

## Original research

## The assessment of magnesium-contained feed additive efficiency on nutrient digestibility and productivity in laying hens

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Received: 27 November 2024  
Revised: 13 January 2025  
Accepted: 10 March 2025

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**Abstract.** In recent years obtained data make great advance into new more effective feed additives development. The strategy for creating these additives targeting, first of all, satisfying the poultry physiological needs in biologically active substances. The practical value of the research lies in usage of a feed additive that does not contain toxic and carcinogenic properties and is absolutely safe for the laying hens. The purpose of our research was to identify the effectiveness of complex supplement in feeding laying hens. Crossbred laying hens were exposed to blended feed additive during 3 months with various 0.2%, 0.3%, and 0.4% doses. Observed results demonstrated that feed additive application increased nutrient digestion in laying hens and productivity by 5.4% in 0.2% exposed group. The most meaningful increase in egg production rate was detected in the groups exposed to 0.3% and 0.4% doses. Feed additive supplementation ameliorated the yolk content in eggs in a dose-dependent manner. One of reasonable mechanism of stimulatory effect of feed additive may relate to protection against magnesium deficiency in the stanard diet. The results of the study showed that the magnesium level has increased in the eggs of the experimental groups by 1.6% and 3.4%. Furthermore, the supplementation of the feed additive demonstrated beneficial effect on the digestibility of nutrients in the diet. All exposed to feed additive groups develop a growth of average egg weight from 5.9% to 8.2% with a dose-dependent manner. In addition, feed additive increased feed conversion coefficient that was bound with a decrease in feed consumption per 1 kg of egg weight. For instance, 2nd experimental group consumed food on 7.3 % lower then the similar indicator in the control group. Most meaningful economic effect of feed additive supplementation was detected in 2nd experimental group in respect to egg production. Therefore, present results evidence that blended feed additive supplementation can be a promising strategy to maintain poultry farming profitability as well as could be proposed for alternative mineral sources implementation.

**Keywords:** poultry farming; blended feed additives; egg quality; nutrient digestion; feed conversion.

## Оцінка ефективності магній-вмісної кормової добавки на перетравність поживних речовин і продуктивність курей-несучок

**Анотація.** Отримані в останні роки дані дозволили зробити великий крок вперед у розробці нових більш ефективних кормових добавок. Стратегія створення цих добавок спрямована, перш за все, на забезпечення фізіологічних потреб птиці в біологічно активних речовинах. Практична цінність дослідження полягає у використанні кормової добавки, яка не має токсичних і канцерогенних властивостей і є абсолютно безпечною для курей-несучок. Метою наших досліджень було виявлення ефективності комплексної добавки в годівлі курей-несучок. Помісні кури-несучки протягом 3 місяців отримували комбікормову добавку в різних дозах 0,2%, 0,3% та 0,4%. Спостережувані результати показали, що застосування кормової добавки підвищило перетравлення поживних речовин у курей-несучок і продуктивність на 5,4% у 0,2% групі, що піддалася впливу. Найбільш достовірне підвищення несучості виявлено в групах, які отримували кормову добавку в дозах 0,3% і 0,4%. Додавання кормової добавки покращувало вміст жовтка в яйцях залежно від дози. Одним із обґрунтованих механізмів стимулюючої дії кормової добавки може бути захист від дефіциту магнію в стандартному раціоні. Результати дослідження показали, що в яйцях дослідних груп рівень магнію підвищився на 1,6% і 3,4%. Крім того, додавання кормової добавки продемонструвало сприятливий вплив на перетравність поживних речовин у раціоні. У всіх групах, які зазнали впливу кормових добавок, спостерігається зростання середньої маси яєць від 5,9% до 8,2% залежно від дози. Крім того, кормова добавка підвищувала коефіцієнт конверсії корму, що було пов'язано зі зниженням витрати корму на 1 кг маси яйця. Так, 2-га дослідна група споживала їжі на 7,3 % менше, ніж у контрольній групі. Найбільш значущий економічний ефект від додавання кормової добавки виявлено у 2-й дослідній групі щодо несучості. Таким чином, наведені результати свідчать про те, що додавання змішаних кормових добавок може бути перспективною стратегією підтримки прибутковості птахівництва, а також, може бути запропоновано для впровадження альтернативних мінеральних джерел.

