ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume 73 12 Number 3, 2025

EFFECTIVENESS OF DIFFERENT LEVELS OF FENNEL SEEDS (*FOENICULUM VULGARE*) IN THE COMPOSITION OF FEED MIXTURES FOR MEAT-TYPE QUAILS

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Link to this article: https://doi.org/10.11118/actaun.2025.012
Received: 4. 12. 2024, Accepted: 22. 3. 2025

Abstract

Fennel seeds in poultry feed positively affect productivity and health. To determine the optimal dose of fennel seed powder in complete feed mixtures for meat-type quails, a scientific and economic experiment was conducted on Pharaoh quail chicks. Four groups of one-day-old quails, each consisting of 100 birds, were formed for the experiment. The control group was fed a basic feed mixture, while the experimental groups received the same mixture with 1–2% fennel seed powder. After a seven-week experiment, it was established that the doses of fennel seeds used positively influenced the productivity and slaughter characteristics of the quails. However, the highest indicators of average daily body weight gain, slaughter weight, and yield were achieved with the inclusion of 1.5% fennel seed in the quail feed. Therefore, incorporating 1.5% fennel seed into the feed for meat-type quails aged 1–42 days can be considered optimal.

Keywords: meat-type quails, phytobiotics, fennel seeds, feeding, productivity, slaughter characteristics, edible carcass parts yield

INTRODUCTION

The breeding of poultry for meat is considered one of the most economically viable and environmentally sustainable sectors of animal husbandry (Khabiri *et al.*, 2022). This sector is global, as poultry is raised worldwide to meet the growing demand for meat (Khabiri *et al.*, 2023). Due to its high adaptability to environmental conditions, poultry farming successfully develops both in industrial and small-scale farming operations. (Mohamadinejad *et al.*, 2024).

In the first days of life, young poultry have an underdeveloped immune system that is still maturing. During this period, birds are highly vulnerable to pathogens in their environment. In the first week of life, mortality due to intestinal infections can reach alarming levels. This has historically driven the widespread use of antibiotics for the prevention and growth stimulation of animals, particularly during the early days and weeks of life (Swelum *et al.*, 2021).

The era of intensive and uncontrolled antibiotic use in animal feeding ended in Europe in 2006, in China in 2016, in the United States in 2017, and in Japan in 2018 (Pham *et al.*, 2024). However, in many countries, this practice continues, though its prevalence is decreasing. This trend is supported by the active search for effective natural alternatives to antimicrobial agents. Numerous studies have demonstrated the antimicrobial properties of various phytobiotics – a group of biologically active compounds with diverse chemical compositions (terpenes, triterpenes, flavonoids, etc.) that plants produce for their own protection against pathogens, and which are now utilized in animal feeding for the same purpose (Urban *et al*., 2024).

Experimental evidence has shown that the use of phytobiotics in recommended doses normalizes the digestive system by stimulating beneficial microorganisms and the secretion of digestive enzymes. The presence of phytobiotics in feed reduces inflammatory processes, improves immune system function, and enhances productivity (Biswas *et al*., 2024; Urban *et al*., 2024; Wang *et al*., 2024).

Among the phytobiotics commonly studied and used in poultry feeding are oregano (*Origanum vulgare*), thyme (*Thymus vulgaris*), anise (*Pimpinella anisum*), mint (*Mentha arvensis*), cinnamon (*Cinnamomum sp.*), lemon (*Citrus limonum*), garlic (*Allium sativum*) (Deminicis *et al*., 2021), wormwood (*Artemisia*) (Ibatullin *et al*., 2022; Sychov *et al*., 2024), pale echinacea (*Echinacea pallida*) (Chudak *et al*., 2017), fennel oil (Kholiavska *et al*., 2024).

Fennel seeds have long been known to positively affect digestive health and improve digestion. However, excessive concentrations in the diet can have toxic effects on animals. A review article by Pakistani and Italian researchers (Khan *et al*., 2022) analyzed approximately 100 studies on the use of fennel in poultry feeding. Typically, small doses of fennel oil, seed powder, or meal are included in feed mixtures, with noted positive effects on productivity, feed consumption and conversion, and slaughter characteristics.

