-36), both supplements showed a higher increase in live weight than in the group without supplementation. The difference was 9.9 and 13.7% (p<0.001), respectively, compared to the data of the control group. On day 36, broilers of the second group showed a trend of more intensive growth

(p<0.01) and outperformed the control group by 4.9%, and the third group by 7.3%.

At the end of the second growing period, the absolute increase in live weight was 3.4% higher when feeding Grover feed and the introduction of the additive Kronocid-L into the diet, and the increase in copper chelate complex was 6.1%. In the final period of rearing, broiler chickens (36-42 days) fed Finisher continued to grow intensively. However, during the last phase of poultry rearing, with the introduction of the additive "Kronocid-L", the live weight of chickens was 6.9% higher (p<0.01) and the copper chelate complex – 13.8% (p<0.001), the relative increase – 7.9 and 27.0 p.p. (p<0.001), respectively. The absolute increase in live weight over the entire period of poultry rearing in the second group was 6.9% higher (p<0.01), and when the chelated copper-glycine complex was introduced into the diet, it was 14.3% higher (p<0.001) compared to the control group. The relative growth during this period in broilers fed with mineral supplements was 4.5 (p<0.01) and 8.5 p.p. (p<0.001) higher, respectively. The introduction of the additives under study into the poultry diet had a positive effect on health, which accordingly affected the safety of the livestock. In the experimental groups, this figure is the same and 4% higher than in the control group. Average daily live weight gain is the main indicator of poultry growth intensity. As Table 2 suggests, the average daily weight gain at different age periods in all groups of broiler chickens differed. The best live weight gains were obtained in broilers when mineral supplements were used in the diet starting from the day 8 of rearing.

Table 2. *Average daily live weight gain of broiler chickens during the period of feeding supplements with chelated microminerals, g*

Rearing period	Group		
	control (MD)	experimental (SK)	experimental (CC)
3-8	25.5±0.7	27.2±0.8	28.0±0.6
8-15	40.2±1.1	46.0±1.1***	46.0±1.1***
15-22	68.4±1.4	74.1±1.6	75.7±1.7
22-29	81.6±1.5	90.9±1.3***	97.3±1.4***
29-36	62.7±2.8	62.1±2.3	67.4±2.6
36-42	83.2±2.1	86.4±1.4	98.9±2.2***
Average for the period of the experiment	62.7±1.3	67.0±0.6**	71.6±0.9***
Feed consumption per weight gain, g	2,197	2,136	1,983

Note*: * – P<0.05; ** – P<0.01; *** – P<0.001 differences between the control and experimental groups; MD – the main diet, SK – supplement Kronocid-L, CC – copper chelate*
Source: *compiled by the authors of this study*

The advantage in average daily weight gain in poultry of the second and third groups during days 8-15 was the same and amounted to 14.4% (p<0.001). In the subsequent periods of rearing, the greatest advantage in this indicator was found in chickens that were supplemented with a copper chelate complex. The increase in the average daily live weight gain was 10.7% during days 15-22, 19.2% (p<0.001) during days 22-29, 7.5% (p<0.01) during days 29-36, and 18.8% (p<0.001) in the final period of rearing. The supplementation of the diet also resulted in lower scores than in the third group, but still higher than in the first control group. The advantage in these periods, starting from day 15 of rearing, for two weeks was 8.3 (p<0.01) and 1.4%, for days 29-36, chickens of the second group were slightly behind in daily live weight gain (by 0.9%). In the next period (days 36-42), broilers retained their growth advantage over control birds and the difference between the groups was 3.8% (p<0.01). On average, over the entire period of the experiment, the highest average daily live weight gain was found in the third group of chickens fed a copper chelate complex. The birds of this group outperformed the control group by 14.2% (p<0.001). In addition, the broiler chickens of the second group, which were fed the supplement, had better average daily live weight gain compared to the control group, with a difference of 6.8% (p<0.01). However, they were 6.4% lower than the third group.

