ANIMAL SCIENCE AND FOOD TECHNOLOGY

Journal homepage: https://animalscience.com.ua/en
Animal Science and Food Technology, 15(3), 101-114
Received 28.03.2024 Revised 18.06.2024 Accepted 15.08.2024

UDC 636.5.086:582.794.1]:582.794.1
DOI: 10.31548/animal.3.2024.101

Productive qualities of young quails with the use of fennel oil (*Foeniculum vulgare*) in compound feed

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Abstract. Due to the emergence of antibiotic resistance of microorganisms, it is important to study the effectiveness of phytobiotics in poultry feeding. The aim of the study was to identify the ideal dosage of fennel oil (*Foeniculum vulgare*) for feeding meat quail. To conduct the study, 4 groups of quails of day-old age were formed, 100 birds each. The first group consumed basic compound feed and was therefore a control group. In the mixed feed of experimental group 2, 0.1% of vegetable oil was replaced with fennel oil, in experimental groups 3 and 4 – 0.2% and 0.3%, respectively. The average daily gains during the growing period were the largest in experimental group 4 – 0.46 g or 7.07% more than the control group. The advantage over the control of quails in experimental group 3 was 0.43 g or 6.61%, and in experimental group 2 – 0.34 g or 5.22%. Throughout the experiment, birds in the experimental groups consumed 2.41-4.49% more feed compared to the control group. However, the feed cost per kilogram of body weight gain was 5.04-6.97% lower than in the control group. Quails in experimental group 2 showed an advantage over the control group, with breast muscle weight higher by 2.5 g (5.22%) and leg muscle weight by 1.1 g (3.74%). The birds of experimental group 3 were ahead of the control in terms of breast muscle weight by 3.5 g or 7.31%, and leg muscles – by 1.5 g or 5.10%. Quails in experimental group 4 surpassed the control group, showing a 3.9 g (8.14%) increase in breast muscle weight and a

Suggested Citation:
Kholiavska, T., & Umanets, D. (2024). Productive qualities of young quails with the use of fennel oil (*Foeniculum vulgare*) in compound feed. *Animal Science and Food Technology*, 15(3), 101-114. doi: 10.31548/animal.3.2024.101.

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1.9 g (6.46%) increase in leg muscle weight. Thus, the introduction of fennel oil in a dose of 0.1-0.3% into the composition of quail compound feed allows improving growth and achieving better productivity indicators

Keywords: phytobiotics; essential oils; poultry meat; slaughter indicators; productivity; body weight gain

Introduction

The extensive use of antibiotics as feed additives to promote growth in livestock and poultry over the past half-century has led to a major negative outcome: the emergence of antibiotic-resistant microflora. Researchers from all over the world, including M. Barrahi *et al*. (2020), concerned that humanity faces the risk of transmission of antibiotic-resistant bacteria from animals to humans through consumption of livestock and poultry products.

In the early 2000s, the use of antibiotics to stimulate animal growth was banned in most developed countries of the world, which created new difficulties – outbreaks of infectious diseases among animals became more frequent. According to M. Murshed *et al*. (2023), the need to protect animals from pathogenic microflora led to the development of a new approach to the problem of antibiotic resistance and led to the search for alternatives to antibiotics that would not have side effects, but reliably protect the health of animals and ensure their high productivity.

Thus, the positive effect of using various herbal preparations in feeding animals was established to protect their health and ensure high productivity. N. Abdelli *et al.* (2021) emphasise that nowadays more than a dozen different plants have been studied and recommended for use in animal husbandry as an alternative to antibiotics. They do not have a negative impact on the quality of products, and accordingly on the person. The most common phytobiotics used in animal feeding, according to W.A.A. El-Ghany (2020), include nutmeg (*Myristica fragrans*), cinnamon (*Cinnamomum zeylanicum*), clove (*Syzygium aromaticum*), parsley (*Petroselinum crispum*), peppermint (*Mentha piperita*), black cardamom (*Amomum subulatum*), celery (*Apium graveolens*), coriander (*Coriandrum sativum*), chili pepper(*Capsicum annuum*), black pepper (*Piper nigrum*), cumin (*Cuminum cyminum*), anise (*Pimpinella anisum*), gunba/fenugreek (*Trigonella foenum-graecum*), horseradish (*Armoracia rusticana*), black mustard (*Brassica nigra*), ginger (*Zingiber officinale*), garlic (*Allium sativum*), rosemary (*Rosmarinus officinalis*), thyme (*Thymus vulgaris*), asparagus (*Asparagus racemosus*), leptadenia (*Leptadenia reticulata*).

R.G.D.S. Deminicis *et al.* (2021) note that the content of active substances and chemical composition of phytobiotics in final products can vary greatly depending on biological factors (plant species, place of cultivation, and harvesting conditions); the parts of the plant used (seeds, leaves, etc.); the method of production (extraction, distillation, and stabilisation); storage conditions (light, temperature, oxygen tension, and time); geographical origin; harvest season. A significant role is also played by the type of animal, dosage, time and method of administration. The action of these compounds is primarily aimed at preventing pathogenic infections and, as a result, improving animal welfare.