The analysis of literary sources dedicated to the use of phytobiotics in quail feeding revealed insufficient research on the impact of different levels of fennel seeds on the productivity of meat-type quails. Existing studies mainly focus on the general aspects of using plant-based additives, leaving a gap in knowledge regarding the optimal fennel dosage to enhance quail meat production efficiency. Therefore, the aim of the research was to determine the optimal level of fennel seeds in complete feed mixtures for meat-type quails aged 1–42 days. This experiment to determine the optimal fennel seed doses for meat-type quails aged 1–42 days was conducted for the first time in the world. This study is part of a broader scientific project aimed at studying the effects of various forms of fennel additives – oil, seeds, and meal – in the composition of compound feed for quail chicks. The results obtained allow for the evaluation of the effectiveness of such additives and their impact on the productivity of meat-type quails.

MATERIALS AND METHODS

The scientific and economic experiment investigated the effect of adding 1.0%, 1.5%, and 2.0% ground fennel seeds to the feed mixtures used during the first and second growth periods of meat-type quails. A total of 400 one-day-old Pharaoh quail chicks were selected for the experiment. The study lasted 42 days and was divided into two periods (days 1–21 and days 22–42) and seven sub-periods, each lasting seven days.

At the end of each sub-period, the quails were weighed individually on KERN PCD electronic scales with an accuracy of 0.01 g. Weighing was carried out in the morning. A total of 7 weighings were performed: at the ages of 1, 7, 14, 21, 28, 35, and 42 days. Using the results of the quail weighings as a basis, their average daily weight gain was calculated by dividing the difference in body weight at the end and at the beginning of the sub-period by the duration of the sub-period in days.

At the end of the experiment, the quails were slaughtered. Complete feed mixtures were used for feeding, with the formulations presented in Tab. I.

The conditions for feeding, watering, housing, care, and disease prevention of poultry during the experiment were organized in accordance with European legislation on animal welfare and comfort (Council Directive 1999/74/EC; Council Directive 1998/58/EU; Council Directive 2010/63/EU).

For the control slaughter, birds with a body weight closest to the average for the group were selected. The gender of the quails was also taken into account. The pre-slaughter weight of the animals was determined by weighing them after a twelve-hour fasting period. After slaughter, the following were determined:

- the weight of undressed carcass was measured by weighing the carcass, from which the feathers and blood had been removed, but all internal organs and body parts were still present;
- the weight of the semi-dressed carcass was measured by weighing the carcass, from which the feathers, blood, intestines, and ovaries had been removed;
- the weight of dressed carcass was measured by weighing the carcass, from which the feathers, blood, all internal organs, head (up to the second cervical vertebra), legs (up to the hock joint), and skin from the neck had been removed.

Additionally, during the study, the following calculations were made:

- The yield of the semi-dressed carcass, defined as the ratio of the weight of the semi-eviscerated carcass to the pre-slaughter weight of the bird, expressed as a percentage.
- The yield of the dressed carcass, defined as the ratio of the weight of the fully eviscerated carcass to the pre-slaughter weight of the bird, expressed as a percentage.
- The yield of edible parts, defined as the ratio of the weight of the edible parts of the carcass to the pre-slaughter weight of the bird, expressed as a percentage. The research on animals was conducted in compliance with the requirements

I: *Composition of Complete Feed Mixtures for Quail Feeding, %*

Indicator	Quail Age 1–21 Days				Quail Age 22–42 Days			
	Group							
	Control	Experimental			Control	Experimental		
	1	2	3	4	1	2	3	4
Corn	47.41	47.61	47.76	47.91	59.20	59.16	59.31	59.50
Soybean meal	26.10	27.70	28.40	29.00	20.80	22.35	23.00	23.75
Sunflower meal	5.50	2.80	1.50	0.30	5.50	3.00	1.80	0.40
Fennel seeds	-	1.00	1.50	2.00	-	1.00	1.50	2.00
Vegetable oil	1.55	1.45	1.40	1.35	2.40	2.40	2.30	2.25
Fish meal	5.00	5.00	5.00	5.00	4.00	4.00	4.00	4.00
Gluten meal	2.00	2.00	2.00	2.00	3.50	3.50	3.50	3.50
Blood meal	8.00	8.00	8.00	8.00	-	-	-	-
Table salt	0.30	0.30	0.30	0.30	0.50	0.50	0.50	0.50
Monocalcium phosphate	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Shell	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L-Lysine	0.04	0.02	0.02	0.01	0.11	0.07	0.06	0.06
L-Threonine	-	0.01	0.01	0.01	-	-	-	0.01
DL-Methionine	0.10	0.11	0.11	0.12	0.02	0.02	0.03	0.03
Premix	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

of the „General Ethical Principles for Animal Experimentation" (Law of Ukraine No. 3447-IV, 2006), as well as the provisions of the „European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes" (European Convention for..., 1986).