**Ключові слова:** птахівництво; комбікормові добавки; якість яєць; перетравлення поживних речовин; конверсія корму.

**Cite this article:** Orishchuk, O. S., Tsap, S. V., Mylostyvyi, R. V., Chernenko, O. I., & Chernenko, O. M. (2025). The assessment of magnesium-contained feed additive efficiency on nutrient digestibility and productivity in laying hens. *Theoretical and Applied Veterinary Medicine*, 13(1), 3–7. doi: 10.32819/2025.13001

## Introduction

Modern industrial poultry farming cannot be imagined without the use of various biologically active substances. Poultry producers are well acquainted with the results of scientific research on the effectiveness of various feed additives used in poultry feeding (Barzegar et al., 2020). In general, to ensure optimal mineral nutrition of laying hens, it is recommended to use balanced compound feeds enriched with the necessary macro- and microelements. In this case, it is necessary to take into account the physiological needs of the bird at different stages of the productive period. The results of studies show that the introduction of feed additives into the diet contributed to an increase in egg production and improved egg quality (Wu et al., 2014). Blended feed additives are important tools in the feeding of laying hens since they are involved in many biochemical processes, including enzyme activation, protein synthesis and nervous system regulation (Abedini et al., 2018).

A key factor in ensuring high productivity and health of laying hens is complete nutrition. Both a lack and an excess of the critical elements content in the diet can provoke a decrease in egg production, deterioration in egg quality and of the general condition of the bird (El-Tarabany et al., 2022).

Therefore, the support of the egg production requires targeted feed additives. The recent proposal to supplement succinic acid salts in animal and poultry feeding is considered as promising strategy that based on the natural compounds including purified minerals as the feed additive. This is a natural organic compound that participates in the tricarboxylic acid cycle and plays an important role in energy metabolism in the various cell types. An application of organic components blended with minerals in the poultry diet has a number of beneficial effects. Similar feed additives stimulate the secretion of digestive enzymes and improves the digestibility of feed (Bodle et al., 2018). Besides, recent data have been demonstrated that the addition of supplements based on succinic acid salts to the diet contributes to an increase of laying hens egg production and live weight gain in broilers (Abd El-Hack et al., 2017a).

In laying hens, improvements in eggshell quality and nutrient content were observed, as well as a 4-6% increase in productivity (Abd El-Hack et al., 2017b). The use of the supplement in broiler diets showed a decrease in feed conversion, an increase in body weight gain by 5-7%, and an improvement in calcium-phosphorus metabolism. The feed additive is a promising additive in poultry feeding due to its metabolic, anti-stress and antioxidant properties. Its use allows to increase the productivity and quality of poultry products (Ibatullin et al., 2020).

The purpose of our study was to assess the efficacy of organic+minerals feed additive on productivity, feed digestibility and egg quality indices.

## Materials and methods

The study carried out with including 400 chick individuals of cross-bred laying hens "Lohmann White" growing on the poultry farm LLC "Agrocenter Ptakhoprom" in Dnipro province. The cohort of chickens was divided for four equal groups accordingly to the method of analog groups, taking into the account live weight

and the main physiological indices. Laying hens of one control group and three groups exposed to feed additive were raised into equal parts of chicken coop.