M. Murshed *et al.* (2023) note that herbal preparations do not have a significant nutritional value for animals, but they have a positive effect on feed conversion, contribute to improving animal productivity and product quality. The primary effect of exposure to phytogenic drugs is the fight against potential pathogenic pathogens and by increasing the

number of beneficial intestinal microflora. It is this mechanism of action that gives phytobiotics antibacterial, antifungal, antiviral, and anticoccidial properties. The secondary effect of these herbal preparations is to improve the health and general condition of animals and reduce the cost of veterinary care and treatment. R.G.D.S. Deminicis *et al*. (2021) highlight that the incorporation of phytobiotics can induce beneficial changes in intestinal morphology, such as elongation of villi and increased depth of intestinal crypts. In many instances, they also regulate the host's immune response by activating cellular components of the innate immune system, including macrophages and heterophils, which protect against gastrointestinal infections. Additionally, they may stimulate the production of pro-inflammatory cytokines that influence adaptive immunity or stabilize the gut microbiome. The primary goal of using immunomodulatory feed additives is to minimize local inflammation, enhance immune function, and ultimately improve the health and productivity of animals. The purpose of the study was to investigate the effect of feeding fennel oil *(Foeniculum vulgare)* on the meat productivity of quails.

Materials and Methods

In furtherance of this goal in the conditions of a small agricultural enterprise in the Weissenburg-Gunzenhausen district "Schambachtal Alpakas" in Germany, a scientific and economic experiment was conducted to determine the optimal levels of this feed agent. To organise the experiment, 400 quails of the Pharaoh breed of day-old age, analogues in age and live weight, which ranged from 9 to 11 grammes, were selected. When forming the groups, the sex of the quails was considered. The birds were assigned to four analogous groups, with the first serving as the control group and the remaining three as experimental groups. The experiment spanned 42 days, divided into two phases: the first phase from day 1 to day 21, and the second from day 22 to day 42. This division corresponded to changes in the quails' feeding standards starting at 22 days of age.Quail growth was monitored every 7 days during the experiment. The planning and execution of the experiment were conducted in accordance with the guidelines provided by O.S. Yaremchuk *et al*. (2019).

During the entire scientific and economic experiment, the experimental bird was invariably kept in single-tier cage batteries of 50 animals in a cage measuring 750×500×250 mm. Thus, the design of the cage provided each individual with 75 cm^2 of floor space and a feeding front with 1.5 cm tray feeders. The bird was provided with water using vacuum drinkers. Quails were provided with unrestricted access to both water and feed. For quail feeding, complete feeds were used, produced at a feed mill according to the recipe provided (Table 1). To ensure adequate feeding, the quail rearing period was divided into two age half-periods: up to and including 21 days of age and after that. To ensure high levels of energy and crude protein during the first three weeks of rearing, quails were fed a significant amount of animal-based feed – fish and blood meal. The only difference between the control quail and those from the experimental groups was the concentration of vegetable oil and fennel oil.

Table 1. *Composition of compound feeds 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				59.20			
Soy cake CP 43.5%	26.10				20.80			

Table 1. Continued

Indicator	Quail age 1-21 days				Quail age 22-42 days			
	Group							
	control	experimental			control	experimental		
	1	2	3	4	1	2	3	4
Sunflower cake CP 31.3%	5.50				5.50			
Fennel oil	-	0.10	0.20	0.30	-	0.10	0.20	0.30
Vegetable oil	1.55	1.45	1.35	1.25	2.40	2.30	2.20	2.10
Fish meal CP 56.7%	5.00				4.00			
Gluten meal CP 71%	2.00				3.50			
Blood meal CP 82.7%	8.00				-			
Table salt	0.30				0.50			
Monocalcium phosphate	1.00				1.00			
Shells	1.00				1.00			
L-lysine	0.04				0.11			
L-threonine	-				-			
DL-methionine	0.10				0.02			
Premix	2.00				2.00			

Source: developed by the authors

The nutritional value of the compound feeds in both the first and second growth periods closely aligned with the recommended feeding standards for meat quails outlined in the guidelines (Bratyshko *et al.*, 2014). Thus, poultry aged 1-21 days consumed mixed feed, the nutritional value of which was 12.5 MJ of metabolic energy per 1 kg. The chemical composition of these mixed feeds was as follows: crude protein – 18.0%, crude fat – 6.5%, crude fibre – 3.5%, nitrogen-free extractives – 42.4%, lysine – 1.79%, methionine with cystine – 1.01%, threonine – 1.15%, tryptophan – 0.35%, calcium – 1.0%, phosphorus – 0.8%, sodium – 0.4%. Quails aged 22-42 days consumed compound feed with a content of 12.9 MJ of metabolic energy per 1 kg, 20.5% crude protein, 7.3% crude fat, 3.4% crude fibre, 49.6% nitrogen-free extractives, 1.03% lysine, 0.74% methionine with cystine, 0.77% threonine, 0.21% tryptophan, 1.0% calcium, 0.8% phosphorus, 0.5% sodium. The content of trace elements and vitamins was the same in the composition of compound feeds of all groups, since it was provided by the introduction of premix for quails.