RESULTS AND DISCUSSION

The body weight of quails raised for meat is the primary indicator for evaluating their productivity during their lifetime. In the course of the scientific and practical experiment, body weight was measured weekly starting from the first day of life, and the average daily weight gain was calculated (Tab. II).

During the first week of the experiment, quails in the 3rd experimental group exceeded the control group in average daily weight gain by 0.24 g or 5.59%. Similarly, the quails in the 4th experimental group showed an advantage of 0.23 g or 5.36%. Quails in the 2nd experimental group surpassed the control group by 0.19 g or 4.43%. The differences during this period between the experimental and control groups were statistically significant.

In the second week, the experimental groups continued to outperform the control group, with the 2nd experimental group exceeding by 0.35 g or 4.55%, the 3rd group by 0.44 g or 5.71%, and the 4th group by 0.40 g or 5.19%. These differences were statistically significant.

During the third week, similar trends were observed, with the highest absolute weight gain in the 3rd experimental group, surpassing the control by 0.56 g or 7.12%. The 4th experimental group also showed significant improvement, exceeding the control by 0.52 g or 6.61%. The 2nd experimental group exceeded the control by 0.44 g or 5.59%. However, the differences in average daily weight gains during this period were not statistically significant.

II: *Dynamics of Average Daily Weight Gains of Experimental Quails, g*

Group	Age, Days						
	1–7	8–14	15–21	22–28	29–35	36–42	1–42
1 Control	4.29 ± 0.038	7.70 ± 0.027	7.87 ± 0.258	7.61 ± 0.083	5.58 ± 0.092	6.03 ± 0.204	6.51 ± 0.105
2 Experimental	4.48 ± 0.032***	8.05 ± 0.039***	8.31 ± 0.191	8.06 ± 0.092***	6.13 ± 0.204*	6.43 ± 0.147	6.91 ± 0.106**
3 Experimental	4.53 ± 0.032***	8.14 ± 0.027***	8.43 ± 0.220	8.18 ± 0.102***	6.29 ± 0.183***	6.32 ± 0.195	6.98 ± 0.114**
4 Experimental	4.52 ± 0.036***	8.10 ± 0.034***	8.39 ± 0.200	8.12 ± 0.127**	6.20 ± 0.157***	6.64 ± 0.221*	6.98 ± 0.118**

Note: *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$ compared to the 1st control group

Between days 22–28, a decline in average daily weight gain was noted across all groups compared to the previous week. Nevertheless, the quails in the 2nd, 3rd, and 4th experimental groups continued to outperform the control group by 0.45 g, 0.57 g, and 0.51 g, or 5.91%, 7.49%, and 6.70%, respectively. These differences were statistically significant.

During the fifth week, the same trends were observed. Quails in the 3rd experimental group showed the highest advantage over the control group in daily weight gain, with an increase of 0.71 g or 12.72%. The 2nd experimental group exhibited the smallest advantage, with a gain of 0.55 g or 9.86%. The 4th experimental group achieved a gain of 0.62 g or 11.11%. Again, the differences between the groups were statistically significant.

The final week of the experiment deviated from the previously observed trend. Quails in the 4th experimental group became the leaders in daily weight gain, exceeding the control group by 0.61 g or 10.12%. The quails in the 2nd experimental group followed closely behind, surpassing the control by 0.40 g or 6.63%. The smallest advantage over the control group in daily weight gain was observed in the 3rd experimental group, which concluded the study with a gain of 0.29 g or 4.81%. The difference in this parameter was statistically significant only between the control group and the 4th experimental group.