According to the aim of study the commercial organic+minerals feed additive was supplemented in the various doses for three experimental groups. Feed additive "Green line" was purchased from "Jala Gold, Ltd". Company does not provide the exact composition of the supplement. The laying hens of the control group were fed complete diet (CD) produced by Agrocenter feed department. Three experimental groups of the laying hens (1st, 2nd, 3rd) were fed complete diet supplemented with "Green line" feed additive at the doses of 0.2%; 0.3% and 0.4% to the standard feed weight according to the experimental scheme (Table 1). The duration of the experiment was 90 days. The compounds as well as complete feed were manufactured by LLC "Agrocenter "Ptakhoprom". Recipe for compound feed for cross-bred laying hens used in the research consisted of corn grain – 30.0%; wheat grain – 24.17%; wheat bran – 7.9%; sunflower meal – 17.0%; soybean meal – 10.0%; miavit – 0.2%; lysine – 0.2%; methionine – 0.1%; table salt – 0.37%; monocalcium phosphate – 0.9%; choline chloride – 0.06%. The control and all experimental groups of laying hens were provided with nutrients in accordance with regulatory requirements during all periods of rearing.

According to the principal approach of experimental procedures in poultry farming regarding the use of new drugs or additives it is recommended to supplement no more than 0.5% of the feed additive in the diet. It is believed that this amount will not harm the productivity of the bird.

Important indicators by which the new feed component, in our case the feed additive "Green line", effectiveness is evaluated, are safety and productivity. In addition to performance indices, feed digestibility and nutrient absorption were assessed. Survival data were measured by daily counting of dead birds in the groups. Determination of digestibility of feed nutrients was performed to assess digestive function. Digestibility was assessed by determining the digestibility coefficient, which is equal to the ratio of the consumed nutrient in the diet to that excreted in the feces and reflects the degree of absorption of the corresponding substance in the digestive tract. Five laying hens were selected from each group for the experiment. They were kept in specially prepared cages. The consumed feed, its residues, and litter were recorded, from which averaged samples were regularly taken for further analysis. Samples taken were preserved with a 10% hydrochloric acid solution in a ratio of 1:10.

The determination of the chemical composition of the samples of compound feed and litter was carried out using traditional methods. The initial humidity level was determined by drying the samples in a specialized oven at the temperature of 60-65 °C to a constant mass. The hygroscopic humidity level estimated via drying the samples at a temperature of 100-105 °C to take a final constant mass. The crude fiber content was detected by the Henneberg and Stoman method. The raw fat content was measured by the Rushkovsky method via detection of the defatted residue content in the Soxhlet apparatus using sulfuric ether. The crude protein was assessed by the Kjeldahl method. The raw ash was measured by the dry ashing method by burning the sample in a muffle furnace at a temperature of 450-500 °C. The chemical composition of chicken eggs was determined with the same methods.

The magnesium content in compound feed and table eggs was detected at the Research Center for Biosafety and Environmental Control of Agricultural and Industrial Complex Resources by the method of atomic emission spectrometry with inductively coupled plasma on an Agilent 5110 device (Oseyko et al., 2024).

Eggs' weight was assessed three times during the study periods particularly at the end of 24-th, 30-th, and 42-nd weeks. The weight of chicken was measured with TVE-12 scales.

Statistical analysis of the results was performed using MS

**Table 1** – The scheme of the experimental groups differentiation

Groups, (n = 100)	Diet content
Control	Complete diet (CD)
1 <sup>st</sup> – experimental	CD + 0.2% feed additive "Green line"
2 <sup>nd</sup> – experimental	CD + 0.3% feed additive "Green line"
3 <sup>rd</sup> – experimental	CD + 0.4% feed additive "Green line"

Excel software, taking into account the significance of differences between groups at  $P < 0.05$ . The results of statistical analysis are presented as mean (M)  $\pm$  standard error of the mean (SE).

## Results

The results of the detection the principal nutrient content have demonstrated that the ratio of crude protein was 17.24%; crude fat – 3.90%; crude fiber – 4.60%; total calcium 3.3% $\leq$ , and total phosphorus – 0.79%. In the feed compound consumed by the control group the content of magnesium was detected equal to 2.0 g/kg. However, the magnesium content in the experimental groups was detected equal to 2.1–2.3 g/kg respectively.