During the scientific and economic experiment, poultry feed consumption was monitored and feed costs per unit of production (body weight gain) were calculated. The feeding, drinking, housing, care, and disease prevention conditions for the animals involved in the experiment adhered to European legislation regarding animal welfare and comfort (Council Directive 1999/74/EC; Council Directive 1998/58/EU; Council Directive 2010/63/EU). At the conclusion of the second phase of the scientific and economic experiment, a controlled slaughter of the experimental poultry was performed. For this, four animals (two females and two males) were selected from each group based on body weights that were close to the average values for their respective groups. Animal studies were conducted in accordance with the "General Ethical Principles for Conducting Animal Experiments," which were endorsed by the 1st National Congress on Bioethics (Law of Ukraine No. 3447-IV, 2006), and the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Scientific Purposes (1986).

Results and Discussion

In quails whose rearing purpose is to produce meat, the main indicator of productivity is body

weight and its changes during the rearing period. Therefore, the main indicators used to assess the effectiveness of using fennel oil productivity in quail feeding were the average daily weight gain (Table 2). In the first week of consuming mixed feeds with varying concentrations of fennel oil, the poultry in the experimental groups showed a significant increase in productivity compared to the control group. Experimental group 2 exhibited an advantage of 0.16 g or 3.73% over the control quails in this regard. The body weight of representatives of experimental group 3 per day increased by 0.20 g or 4.66% more than the control analogues. The greatest difference was in the average daily weight gain between quails of the control and experimental group 4 – by 0.24 g or 5.59% in favour of the latter. The difference was statistically significant.

Table 2. *Changes in the average daily weight gain of experimental quails, in grams*

Group	A ge, days						
	1–7	8–14	15–21	22–28	29–35	36–42	1–42
Control 1	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
Experimental 2	4.45 ± 0.037**	7.99 ± 0.035***	8.24 ± 0.190	8.02 ± 0.083***	6.06 ± 0.175*	6.38 ± 0.110	6.85 ± 0.098*
Experimental 3	4.49 ± 0.037***	8.06 ± 0.028***	8.34 ± 0.185	8.12 ± 0.101***	6.18 ± 0.185**	6.51 ± 0.128*	6.94 ± 0.101**
Experimental 4	4.53 ± 0.035***	8.08 ± 0.028***	8.33 ± 0.195	8.12 ± 0.099***	6.26 ± 0.144***	6.55 ± 0.203*	6.97 ± 0.110**

Note: *P < 0.05, **P < 0.01, ***P < 0.001 compared to control group 1
Source: developed by the authors

The next age period (8-14 days) was characterised by an increase in the advantage of poultry from experimental groups over the control group for average daily weight gain in physical terms. A reduction in the disparity between the animals in experimental groups 3 and 4 was observed. During that week, the quails in experimental group 2 outperformed the control birds by 0.29 g, or 3.77%. However, the indicators of animals of experimental group 3 were higher than the control ones by 0.36 g or 4.68%, and experimental group 4 – by 0.38 g or 4.94%. All the recorded difference was significant.

At the age of 15-21 days, quails of experimental groups 3 and 4 had almost the same average daily gains, which, respectively, were 0.47 and 0.46 g or 5.97 and 5.84% higher than the control indicators. This difference was not statistically significant. There was also no significant difference between the control and animals of experimental group 2 – 0.37 g or 4.70% in favour of the latter. The age period of 22-28 days was characterised by a decrease in the average daily weight gain in animals of all groups due to changes in mixed feed. During this time, quails in experimental groups 3 and 4 displayed identical metrics, surpassing the control group by 0.51 g, or 6.70%. During this period, poultry in experimental group 2 outperformed the control group by 0.41 g, which is equivalent to a 5.39% increase. The difference in this indicator at the age of 22-28 days was statistically significant.

During the penultimate week of rearing, which coincided with the age period of 29-35 days, the average daily weight gain in quails from experimental groups significantly decreased compared to previous periods. Poultry of experimental group 4 outperformed the control group according to this indicator by 0.68 g or 12.19%. The advantage of quails in experimental group 3 was somewhat less, at 0.60 g, representing an increase of 10.75%. Animals of experimental group 2 prevailed the least – by 0.48 g or 8.60%. All the differences between the experimental and control animals were statistically significant.

The last week of poultry rearing was characterised by an increase in daily body weight gain in animals of all groups, which is physiological at this time for quails of meat

productivity. Poultry of experimental group 2 outnumbered control analogues by 0.35 g or 5.80%. It is important to highlight that this difference was not statistically significant, unlike the differences observed between the animals in experimental groups 3 and 4 compared to the control group, which were 0.48 g or 7.96% and 0.52 g or 8.62%, respectively.