The study demonstrates the benefits of mineral supplements in the poultry diet to pay for feed gain in broilers. Less feed was consumed per unit of live weight gain in chickens fed a copper chelate complex. The birds of the control group were 9.7% lower in this indicator, and those of the second group were 7.2% lower. However, the broilers fed the supplement consumed 2.8% less feed per unit of live weight gain compared to the control. The results of the balance studies revealed an improvement in feed conversion, i.e., an increase in the digestibility of nutrients in the diet of broiler chickens.

The introduction of a copper chelate complex into the broiler diet increased the digestibility of dry matter by 20 p.p. (p<0.01), organic matter – by 3.7 p.p. (p<0.001), protein – by 4.1 p.p. (p<0.001), fat – by 3.1 p.p. (p<0.001), fibre – by 11.7 p.p. (p<0.001) and roentgen equivalent man (REM) – by 2.3 p.p. (p<0.001). In the second group of poultry, a similar trend is observed to increase the digestibility of nutrient components of the feed. Thus, an increase in the conversion of dry matter by 1.0 pp, organic matter – by 3.1 p.p. (p<0.001), protein – by 2.7 p.p. (p<0.001), fat – by 1.4 p.p. (p<0.01), fibre – by 7.0 p.p. (p<0.01), and REM – by 1.3 p.p. (p<0.01) (Table 3).

Table 3. *Digestibility of feed nutrients by broiler chickens with the introduction of additives with chelated microminerals into the diet, %*

Indicator	Group		
	control (MD)	experimental (SK)	experimental (CC)
Dry matter	80.5±0.3	81.3±0.2*	82.1±0.2**
Organic matter	81.2±0.3	83.7±0.4***	84.2±0.6***
Protein	83.1±0.4	85.3±0.3***	86.5±0.7***
Fat	78.3±0.3	79.4±0.2**	80.7±0.2***
Fibre	12.8±0.08	13.7±0.11***	14.3±0.09***
REM	82.7±0.2	83.8±0.3**	84.6±0.3***

Note*: * – P<0.05; ** – P<0.01; *** – P<0.001 differences between the control and experimental groups; MD – the main diet, SK – supplement Kronocid-L, CC – copper chelate*
Source: *compiled by the authors of this study*

Supplementation of the broiler chickens' diet also had a positive impact on slaughter rates, carcass, meat, and internal organ yields. The carcass yield of broilers fed the copper chelate complex and the additive under study was higher than that of the control group. Comparing the pectoral muscle yield in the third group with the control group, it is 6.2 percentage points higher (p<0.01). The second group of chickens also obtained more (p<0.05) pectoral muscles (by 5.3 p.p.) than chickens that were not fed mineral supplements. Birds of the second and third groups had higher thigh meatiness. In these groups, the number of thigh muscles was slightly higher, but the number of lower leg muscles was lower (by 2.1 and 2.7 p.p., respectively) (Table 4).

Table 4. *Indicators of slaughter of broiler chickens under the influence of additives with chelated trace minerals*

Poultry age	Group		
	control (MD)	experimental (SK)	experimental (CC)
Pre-slaughter weight, g	2,690.0±37.8	2,893±18***	2,911± 34***
Weight of half-eviscerated carcass, g	2,193.0±43.7	2,390±31***	2,513±39***
Weight of eviscerated carcass, g	2,009.7±34.5	2,146±19***	2,189±28***
Slaughter yield, %	74.6±0.2	75.0±0.4	75.2±0.2*
Weight of pectoral muscles, g	610.3±32.9	695.0±19.1*	708.0±20.0*
in % of eviscerated carcass	30.4±0.4	32.0±0.3*	32.3±0.5**
Weight of thigh muscles, g	237.7±5.0	257.3±4.9*	262.3±4.9**
in % of eviscerated carcass	11.83±0.07	11.87±0.03	11.98±0.09
Lower leg muscle mass, g	192±3.4	202.6±4.4	203.3±4.3*
in % of eviscerated carcass	9.55±0.07	9.35±0.2	9.29±0.08
Weight, g: liver	57.3±3.3	68.4±3.0*	68.2±2.2*
hearts	14.7±0.1	13.8±0.2**	14.2±0.2
muscular stomach	18.6±0.2	18.3±0.2	17.8±0.1**