Analyzing the daily weight gain over the entire 42-day study, it was evident that quails in the 3rd and 4th experimental groups had an advantage over the control group by 0.47 g or 7.22%. Quails in the 2nd experimental group demonstrated a gain of 0.40 g or 6.14% over the control group. This difference between the control and experimental groups was statistically significant.

Thus, the analysis of weight changes and weight gains in quails revealed that the highest performance was achieved in the 4th and 3rd experimental groups, where the fennel seed content in the feed was 2.0% and 1.5%, respectively. It is also worth noting that the inclusion of 1.0% fennel seed in the feed of the 2nd experimental group had a positive effect on the productivity of meat-type quails.

The survival rate of birds in the 1st control group and the 4th experimental group was 93%, while in the 2nd and 3rd experimental groups, it was 94%. No correlation was established between the inclusion of fennel seeds in the feed and bird survival.

The majority of expenses in poultry farming come from feed. Growth intensity and feeding efficiency also depend on the proper organization of feeding. In this regard, monitoring the amount of feed consumed plays an important role. Throughout the entire growing period, it was observed that the highest feed consumption was recorded in the 3rd experimental group at 22.20 g per bird per day, which was 1.03 g or 4.87% more than the control group (21.17 g per bird per day). Slightly lower was the consumption in the 4th experimental group, which exceeded the control by 1.00 g or 4.72%, averaging 22.17 g per bird per day. The lowest consumption advantage over the control was observed in the 2nd experimental group, where the quails consumed 21.75 g per bird per day – 0.58 g or 2.74% more than the control.

Since the birds grew unevenly and consumed feed at different rates, feed conversion was analysed – feed intake per unit of weight gain. According to the study results, the lowest feed conversion rate was observed in the 3rd experimental group, which consumed feed containing 1.5% fennel seeds, with a feed conversion rate of 3.496 g/g. This group outperformed the control group by 292 mg or 7.71%. When 2.0% fennel seeds were included in the feed, the feed conversion rate was 3.526 g/g, which was 262 mg or 6.92% lower than the control. The 2nd experimental group, with 1.0% fennel seeds in their feed, also showed an advantage of 208 mg or 5.49% over the control group, with a feed conversion rate of 3.580 g/g.

During the experiment aimed at assessing the efficiency of using feeds with different fennel seed content for quails, slaughter indicators, and the yield of meat and other edible carcass parts were analyzed.

Since the quails selected for slaughter were those whose weights were closest to the group average, the preslaughter weight varied proportionally to the body weight of the birds at 42 days of age (Tab. III). The 3rd experimental group showed the highest advantage over the control group, with 19.8 g or 6.96%. The advantage of the 4th experimental group over the control was 19.7 g or 6.92%. Quails in the 2nd experimental group also outperformed the

III: *Slaughter characteristics of quails, g*

Indicator	Group			
	Control	Experimental		
	1	2	3	4
Preslaughter body weight	284.6 ± 1.72	301.0 ± 1.73**	304.4 ± 1.53***	304.3 ± 0.29**
Weight of undressed carcass	249.1 ± 2.09	264.7 ± 2.17**	269.2 ± 1.84***	268.8 ± 0.76**
Weight of semi-dressed carcass	230.5 ± 1.95	244.3 ± 1.89**	247.9 ± 1.61**	247.7 ± 0.67**
Weight of dressed carcass	210.0 ± 1.97	222.9 ± 2.04**	226.3 ± 1.75**	225.9 ± 0.88**

Note: $P < 0.01$ compared to the control group, $P < 0.001$ compared to the control group control in this indicator by 16.4 g or 5.76%. It should be noted that the difference in preslaughter weight among the groups was statistically significant.

In terms of unprocessed carcass weight, the birds of the 3rd experimental group showed the greatest advantage over the control counterparts – 20.1 g or 8.07%. The smallest difference was observed in the 2nd experimental group, where birds exceeded the control by 15.6 g or 6.26%. Birds in the 4th experimental group surpassed the control group by 19.7 g or 7.91%. The difference between the experimental and control groups for this parameter was statistically significant.

A significant and statistically notable difference was also observed in the semi-dressed carcass weight between the quails of the control and experimental groups. The advantage over the control group was 13.8 g or 5.99% for the 2nd group, 17.4 g or 7.55% for the 3rd group, and 17.2 g or 7.46% for the 4th group.