An analysis of daily weight changes in quails throughout the entire rearing period revealed that the highest measurements were recorded in the animals from experimental group 4, which surpassed the control group by 0.46 g or 7.07%. Experimental group 3 showed a slightly lower advantage over the control group, with an increase of 0.43 g or 6.61%. Animals of experimental group 2 prevailed the least – by 0.34 g or 5.22%. All the difference is statistically significant. A key economic metric is the total feed intake of the experimental birds, as well as the quantity of mixed feed consumed per unit of body weight gain (Table 3).

Table 3. *Indicators of feed consumption*

Group	Age, days						
	1-7	8-14	15-21	22-28	29-35	36-42	1-42
	Mixed feed consumption, g/animal/day						
Control 1	3.95	12.07	19.22	25.24	34.03	31.97	21.17
Experimental 2	4.18	12.55	19.65	25.89	34.71	32.47	21.68
Experimental 3	4.42	12.95	19.96	26.28	35.17	32.88	22.12
Experimental 4	4.36	12.84	19.91	26.23	35.24	32.86	22.05
	Feed consumption per unit of body weight gain, g/g						
Control 1	1.315	1.694	2.277	3.315	4.035	10.090	3.788
Experimental 2	1.322	1.692	2.230	3.228	3.892	9.217	3.597
Experimental 3	1.378	1.730	2.240	3.237	3.890	9.011	3.581
Experimental 4	1.343	1.710	2.236	3.232	3.864	8.759	3.524

Source: developed by the authors

The table shows that during the first week of life, the birds in the experimental groups had a higher feed consumption of the mixed feed compared to the control group. Thus, the advantage in terms of the amount of feed consumed during this period was for quails of experimental group2 – 0.23 g/animal/day or 5.82%, experimental group 3 – 0.47 g/animal/day or 11.90%, and experimental group4 – 0.41 g/animal/day or 10.38%. During the age period of 7-14 days, poultry of all groups increased their feed intake compared to the previous period. As before, quails of the experimental groups dominated the control indicators for feed consumption. Animals of experimental group 3 consumed the most compound feed at this time – 0.88 g/animal/day or 7.29% more than their control analogues. The advantage of quails of experimental group 4 was slightly lower – 0.77 g/animal/day, or 6.38%. Quail of experimental group 2 prevailed least over the control analogues – 0.48 g/animal/day or 3.98%.

The third week of life of experimental quails was characterised by a further increase in the amount of daily consumption of mixed feed. The leading positions in terms of the amount of feed consumed continued to be held by the birds of experimental group 3, ahead of the control analogues by 0.74 g/animal/day or 3.85%. The birds in experimental group 4 outperformed the control group by 0.69 g per animal per day, or 3.59%, while those in experimental group 2 exceeded the control by 0.43 g per animal per day, or 2.24%.During the fourth week of the scientific and economic experiment, the bird further increased the amount of feed consumed, despite the fact that during this period there was a change in mixed feed recipes. Animals of experimental group 3 were consistently in the lead in terms of the amount of feed

consumed, surpassing the control by 1.04 g/animal/day or 4.12%. In addition, the animals of experimental group 2 were the least likely to exceed the control indicator – by 0.65 g/animal/day, or 2.58%. During this period, quails in experimental group 3 surpassed the control group by 0.99 g per animal per day, which is equivalent to 3.92%.

During the penultimate week of rearing, poultry of all groups consumed even more mixed feed. As in the course of previous age periods, quails of experimental group 2 differed least from the control – 0.68 g/animal/day or 2.00% in favour of the latter. Quails of experimental groups 3 and 4 outnumbered control animals, respectively, by 1.14 g/animal/day or 3.35% and 1.21 g/animal/day or 3.56%. During the last week of the scientific and economic experiment, the advantage of animals from experimental groups 2, 3, and 4 over the control in terms of the amount of feed consumed per day was 0.50 g, 0.91 g, and 0.89 g, respectively, or 1.56%, 2.85%, and 2.78%. Analysing the results of quail feed consumption during the entire scientific and economic experiment, it can be argued that this indicator was highest in poultry of experimental group 3 – 0.95 g/animal/day or 4.49% more than the control. The advantage of poultry in experimental group 4 over the control group was slightly lower at 0.88 g per animal per day, or 4.16%. Meanwhile, the smallest advantage was observed in experimental group 2, where the animals consumed 0.51 g or 2.41% more feed per day than the controls.

During the first week of life, the poultry of the control group spent the least feed on body weight gain, less than the animals of experimental group 2 by 0.007 g or 0.53%; less than experimental group 3 – by 0.063 g or 4.79%; and less than experimental group 4 – by 0.028 g or 2.13%. Analysis of feed costs per unit of quail body weight gain during the second week of life showed a slightly different pattern. The lowest feed consumption per unit of body weight gain was in quails of experimental group 2 – 0.002 g or 0.12% less than the control indicator. Animals of experimental groups 3 and 4, on the contrary, exceeded the analogues of control group, respectively, by 0.036 g or 2.13% and 0.016 g or 0.94%.