Note*: * – P<0.05; ** – P<0.01; *** – P<0.001 differences between the control and experimental groups; MD – the main diet, SK – supplement Kronocid-L, CC – copper chelate*
Source: *compiled by the authors of this study*

There were changes in the weight of internal organs after the introduction of mineral additives into the poultry diet. In the second group of broiler chickens, 19.4 and 19.0% more liver weight was obtained ($p<0.05$). The heart weight of the second group was 6.1% lower ($p<0.01$). There was no significant effect of the mineral supplements on stomach muscle mass. The studies confirmed that the use of feed additives containing chelated trace elements for broiler chickens had a positive effect on economic traits, which contributed to an increase in live weight, slaughter yield, and conversion of feed nutrients.

According to researchers who have investigated this subject, mineral additives are among the products that reduce feed costs for production, improve feed conversion, and increase live weight (Fotina *et al.*, 2021). Recently, chelated micronutrient additives have been increasingly used in livestock production as growth stimulants that improve the general condition of animals and poultry, increase productivity, which helps livestock, including poultry, to develop economically (Bhagwat *et al.*, 2021). S. Villagómez-Estrada *et al.* (2020) managed to increase the productivity and mineral status of pigs by adding copper to their diet at the permissible levels of the European Union. Mineral copper supplementation can be effective for more intensive growth if poultry are fed above the minimum requirements. O. Olukosi *et al.* (2018) found an increase in the growth performance of broiler chickens and meat yield under the influence of zinc and copper hydroxychloride. M. Hamdi *et al.* (2018) confirmed the increase in live weight of poultry with the introduction of chelated copper supplements into the diet.

Copper is often used in combination with amino acids, particularly glycine. V. Sakara & A. Melnyk (2019) also confirm the higher efficiency of the use of vitamin-amino acid chelates of zinc and manganese in poultry feeding, which contributed to an increase in live weight and improved blood counts. The conclusions of the study on the impact of the effectiveness of the use of additives with chelated forms of trace minerals in the feeding of broiler chickens coincided with the previous results of scientists. The effect of the introduction of chelated trace element additives with free access to feed into the poultry diet affected live weight, absolute and average daily weight gain. Studies have revealed differences in the growth of broiler chickens fed supplements containing chelated trace elements. The diet containing additives containing chelated trace elements (chelated copper complex with glycine and Kronocid-L) improved the live weight and growth rate of chickens compared to the diet without additives.

Chelated forms of trace elements improve the overall health of broilers, which subsequently has a positive impact on poultry safety. Higher mineral digestibility, a positive effect on growth rate, bone mineralisation, slaughter performance, and organoleptic properties of meat were obtained by using chelated forms of trace elements in poultry feeding, as described by H. Ghasemi *et al.* (2020). Comparable results were obtained in the current study on broiler chickens. By the end of rearing, the introduction of chelated micronutrients increased the safety of poultry in these groups. The evaluation of the economic and useful properties of broiler chickens under the influence of additives with chelated microminerals (copper chelate complex, the additive under study) in the free access was assessed by the results of a control slaughter carried out at the age of 42 days. Slaughter rates can reflect the meat productivity of animals and poultry, which is a key indicator that affects the economic performance of livestock farming. Adjustment of animal diets with mineral premixes improves not only slaughter yield, but also increases the yield of quality meat (Yaremchuk *et al.*, 2022; Farionik *et al.*, 2023). The studies by S. Van Kuijk *et al.* (2021) and T. Santos *et al.* (2021) confirm the current results on the positive impact of mineral supplements on slaughter performance and carcass characteristics.