The comparative assess of mortality among control and experimental groups have shown that application of the feed additive contributed to an increase in the survival of laying hens in the experimental group by 2.1% compared to the control.

The live weight of laying hens was applied as important index to assess the effect of feed additive on productivity. The supplementation of feed additive induced live weight increase in exposed groups on 0.3% and 0.6% higher in compare with the control group.

During the first month of the experiment, an insignificant number of eggs was collected in all experimental groups, as that was a beginning of egg laying period. Subsequently, the number of eggs laid increased, reaching a maximum in the control group in the third month of the experiment.

The best results were achieved in the 2nd experimental group (introduction rate 0.3%) of laying hens consuming feed additive “Green line”. In this group, the maximum gross collection was higher than the control indicator by 5.4% due to the additive, which stimulated better feed absorption, which led to an increase in productivity. In the 1st and 3rd experimental groups, a gradual decrease in the number of collected eggs was observed, although these indicators were higher than those in the control group by 3.7% and 4.0%.

Maximum egg production rate (88.4%), out of all experimental groups, was observed in a group 2 (0.3% addition of the feed additive “Green line” into the diet).

The aforementioned results are fully consistent with the indicators of egg production intensity (Table 2).

The analysis of obtained data has shown that during three month of the study the egg-laying intensity gradually increased in every experimental group. For example, in the first month of the experiment, this indice in the control group was 76.5%, while the same indice in the experimental ones was observed in a range of 78.0 – 78.7%. On average, over the 3 months of the exposure to feed additive, the egg production intensity index in the control group was 86.7%. In the experimental groups of poultry fed with the feed additive the most fruitful results were achieved in 2nd and 3rd groups.

The results demonstrated that with the age of the birds, the average egg weight in all groups increased. In the control group, the average egg weight increased from 57.3 g at the 24th week of age to 60.2 g at the 30th week of age and to 63.7 g at 42nd week of age. The eggs of birds in the experimental groups exceeded these indicators. Of the first three experimental groups, the best results were recorded in group 2, which received 0.3% of the feed additive in the diet at 2.7%, 2.8% and 2.5% increase respectively. One of the main integrative index of egg productivity is the yield of the total egg mass. During the research period egg masses in the experimental groups were by 5.9%, 6.8 and 8.2% higher then in control group. The best indicators were noted when using a feed additive in the amount of 0.3%.

The results of study demonstrated the modulation of chemical composition in egg including total protein content. The results have shown that in the 2nd and 3rd groups the dry matter content was higher than in the control by 0.3% and 1.2% correspondingly. The observed increase in dry matter occurred due to a growth of the crude protein content in egg.

Almost the same trend was observed in respect with the chemical composition of the yolk (Table 3). Dry matter content in the yolk of eggs of the experimental groups (1st, 2nd, 3rd) increased by 0.8%, 2.2% and 2.6% respectively. The higher dry matter content was due to the increase in the amount of crude protein in the yolk of eggs of laying hens of the experimental groups. The difference between the groups in terms of crude fat content in the yolk was less pronounced. The maximum values were observed in the 3rd experimental group (32.3%).

**Table 2** – Intensity egg production, % ( M  $\pm$  SE , n = 100 )

Indicator	Control	1 <sup>st</sup> – experimental	2 <sup>nd</sup> – experimental	3 <sup>rd</sup> – experimental
1st month	76.46 $\pm$ 0.43	78.00 $\pm$ 0.38	78.70 $\pm$ 0.47	78.57 $\pm$ 0.35
2nd month	90.37 $\pm$ 0.70	89.90 $\pm$ 0.62	91.40 $\pm$ 0.54	91.33 $\pm$ 0.84
3rd month	93.30 $\pm$ 0.91	94.07 $\pm$ 0.55	95.00 $\pm$ 0.83	94.20 $\pm$ 0.63
During the study period	86.71 $\pm$ 0.63	87.32 $\pm$ 0.43	88.36 $\pm$ 0.51	88.03 $\pm$ 0.64

Note: data present as % (M  $\pm$  SE, n = 100).