During the third week of the scientific and economic experiment, the animals of the control group took the leading positions in terms of the amount of feed spent per unit of body weight gain, surpassing quails of experimental groups 2, 3, and 4, respectively, by 0.047 g or 2.06%, 0.037 g or 1.63%, and 0.041 g or 1.80%. At the 4t^{h} week of life, the leadership of the animals of the control group 1 in terms of the amount of feed consumed per body weight gain was maintained. Quails of experimental group 2 during this period consumed the least feed – by 0.087 g or 2.62%. Poultry of experimental groups 3 and 4 showed very similar indicators during this period, losing to the control group, respectively, by 0.078 g or 2.35% and 0.083 g or 2.50%. During the 5th week of poultry rearing, the highest feed costs per unit of body weight gain were in animals of the control group, and the lowest – analogues of experimental group 4. During this period, experimental group 2 was inferior to the control group according to this indicator, respectively, by 0.143 g or 3.54%, experimental group 3 – by 0.145 g or 3.59%, experimental group 4 – by 0.171 g or 4.24%.

In the final week of poultry rearing, the control group demonstrated a distinct advantage in terms of feed efficiency for body weight gain. Conversely, among the experimental groups, the amounts of feed consumed were inversely related to the proportion of oil included in their diet.

Thus, the quails of experimental group 4 differed the most from the control – they were inferior by 1.331 g or 13.19%. Animals of experimental group 3 were 1.079 g or 10.69% inferior to the control group according to this indicator. Poultry of experimental group 2 spent 0.873 g or 8.65% less feed on body weight gain than their control counterparts. For the entire peri-

od of quail rearing from the 1st to the 42nd day inclusive, representatives of the control group spent the most feed per unit of body weight gain, and analogues of experimental group 4 spent the least. The poultry of experimental group 2 spent 0.191 g or 5.04% less feed per increase during the experiment period than the control analogues. Animals of experimental group 3 were 0.207 g or 5.46% behind the control group, and 0.264 g or 6.97% behind experimental group 4.

The main products of meat poultry are meat and other edible parts of the carcass. Consequently, a scientific and economic experiment was conducted to evaluate the effectiveness of varying levels of fennel oil in quail feeding, which included an analysis of the indicators from the control slaughter (Table 4).

Table 4. *Slaughter indicators of quails*

Indicator	Group			
	control	experimental		
	1	2	3	4
Pre-slaughter body weight, g	284.6 ± 1.72	298.3 ± 1.18**	302.3 ± 1.06***	303.0 ± 1.32***
Weight of uneviscerated carcass, g	249.1 ± 2.09	262.1 ± 1.65**	266.2 ± 1.38**	267.3 ± 1.60**
Weight of semi-eviscerated carcass, g	230.5 ± 1.95	242.0 ± 1.52**	245.7 ± 1.35**	246.4 ± 1.50**
Weight of eviscerated carcass, g	210.0 ± 1.97	220.6 ± 1.66*	224.0 ± 1.47**	224.9 ± 1.70**
Output of semi-eviscerated carcass, %	81.0 ± 0.20	81.1 ± 0.20	81.3 ± 0.18	81.3 ± 0.15
Output of eviscerated carcass, %	73.8 ± 0.25	74.0 ± 0.27	74.1 ± 0.25	74.2 ± 0.25
Breast muscles, g	47.9 ± 0.68	50.4 ± 0.69	51.4 ± 0.55*	51.8 ± 0.67*
Leg muscles, g	29.4 ± 0.27	30.5 ± 0.83	30.9 ± 0.46	31.3 ± 0.48*
Skin, g	17.9 ± 0.28	18.6 ± 0.27	18.9 ± 0.30	19.2 ± 0.15*
Internal fat, g	2.2 ± 0.11	2.4 ± 0.07	2.5 ± 0.11	2.5 ± 0.15
Liver, g	6.8 ± 0.09	7.1 ± 0.11	7.2 ± 0.08*	7.3 ± 0.08*
Lungs, g	2.5 ± 0.06	2.6 ± 0.12	2.7 ± 0.09	2.7 ± 0.08
Kidneys, g	1.5 ± 0.05	1.6 ± 0.07	1.7 ± 0.09	1.7 ± 0.13
Gizzard stomach, g	5.2 ± 0.09	5.8 ± 0.12*	5.8 ± 0.14*	6.0 ± 0.12**
Heart, g	2.2 ± 0.05	2.4 ± 0.11	2.5 ± 0.29	2.5 ± 0.17

Note: *P < 0.05, **P < 0.01, ***P < 0.001 compared to control group 1
Source: developed by the authors