Raising broilers on feed with chelated trace elements reduces feed costs per unit of growth (Fotina *et al.*, 2021). The feed consumption of poultry in the three groups was almost the same, but there was a difference in feed consumption for live weight gain. Feed costs per unit of weight gain in broilers fed a copper chelate complex and a supplement with free-access chelated trace minerals were significantly lower. In livestock and poultry farming, the nutrient balance method is used to determine the nutrient absorption potential of the diet. The inclusion of additives with chelated trace elements in the diet of broiler chickens had a positive effect on the absorption of feed nutrients. In the studies conducted, the chickens' diets were formed according to the three-phase feeding system and contained all the necessary components for successful development. When copper chelate complex and additives are introduced into the chicken diet, the digestibility of nutrient components of feed increases. The digestibility coefficients of feed nutrients in these groups of poultry were significantly higher than in the control group. The data obtained from studies on broiler chickens are consistent with the findings of R. Tymoshenko *et al.* (2018), who confirmed that chelated forms of trace elements have a greater ability to be absorbed by the body, which contributes to an increase in poultry productivity. Based on the data from the study, it can be concluded that additives with chelated forms of micronutrients are effective in increasing growth performance, improving feed nutrient absorption and increasing meat yield.

CONCLUSIONS

It was found that the live weight of broiler chickens consuming a diet with additives containing chelated forms of trace minerals) at the age of 7, 14, 21, 28, 35, and 42 days was higher than that of broilers without additives. Live weight was 13.8% higher at 42 days of

age with the introduction of copper chelate complex and 6.9% higher with the supplementation, while the growth rate of broilers in terms of relative live weight gain at the end of the experiment in these groups was 8.5 and 4.5 percentage points higher, respectively.

Chickens grew more intensively when supplemented with chelated micronutrients, which increased the average daily live weight gain in the group where copper chelate complex was introduced into the diet by 14.2% and the supplement by 6.8%. Better availability of trace elements of the additives under study had a positive effect on poultry performance.

The survival rate of young animals where chelated micronutrients were used in feeding was 4% higher. The introduction of additives with chelated trace elements to the broiler diet increased the digestibility of organic matter by 3.1-3.7 p.p., protein by – 2.7-4.1 p.p., fat – by 1.4-3.1 p.p., and fibre – by 7.0-11.7 p.p., which led to a reduction in feed costs in these groups. Feed costs per unit of weight gain were lower in the broiler group with the addition of Kronocid-L to the diet by 2.8% and copper chelate complex by 9.7%, which will help reduce the total cost of raising poultry and increase profitability in the poultry industry.

Growing broiler chickens on feed with chelated forms of microminerals increases the slaughter yield by 1.6 p.p. and significantly increases the yield of breast muscles by 5.3-6.2%. The yield of thigh muscles in the group of poultry administered copper chelate complex was 10.3% higher.

The findings of this study strongly suggest that the use of copper chelate complex and additives as part of an intensive broiler rearing strategy contributes to better availability of micronutrients, which increases growth intensity and slaughter yield while reducing costs per unit of growth and, as a result, reduces overall production costs. Future research may include studying a wider range of micronutrients, determining optimal doses and ratios of micronutrients in the diet to maximise performance, and investigating different forms of chelates to maximise bioavailability.

ACKNOWLEDGEMENTS

The authors of this study express their sincere gratitude to the Ministry of Education and Science of Ukraine for financial support and the opportunity to conduct research within the framework of the research work "Development of the concept of using mineral additives in the cultivation of farm animals to obtain high-quality and environmentally friendly products" (state registration number 0122U000853).

CONFLICT OF INTEREST

The authors of this study declare no conflict of interest.

REFERENCES

[1] Bhagwat, V.G., Balamurugan, E., & Rangesh, P. (2021). Cocktail of chelated minerals and phytogenic feed additives in the poultry industry: A review. *Veterinary World*, 14(2), 364-371. doi: 10.14202/vetworld.2021.364-371.