**Table 3** – Laying hens eggs’ chemical composition

Indicator	control	1 <sup>st</sup> – experimental	2 <sup>nd</sup> – experimental	3 <sup>rd</sup> – experimental
White				
Dry matter	11.7 $\pm$ 0.26	12.0 $\pm$ 0.20	12.7 $\pm$ 0.28	12.5 $\pm$ 0.20
Crude protein	10.0 $\pm$ 0.26	10.5 $\pm$ 0.21	11.2 $\pm$ 0.28	10.8 $\pm$ 0.22
Crude fat	–	–	–	–
Yolk				
Dry matter	50.8 $\pm$ 0.7	51.2 $\pm$ 0.8	52.1 $\pm$ 0.8	51.9 $\pm$ 0.5
Crude protein	16.6 $\pm$ 0.4	17.1 $\pm$ 0.3	17.6 $\pm$ 0.4	16.9 $\pm$ 0.2
Crude fat	31.4 $\pm$ 0.3	31.3 $\pm$ 0.2	31.8 $\pm$ 0.4	32.3 $\pm$ 0.4

Note: data present as % (M  $\pm$  SE, n = 100).

**Table 4** – Digestibility coefficients of dietary nutrients

Group	Dry substance	Organic substance	Raw protein	Raw cellulose	Raw fat
Control	78.5 ± 0.57	79.9 ± 0.55	79.1 ± 0.49	25.5 ± 0.37	80.3 ± 0.49
1 <sup>st</sup> experimental	80.7 ± 0.53	82.4 ± 0.61	81.4 ± 0.60	27.2 ± 0.45	81.3 ± 0.60
2 <sup>nd</sup> experimental	79.4 ± 0.44	81.0 ± 0.47	80.6 ± 0.44	26.4 ± 0.35	80.9 ± 0.55
3 <sup>rd</sup> experimental	81.0 ± 0.60	82.6 ± 0.66	81.9 ± 0.52	27.5 ± 0.42	81.4 ± 0.52

Note: data present as % (M ± SE, n = 100).

Research has shown that the feed additive prevented magnesium deficiency in bird's diets. The supplementation of a magnesium-containing feed additive in the diet of laying hens contributed to the normalization of the content of this element under conditions of the high-intensity poultry farming. The important mechanism to provide healthy nutrition relates to the fact while an insufficient magnesium intake initiates detrimental changes in bone development, muscle functioning and overall health. The obtained in present study data have shown that the level of magnesium in the eggs of both 2nd and 3rd experimental groups was higher than in control group eggs by 1.6% and 3.4% respectively.

The feed additive "Ggeen line" had a positive effect on the digestibility and absorption of the nutrients of the diet (Table 4). Although the difference between the control and experimental groups was not significant the indicators for crude fat were quite high.

In general, it should be noted that the most meaningful effect of the feed supplement application to the diet of chicken was observed in 3rd experimental a group of laying hens compared with the control group. Besides, the results demonstrated that digestibility level of the nutrients increased by 2.5 %, organic substances – by 2.7%, crude protein – by 2.8%, crude fiber – by 2.0%.

Additionally, the application of the feed additive "Green line" ensured a reduction in feed consumption per kg of the egg mass: in experimental group 1 – by 5.7%, in group 2 – by 7.3%, and in group 3 – by 6.0%.

## Discussion

Recent reports evidence that the feed additives supplementation is a promising and important aspect for the further development of the poultry industry which can increase its efficiency and realize the genetic potential of poultry productivity. Feed additives allow normalizing digestion processes, effectively assimilating diet components, and increasing feed conversion (Ibatullin et al., 2015; 2020).