For the control slaughter, birds were selected with a body weight that corresponded to the group average. The sex of quails was also considered, since there is a fundamental difference between males and females. That is why the pre-slaughter body weight of the bird of experimental group 2 was 13.7 g or 4.81% higher than that of the control group. Representatives of experimental group 3 also dominated the control – by 17.7 g or 6.23%. This indicator was highest in poultry of experimental group 4 – by 18.4 g or 6.47%. The difference between the control group and all study groups in terms of pre-slaughter body weight was statistically significant. The weight of an uneviscerated carcass, that is, already without plumage and blood, but before the removal of internal organs and the separation of certain parts of the body, was predicted to be directly related to the pre-slaughter body weight of quail. Therefore, the poultry from experimental groups 2, 3, and 4 in this indicator was larger than the control analogues, respectively, by 13.0 g, 17.1 g, and 18.2 g, which in percentage terms is 5.22%,

6.86%, and 7.31%, respectively. Such a difference was statistically significant.

According to the weight of the semi-eviscerated carcass (without plumage, blood, intestines, ovary, and oviduct), similar to the two previous indicators, quails of experimental group 4 had the highest result, surpassing the control by 15.9 g or 6.90%. A slightly smaller advantage was the poultry of experimental group 3 – 15.2 g or 6.59%. Animals of experimental group 2 prevailed the least – by 11.5 g or 4.99%. The statistical probability of this difference was also confirmed during calculations. The weight of the eviscerated carcass, namely without plumage, blood, all internal organs, head and neck, legs on the ankles, was also the largest in the bird of experimental group 4 – 14.9 g or 7.10% more than the control. A similar result, namely an advantage over the control group by 14 g or 6.67%, was demonstrated by quails of experimental group 3. By 10.6 g or 5.05% exceeded the control analogues by weight of the eviscerated carcass of the animal of experimental group 2. The difference between the experimental animal groups and the control group was statistically significant.

Quails of experimental groups 3 and 4 had the same yield indicators of semi-eviscerated carcass, in which they outnumbered their control counterparts by 0.3 %. The advantage of poultry of experimental group 2 over the control for this indicator was 0.1%. The yield of eviscerated carcass in quails of groups 3 and 4 was different, and the advantage of animals of these groups over the control was 0.3% and 0.4%, respectively. The yield of eviscerated carcass in poultry of experimental group 2 was 0.2% higher than the control indicator. The most desirable product that is obtained by raising young quails is meat, namely the muscle tissue of the breast and legs. The breast muscles of quails of experimental group 2 were heavier than the same indicator of animals of the control group by 2.5 g or 5.22%. The advantage of poultry in experimental group 3 over the control group was 3.5 g or 7.31%, and in experimental group 4 – 3.9 g or 8.14%. The difference between the control animals and representatives of experimental groups 3 and 4 was statistically significant.

In terms of muscle weight of the lower extremities (femoral), quails of experimental group 4 also occupied the leading positions, surpassing the control by 1.9 g or 6.46%. According to this indicator, only the difference between the analogues of the control and experimental group 4 was statistically significant. Quails in experimental group 3 had an advantage of 1.5 g or 5.10% compared to the control group. According to this indicator, the control was least exceeded by poultry of experimental group 2 – by 1.1 g or 3.74%. It is logical to increase the skin weight in the animals of the experimental groups, since these quails were larger in size. Therefore, the advantage of poultry of experimental group 2 in the control group was 0.7 g or 3.91%, experimental group 3 – 1.0 g or 5.59%, experimental group 4 – 1.3 g or 7.26%. It is worth noting that according to this indicator, the difference between the control and animals of experimental group 4 was statistically significant.

Similar to previous indicators, with an increase in body weight and the concentration of fennel oil in mixed feed, the mass of internal fat in the body of birds also increased. Thus, quails of experimental group 2 according to this indicator surpassed the control group by 0.2 g or 9.09%, experimental groups 3 and 4 – by 0.3 g or 13.64%. Statistically significant is the difference between animals of experimental groups 3 and 4 and controls, by liver weight. It was, respectively, 0.4 g or 5.88% and 0.5 g or 7.35% in favour of the latter. Quails of experimental group 2 also dominated the control for this indicator, but only by 0.2 g or 4.41%. By lung weight, animals of experimental groups 3 and 4 also showed the same results, which were higher than the control indicator by 0.2 g or 8.00%. A slightly smaller advantage was the poultry of experimental group 2 over the control – 0.1 g or

4.00%. The kidney weight was also the same in poultry of experimental groups 3 and 4 – 0.2 g or 13.33% more than the control indicator. However, the advantage of quails of experimental group 2 was 0.1 g or 6.67%.

Quails of experimental groups 3 and 4 also had a common heart weight index, which exceeded the control by 0.3 g or 13.64%. The advantage of poultry of experimental group 2 over the control group was slightly less – 0.2 g or 9.09%. The gizzard stomachs of birds of experimental groups 2 and 3 had the same weight, exceeding the control by 0.6 g or 11.54%. According to this indicator, quails of experimental group 4 outperformed control analogues by 0.8 g or 15.38%. It is worth noting that the difference in weight of the gizzard stomach between the control and experimental groups of poultry was statistically significant. Thus, feeding meat quails with feed containing 0.1-0.3% fennel oil had a positive effect on their growth and slaughter indicators. This effect can be explained by the antioxidant and antimicrobial effects of fennel essential oil (Anwar *et al*., 2009; Brenes & Roura, 2010; Saki *et al*., 2014).