[2] Chen, J., Yan, F., Kuttappan, V.A., Wedekind, K., Vázquez-Añón, M., & Hancock, D. (2023). Effects of bis-chelated copper in growth performance and gut health in broiler chickens subject to coccidiosis vaccination or coccidia challenge. *Frontiers in Physiology*, 13, article number 991318. doi: 10.3389/fphys.2022.991318.

[3] DSTU 3136:2017. (2019). *Poultry for slaughter. Technical specifications*. Retrieved from http://online.budstandart.com/ua/catalog/doc-page?id_doc=73413.

[4] European convention for the protection of vertebrate animals used for experimental and other scientific purposes. (1986). Retrieved from https://rm.coe.int/168007a67b.

[5] Faghih-Mohammadi, F., Seidavi, A., & Bouyeh, M. (2022). The effects of chelated microelements feeding in broiler breeder hens and their progeny: A review. *Tropical Animal Health and Production*, 54, article number 323. doi: 10.1007/s11250-022-03317-1.

[6] Farionik, T.V., Yaremchuk, O.S., Razanova, O.P., Ohorodnichuk, G.M., Holubenko, T.L., & Glavatchuk, V.A. (2023). Effects of mineral supplementation on qualitative beef parameters. *Regulatory Mechanisms in Biosystems,* 14(1), 64-69. doi: 10.15421/022310.

[7] Forouzandeh, A., Blavi, L., Abdelli, N., Melo-Duran, D., Vidal, A., Rodríguez, M., Monteiro, A.N.T.R., Pérez, J.F., Darwich, L., & Solà-Oriol, D. (2021). Effects of dicopper oxide and copper sulfate on growth performance and gut microbiota in broilers. *Poultry Science,* 100(8), article number 101224. doi: 10.1016/j.psj.2021.101224.

[8] Fotina, T., Fotina, H., Nazarenko, S., Tymoshenko, R., & Fotin, O. (2021). Effect of feeding of chelated zinc form on security, productivity and slaughter parameters of broilers. *EUREKA: Health Sciences*, 3, 110-118. doi: 10.21303/2504-5679.2021.001856.

[9] Ghasemi, H.A., Hajkhodadadi, I., Hafizi, M., Taherpour, K., & Nazaran, M.H. (2020). Effect of advanced chelate technology based trace minerals on growth performance, mineral digestibility, tibia characteristics, and antioxidant status in broiler chickens. *Nutrition & Metabolism*, 17, article number 94. doi: 10.1186/s12986-020-00520-5.

[10] Hamdi, M., Solà, D., Franco, R., Durosoy, S., Roméo, A., & Pérez, J.F. (2018). Including copper sulphate or dicopper oxide in the diet of broiler chickens affects performance and copper content in the liver. *Animal Feed Science and Technology,* 237, 89-97. doi: 10.1016/j.anifeedsci.2018.01.014.