Analysis of recent published results showed that actual problem of poultry is a wide search and study of various additives that could be the accessible source of nutrients in the feeding of farming animals (Liao et al., 2015). Therefore, the attention of the current study should be focused on the farming animal health and targeted on the strategy eco-friendly biological products as well as on the strategy complex feed additives supplementation in poultry feeding (Hassan et al., 2022).

Our research has shown that the introduction of a feed additive into the composition of the compound feed of laying hens of the 2nd experimental group in the amount of 0.3% contributed to an increase in productivity by 5.4%. At the same time, the egg production per average laying hen increased by 4.5%. The results of our research on the use of organic additives are to some extent substantiated by other researchers (Hayat et al., 2021).

At the same time, the positive effect of the feed additive on the chemical composition of eggs was experimentally confirmed. The highest levels of crude protein in the egg white and yolk of the 2nd experimental group was 11.2% and 17.6%; in the 1st and 3rd experimental groups - 10.5% and 10.8% and 17.1% and 16.9%

respectively. Introduction of the additive into the composition of compound feeds had no negative impact on chemical composition, since the difference between the groups in indicators was insignificant and statistically unreliable. The results of our research on egg quality indicators are confirmed by data from other researchers (Zampiga et al., 2018; Suchov et al., 2022).

A positive effect of the use of the additive on the morphological indicators of edible eggs was also revealed. Feeding laying hens 0.3% of the additive in the composition of compound feed was accompanied by a tendency of the egg weight increase. The best results were recorded in the 2nd experimental group. The weight of eggs at 24th week of hen's age was 58.9 g, at 30th week of age – 61.9 g and at 42nd week of age – 65.3 g. Research results by other scientists confirm that the use of various feed additives in poultry feeding had a positive effect on productivity and contributed to increasing the profitability of the poultry industry (Polehenka, 2019; Shevczova, 2021; Tsap & Orishchuk, 2023).

The global analysis of poultry farming profitability demonstrated that the increase in economic indicators is achieved by increasing income from the sale of eggs and reducing the costs of their production. In our studies, feed consumption per 1 kg of egg mass decreased by 7.3% in the 2nd experimental group when using 0.3% of the additive. When using 0.2% and 0.4% of the additive, feed consumption was lower by 5.7% in the 1st group and by 6.0% in the 3rd group, respectively (Boerboom et al., 2018; Gavilej et al., 2021).

Observed in our study results confirm that feed additives based on organic compounds play an important role in poultry feeding. They maintain high productivity, prevent stress and, ultimately, are a tool for creating efficient production of poultry products (Belloir et al., 2019; Masiuk et al., 2024). Therefore, the results of the study showed that feeding the additive as part of compound feed allowed for additional production and profits, which creates the prerequisites for recommending "Green line" feed additive to poultry farmers of various ownership types.

## Conclusions

The results of the study showed that the supplementation of feed additive in a dose 0.3% into the diet of laying hens contributed to an increase in productivity by 5.4%. The content of crude protein in the yolk and egg white increased by 1.0% and 1.2% respectively. The level of magnesium in the eggs of 2nd and 3rd experimental groups was higher by 1.6% and 3.4% respectively. The digestibility of dry matter increased by 2.5%, organic matter by 2.7%, crude protein by 2.8%, crude fiber by 2.0%. In general, the use of magnesium-containing feed additive contributed to an increase in productivity and a decrease in feed costs of poultry products. Furthermore, this blended feed additive application can lead to increase in feed conversion as well as decrease in food expenditures. The further study is required to clarify the molecular and cellular mechanisms of feed additive stimulatory effects on the laying hens productivity.

## Funding

This research received no external funding.

### Acknowledgement

The authors thankful Valentin Yefimov for consulting authors on the laboratory diagnostics methods application.

### Conflicts of Interests

The authors declare no conflict of interests.

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