The research results demonstrated the beneficial impact of diets with varying levels of fennel oil (*Foeniculum vulgare*) on the average daily weight gain, slaughter quality, and feed costs per unit of production in young quail raised for meat. Throughout the entire growth period, the birds in the experimental groups showed an average daily weight gain that exceeded that of the control group by 5.22% to 7.07%. The highest average daily weight gain was observed in the poultry from experimental group 4, which received a complete mixed feed formulation containing 0.3% fennel oil.

Recently, phytogenic substances, which are biologically active compounds, have garnered increasing interest as feed additives, particularly in poultry farming. This is due to their ability to enhance feed efficiency by promoting digestive secretions and improving nutrient absorption, while also reducing pathogenic load in the intestines and alleviating the immune burden on animals (Adbelli *et al*., 2021). Literature provides evidence for the use of fennel (*Foeniculum*) feed additives as phytogenic supplements in poultry diets. Among these, fennel oil stands out as one of several phytobiotics that warrants further scientific investigation.

After analysing a significant number of scientific papers in their review, M. Kumar *et al*. (2014) noted that phytobiotics improve digestibility, exhibit antimicrobial, anti-inflammatory, antioxidant, and immunostimulating activity. They are desirable not only in feeding animals, but also in feeding people. The findings are consistent with the data on the positive effect of introducing fennel oil into the poultry diet by other researchers.

Thus, a group of researchers led by R.U. Khan *et al.* (2022) presented a number of research papers that showed an increase in productivity, feed consumption, and a decrease in conversion for the consumption of fennel oil in mixed feeds for broiler chickens, laying hens, and quails of various productivity areas. In particular, the results of experiment by H.R. Gharehsheikhlou *et al.* (2018) showed that adding 0.15 and 0.25 g/kg of fennel oil to broiler chicken feed has a positive effect on growth rates. The highest increase in this case was achieved by animals whose diet contained 0.25 g/kg of fennel oil. Their average daily weight gain was 11.07% higher than the control, while with a dose of 1.5% fennel oil in the diet, quail weight gain increased by only 1.63%, which is consistent with the results of the present study. Similar data were obtained during the experiment on turkeys conducted by O.S. Yacoub *et al*. (2016). The positive effect of introducing 0.2 and 0.5 g of fennel oil to 1 kg of turkey diet was found, which contributed to an increase in body weight and average daily weight gain of experimental poultry. Whereas, S.S. Cengiz *et al.* (2016) found that feeding fennel oil in the amount of 0.1 g/kg did not affect the productivity and slaughter indicators of broiler chickens.

Instead, A.R. Ghiasvand *et al.* (2021) obtained the opposite result. The researchers found that when 0.2 g/kg of fennel oil was introduced into mixed feed, a negative dynamics of changes in the body weight of broiler chickens was noted.

Feeding quails mixed feeds with different levels of fennel oil was conditioned by the fact that during the experiment period, the poultry of the experimental groups consumed more feed than the analogues of the control group by 2.41-4.49%. However, feed costs per kilogramme of body weight gain were less than the control by 5.04-6.97%. This is due to its antibacterial and antifungal properties, which ultimately result in a reduction of pathogenic microbes in the digestive system, along with enhanced immunity and productivity in chickens. The reduction in feed consumption per unit of production is influenced by the specific types of phytobiotics incorporated into the poultry diet. Feeding young quails diets with different levels of fennel oil resulted in an increase in liver weight by 4.41-7.35%, heart weight by 9.09-13.4%, and kidney weight – 6.67-13.33%. This is consistent with the results of H.R. Gharehsheikhlou *et al.* (2018), who report that feeding broiler chickens fennel oil *(Foeniculum vulgare)* in the amount of 0.15 and 0.25 g/kg contributed to an increase in the weight of internal organs. Thus, the heart weight was 0.17% higher than the control at the doses of 0.15 g/kg and 5.97% at the doses of 0.25 g/kg of fennel oil. The increase in kidney weight was 3.38% and 11.86%, respectively.

A number of studies have been conducted using fennel seeds. Thus, according to A.M. Henda (2014), among the studied doses of fennel seeds (0.25, 0.50, or 0.75 g/kg of feed), 0.5 g/kg was the most optimal. However, all concentrations of phytobiotic had a positive effect on the productive qualities of quails under 42 days of age, and it was proved that fennel seeds increase hunger, stimulate endogenous digestive enzymes, and cause an immunological response. In the course of experiments by Indian researchers K. Premavalli & A.V. Omprakash (2020), a positive effect on the productivity of young quails at 0.5, 1.0, and 1.5% of fennel seeds in mixed feed was confirmed. The most optimal doses were 1.0 and 1.5% of quails that consumed mixed feed with such a content were 4.4-5.1% superior to control analogues by live weight.