[11] ISO/IEC 17025:2005. (2006). Retrieved from http://online.budstandart.com/ua/catalog/doc-page.html?id_doc=50873.
[12] Kong, J., Qiu, T., Yan, X., Wang, L., Chen, Z., Xiao, G., Feng, X., & Zhang, H. (2022). Effect of replacing inorganic minerals with small peptide chelated minerals on production performance, some biochemical parameters and antioxidant status in broiler chickens. *Frontiers in Physiology*, 13, article number 1027834. doi: 10.3389/fphys.2022.1027834.
[13] Kwiecień, M., Winiarska-Mieczan, A., Milczarek, A., & Klebaniuk, R. (2017). Biological response of broiler chickens to decreasing dietary inclusion levels of zinc glycine chelate. *Biological Trace Element Research*, 175, 204-213. doi: 10.1007/s12011-016-0743-y.
[14] Law of Ukraine No. 249 "On the Procedure for Carrying out Experiments and Experiments on Animals by Scientific Institutions". (2012, March). Retrieved from https://zakon.rada.gov.ua/laws/show/z0416-12#Text.
[15] Olukosi, O.A., Van Kuijk, S., & Han, Y. (2018). Copper and zinc sources and levels of zinc inclusion influence growth performance, tissue trace mineral content, and carcass yield of broiler chickens. *Poultry Science*, 97(11), 3891-3898. doi: 10.3382/ps/pey247.
[16] Sakara, V., & Melnyk, A. (2019). The influence of Zinc and Manganese chelates (pantothenates) on some chicken broiler metabolism indicators. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences,* 21(96), 134-140. doi: 10.32718/nvlvet9624.
[17] Santos, T.S., dos Augusto, K.V.Z., Han, Y., Sartori, M.M.P., Denadai, J.C., Santos, C.T., Sobral, N.C., Roça, R.O., & Sartori, J.R. (2021). High levels of copper and zinc supplementation in broiler diets on growth performance, carcase traits and apparent ileal mineral absorption. *British Poultry Science*, 62(4), 579-588. doi: 10.1080/00071668.2021.1887453.
[18] Tymoshenko, R.V., Opanasenko, Y.M., & Vievskyi, G.S. (2018). The influence of organic trace elements on the preservation and productivity of poultry. *Bulletin of the Sumy National Agrarian University (Veterinary Medicine)*, 1(42), 50-53.
[19] Van Kuijk, S.J.A., Han, Y., Garcia-Ruiz, A.I., & Rodiles, A. (2021). Hydroxychloride trace minerals have a positive effect on growth performance, carcass quality and impact ileal and cecal microbiota in broiler chickens. *Journal of Animal Science and Biotechnology*, 12, article number 38. doi: 10.1186/s40104-021-00553-7.
[20] Vieira, R., Ferket, P., Malheiros, R., Hannas, M., Crivellari, R., Moraes, V., & Elliott, S. (2020). Feeding low dietary levels of organic trace minerals improves broiler performance and reduces excretion of minerals in litter. *British Poultry Science*, 61(1), 574-582. doi: 10.1080/00071668.2020.1764908.
[21] Villagómez-Estrada, S., Pérez, J.F., Darwich, L., Vidal, A., Kuijk, S., Melo-Durán, D., & Solà-Oriol, D. (2020). Effects of copper and zinc sources and inclusion levels of copper on weanling pig performance and intestinal microbiota. *Journal of Animal Science*, 98(5), 1-15. doi: 10.1093/jas/skaa117.
[22] Winiarska-Mieczan, A., Kwiecień, M., Mieczan, T., Kwiatkowska, K., & Jachimowicz, K. (2021). The effect of Cu, Zn and Fe chelates on the antioxidative status of thigh meat of broiler chickens. *Animal,* 15(10), article number 100367. doi: 10.1016/j.animal.2021.100367.
[23] Yaremchuk, O.S., Razanova, O.P., Skoromna, O.I., Chudak, R.A., Holubenko, T.L., & Kravchenko, O.O. (2022). Post-slaughter indicators of meat productivity and chemical composition of the muscular tissues of bulls receiving corrective diet with proteinvitamin premix. *Regulatory Mechanisms in Biosystems,* 13(3), 219-224. doi: 10.15421/022228.
[24] Zamany, S., Sedghi, M., Hafizi, M., Nazaran, M.H., &, Kimiaei, T.M.V. (2023). Organic acid-based chelate trace mineral supplement improves broiler performance, bone composition, immune responses, and blood parameters. *Biological Trace Element* Research, 201(10), 4882-4899. doi: 10.1007/s12011-023-03555-w.
[25] Zhu, Z., Yan, L., Hu, S., An, S., Lv, Z., Wang, Z., Wu, Y., Zhu, Y., Zhao, M., Gu, Ch., & Zhang, A. (2019). Effects of the different levels of dietary trace elements from organic or inorganic sources on growth performance, carcass traits, meat quality, and faecal mineral excretion of broilers. *Archives of Animal Nutrition,* 73, 324-337. doi: 10.1080/1745039X.2019.1620050.