The dressed carcasses of the quails in the 3rd experimental group exceeded the control in weight by 16.3 g or 7.76%. A slightly smaller difference was noted between the birds of the 4th group and the control – 15.9 g or 7.57%. Additionally, the quails in the 2nd group surpassed the control group by 12.9 g or 6.14%. The differences observed between the control and experimental groups in dressed carcass weight were statistically significant.

Despite the substantial differences in carcass weight among the groups, the calculation of slaughter yield allowed for an assessment of changes in slaughter parameters relative to the initial pre-slaughter live weight (Tab. IV).

In the experimental groups, a slight increase in the yield of semi-eviscerated and eviscerated carcasses relative to the pre-slaughter body weight was observed. For semi-eviscerated carcass yield, the birds in the 3rd experimental group surpassed the control by 0.5%, the 4th group by 0.4%, and the 2nd group by 0.2%. The advantage of these groups over the control in terms of eviscerated carcass yield was 0.6%, 0.5%, and 0.2%, respectively. None of the differences in the yield of semi-eviscerated or eviscerated carcasses between the groups were statistically significant.

During the control slaughter within the scientific-economic experiment aimed at determining the effect of fennel seed concentration in quail compound feed on their meat productivity, the mass of individual organs and body parts that could be used for human and animal consumption was studied (Tab. V).

With an increase in pre-slaughter body weight, the yield of breast muscles in quails also increased. The highest value for this indicator was observed in the birds of the 3rd experimental group, exceeding the control value by 0.50%. Birds of the 4th and 2nd experimental groups showed very similar breast muscle yields, surpassing the control counterparts by 0.28% and 0.24%, respectively.

In terms of leg muscle yield, quails from the 3rd and 4th experimental groups had very similar results, exceeding the control by 0.16% and 0.17%, respectively. Meanwhile, birds of the 2nd experimental group lagged behind the control by 0.15% for this indicator.

The skin yield showed minimal differences between the control and experimental groups. Birds

IV: *Slaughter characteristics of quails, % of pre-slaughter live weight*

Indicator	Group			
	Control	Experimental		
	1	2	3	4
Semi-dressed carcass yield	81.0 ± 0.20	81.2 ± 0.18	81.5 ± 0.13	81.4 ± 0.15
Dressed carcass yield	73.8 ± 0.25	74.0 ± 0.27	74.4 ± 0.23	74.3 ± 0.23

V: *Yield of edible parts as a percentage of pre-slaughter body weight*

Indicator	Group			
	Control	Experimental		
	1	2	3	4
Breast muscles	16.82 ± 0.170	17.06 ± 0.140	17.32 ± 0.260	17.10 ± 0.160
Leg muscles	10.35 ± 0.060	10.20 ± 0.220	10.51 ± 0.080	10.52 ± 0.230
Skin	6.30 ± 0.110	6.26 ± 0.080	6.29 ± 0.080	6.34 ± 0.060
Internal fat	0.78 ± 0.040	0.82 ± 0.040	0.84 ± 0.030	0.84 ± 0.040
Liver	2.39 ± 0.020	2.37 ± 0.030	2.43 ± 0.020	2.41 ± 0.020
Lungs	0.87 ± 0.020	0.88 ± 0.020	0.92 ± 0.020	0.91 ± 0.030
Kidneys	0.52 ± 0.020	0.54 ± 0.020	0.57 ± 0.030	0.56 ± 0.030
Gizzard	1.83 ± 0.020	1.93 ± 0.050	2.01 ± 0.040*	2.01 ± 0.050*
Heart	0.79 ± 0.010	0.81 ± 0.030	0.86 ± 0.050	0.83 ± 0.080

from the 2nd and 3rd experimental groups had slightly lower values than the control by 0.04% and 0.01%, respectively. On the other hand, the 4th experimental group exceeded the control by 0.04%.

Quails from the 3rd and 4th experimental groups showed identical internal fat yields, surpassing the control by 0.06%. The advantage for birds in the 2nd experimental group was 0.04%.

The 3rd and 4th experimental groups of birds also showed an advantage over the control in liver yield by 0.04% and 0.02%, respectively. However, the liver yield of the 2nd experimental group quails was 0.02% lower than the control value.