Вплив добавок з хелатними формами мікромінералів на продуктивність росту курчат-бройлерів, перетравність поживних речовин корму та характеристики туші

Олена Петрівна Разанова
Кандидат сільськогосподарських наук, доцент
Вінницький національний аграрний університет
21008, вул. Сонячна, 3, м. Вінниця, Україна
https://orcid.org/0000-0001-5552-9356

Галина Михайлівна Огороднічук
Кандидат сільськогосподарських наук, доцент
Вінницький національний аграрний університет
21008, вул. Сонячна, 3, м. Вінниця, Україна
https://orcid.org/0000-0002-9008-4927

Тарас Володимирович Фаріонік
Кандидат ветеринарних наук, доцент
Вінницький національний аграрний університет
21008, вул. Сонячна, 3, м. Вінниця, Україна
https://orcid.org/0000-0002-0706-2445

Оксана Іванівна Скоромна
Кандидат сільськогосподарських наук, доцент
Вінницький національний аграрний університет
21008, вул. Сонячна, 3, м. Вінниця, Україна
https://orcid.org/0000-0003-1332-5579

Віта Анатоліївна Главатчук
Кандидат сільськогосподарських наук
Вінницький національний аграрний університет
21008, вул. Сонячна, 3, м. Вінниця, Україна
https://orcid.org/0000-0002-9794-319X

Анотація. Попит на куряче м'ясо останніми роками зростає, що вимагає високого рівня виробництва та ефективної конверсії кормів. Метою даного дослідження було визначення продуктивності, збереженості та забійних показників курчат-бройлерів, конверсії корму на фоні годівлі добавками з хелатними формами мікромінералів. Визначення інтенсивності росту птиці проводили за зоотехнічними методами, показників забою – за морфологічними, при цьому використовували статистичний аналіз результатів. До кінця періоду вирощування жива маса курчат-бройлерів у групах, де вводили до раціону та досліджувана добавка з хелатними мікромінералами (друга група) та хелатний комплекс міді (третя група), достовірно вища за дані контрольної групи – на 6,9 % і 13,8 % та відносний приріст – на 4,5 п.п. і 8,5 п.п. відповідно. Швидкість росту бройлерів за середньодобовим приростом вища у зазначених групах відповідно на 6,8 % і 14,2 %. Збереженість поголів'я птиці у дослідних групах краща на 4 % щодо контролю. Конверсія корму раціону з хелатними мікроелементними добавками вища. Витрата кормів у дослідних групах знижувалась за згодовування обраної добавки на 2,8 % і з хелатним комплексом міді – на 9,7 %. За результатами балансових досліджень виявлено підвищення перетравності поживних речовин раціону курчат-бройлерів. Добавки з хелатами мікромінералів ефективні у підвищенні забійного виходу, м'ясистості стегон та гомілки, грудних м'язів – на 5,3-6,2 п.п. Бройлери дослідних груп мали вищу м'ясистість стегон та гомілки. Найвищий темп росту виявлено у бройлерів, яким у раціоні вводився хелатний комплекс міді. Нижча конверсія корму у контрольній групі пов'язано з нижчою масою тіла цих курчат. На підставі отриманих даних досліджень встановлено можливість ефективного введення до раціону курчат-бройлерів добавок з хелатними мікромінералами, що дозволило підвищити інтенсивність росту та вихід м'яса. Результати можуть бути використані у фермерських птахівничих господарствах для отримання більшої кількості продукції та здешевити виробництво курятини

Ключові слова: інтенсивність росту; птиця; м'ясна продуктивність; показники забою; конверсія корму; витрати корму; прирости живої маси