The advantage in lung yield for quails in the 2nd, 3rd, and 4th experimental groups was 0.01%, 0.05%, and 0.04%, respectively.

Changes in kidney yield among birds from the experimental groups compared to the control were minimal. Quails from the 2nd group exceeded the control by 0.02%, while birds from the 3rd and 4th groups surpassed the control by 0.05% and 0.04%, respectively.

A statistically significant difference was observed in the gizzard yield, where the birds of the 3rd and 4th experimental groups surpassed the control by 0.18%. Birds from the 2nd experimental group also outperformed the control in this indicator by 0.10%.

Regarding heart yield, the leading position was held by quails from the 3rd experimental group, exceeding the control by 0.07%. Birds from the 2nd and 4th experimental groups surpassed the control counterparts by 0.02% and 0.04%, respectively.

The results of our research should be compared with the findings made by Dr. K. Premavalli and Dr. A. V. Omprakash during their experiment on Japanese quail chicks (Premavalli and Omprakash, 2020). This group of Indian scientists observed that among the studied levels of fennel seeds (0.5%, 1.0%, and 1.5%), the highest body weight gain and the lowest feed conversion ratio were achieved with a dose of 1.5%. Additionally, this group of birds showed the highest survival rate.

Regarding slaughter metrics, the results of an experiment conducted by Turkish scientists (Çetin *et al*., 2022) demonstrated that the best slaughter performance in quails was achieved with feed containing 2.0% fennel seeds, which aligns with our conclusions. The comparison was made by feeding adjacent groups with compound feeds containing 1.0% and 4.0% fennel seeds.

Similar studies involving the feeding of different doses of fennel seeds were conducted on broiler chickens. For instance, a group of Iraqi scientists (Mohammed and Abbas, 2009) noted an increase in body weight in broilers when their compound feed included 1–3 g/kg of fennel seeds. Improvements in slaughter performance were recorded with fennel seed content of 1–3.2% in the diet (Al-Sagan *et al*., 2020).

Another group of researchers (Nassar *et al*., 2024) conducted an experiment on broiler chickens, feeding them complete compound feeds containing 10 g, 20 g, and 30 g of fennel seeds per 1 kg of feed. The experiment did not reveal differences in the amount of feed consumed, but the birds' body weight, weight gain, feed conversion ratio, carcass yield, breast yield, liver weight, and spleen weight improved compared to the control group. The best results were observed when consuming compound feeds containing 30 g of fennel seeds per 1 kg of complete feed.

In comparative studies on turkey poults, the impact of various phytobiotics at the same dose on productivity and slaughter qualities was examined. Turkeys were fed compound feeds containing 0.5% thyme seeds, fenugreek seeds, fennel seeds, and cumin seeds. Although fennel did not show the best results in the overall scientific study, it is noteworthy that during the first two weeks of rearing, which are critical in the life of poultry, the consumption of fennel seeds contributed to the highest productivity levels. However, no significant impact on slaughter qualities at eight weeks of age was noted (Bhaisare *et al*., 2014).

In summary, the results of various studies indicate a positive effect of including 1–2% fennel seeds in compound feeds on the productivity of meat-type quails.

CONCLUSION

The inclusion of fennel seeds at a dosage of 1–2% in complete compound feeds positively impacts the productivity of meat-type quails. Specifically, an increase in average daily weight gains by 0.40–0.47 g or 6.14–7.22% was observed, with the highest gains achieved at 1.5% and 2% fennel seed inclusion.

Analysis of data from the control slaughter revealed that the best eviscerated carcass weight was achieved by quails fed compound feeds containing 1.5% fennel seeds. These quails surpassed the control group in eviscerated carcass weight by 16.3 g or 7.76% and in eviscerated carcass yield by 0.6%. Similarly, with a 2.0% fennel seed powder content, the quails outperformed the control group by 15.9 g or 7.57% in eviscerated carcass weight and 0.5% in carcass yield.

The inclusion of 1.0% fennel seeds in the compound feeds of meat-type quails also contributed to an increase in eviscerated carcass weight by 12.9 g or 6.14% and its yield by 0.2% compared to the control. Although no significant changes were observed in the yield of edible parts of the quails, there was a clear tendency for increased breast muscle mass and gizzard weight.

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