Improvements in the growth rates of broiler chickens were recorded by other Indian researchers L. Saleh *et al.* (2018), feeding poultry 0.5, 1.0, and 1.5% fennel seeds in mixed feed. The positive effect of including fennel seeds in the amount of 1, 2, and 3 g/kg of mixed feed of broiler chickens was noted by A. Mohammed & R.G. Abbas (2009). The results of their experiments recorded a significant improvement in the body weight of broilers. Significant differences in the weight of the gizzard stomach and pancreas were noted. Among Ukrainian researchers, a large effort to study the effectiveness of phytobiotics in quail feeding was carried out by R.A. Chudak *et al.* (2020). According to the results of experiments, a positive effect of pale purple coneflower supplements on the productivity of quails in various areas of productivity was noted. When using this feed additive, quail body weight gains increased in the range of 14.3-23.1%, and feed conversion decreased by 9.7-14.9%. The breast muscles mass of quails that consumed mixed feed with an optimal level of feed additive was 23.3% higher than the control. The weight of the muscles of the lower extremities exceeded the control indicator by 15.4%. It is worth paying attention to the weight of the gizzard stomach, which was 17.0% higher than the control, the liver, whose weight was 15.3% higher than the control indicator, the kidneys, whose weight was 27.2% higher than the control analogues, and the heart, which exceeded the control by 19.0%.

Therefore, the effectiveness of using phytobiotics as feed additives in animal and poultry diets is influenced by the specific type and form of the additive. This makes the investigation of their impact on the productive traits of animal groups or species especially relevant

today, given the heightened demands for the quality of end products. The results obtained align well with findings from other researchers and demonstrate the beneficial effects of fennel oil *(Foeniculum vulgare*) at concentrations of 0.1%, 0.2%, and 0.3% on the meat productivity of quails, leading to improvements in both quantitative and qualitative product indicators, as well as a reduction in feed conversion rates.

Conclusions

The experiment concluded that incorporating compound feed with fennel oil into the diet of young quail aimed at meat production positively impacts their meat productivity, yield of the finished product, and feed efficiency. Experimentally, it was found that the optimal level of fennel oil in mixed feed of young quails under the age of 42 days is 0.3%. However, the results obtained for the introduction of 0.2 and 0.1% fennel oil in the composition of mixed feeds of young quails also indicate a positive effect on poultry productivity compared to the control group. At the concentration of 0.3% fennel oil in the diet of young quails, an increase in the average daily weight gain of 0.46 g or 7.07% ($p < 0.01$), the yield of eviscerated carcass – by 0.4%, the weight of breast muscles – by 3.9 g or 8.14% ($p < 0.05$), the muscle weight of the lower extremities – by 1.9 g or 6.46% ($P < 0.05$), the liver weight – by 0.5 g or 7.35% ($p < 0.05$), and weight of the gizzard stomach – by 0.8 g or 15.38% ($p < 0.01$) compared to the indicators of control animals whose mixed feed did not contain the feed additive under study. There was a decrease in feed costs for body weight gain by 0.264 g or 6.97% compared to the control. An increase in poultry productivity and a reduction in feed costs per unit of body weight gain were achieved due to the antimicrobial, anti-inflammatory, antioxidant, and immunostimulating effects of fennel oil. Thus, given the positive effect of fennel oil on the growth and productivity of young meat quails, it would be appropriate to conduct further research on the influence of fennel oil and other feed additives on the productivity and quality of the resulting products of animals and poultry of other species and groups.

Acknowledgements

None.

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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Продуктивні якості молодняку перепелів за використання олії фенхелю (*Foeniculum vulgare*) у складі комбікормів

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Анотація. У зв'язку з виникненням антибіотикорезистентності мікроорганізмів актуальними є дослідження ефективності використання фітобіотиків у годівлі сільськогосподарської птиці. Метою досліджень було встановлення оптимальної дози олії фенхелю (Foeniculum vulgare) у годівлі перепелів м'ясного напряму продуктивності. Для проведення дослідження було сформовано 4 групи перепелів добового віку по 100 голів у кожній. Перша група споживала базовий комбікорм і тому була контрольною. У комбікормі 2-ї дослідної групи 0,1 % рослинної олії замінили на олію фенхелю, 3-ї та 4-ї дослідних груп – відповідно, 0,2 та 0,3 %. Середньодобові прирости за період вирощування були найбільшими у 4-ї дослідної групи – на 0,46 г або 7,07 % більше контролю. Перевага над контролем перепелів 3-ї дослідної групи становила 0,43 г або 6,61 %, а 2-ї дослідної групи – 0,34 г або 5,22 %. Протягом досліду птиця дослідних груп спожила більше корму, ніж аналоги контрольної групи на 2,41-4,49 %. Проте, витрати корму на кілограм приросту маси тіла були меншими за контроль на 5,04-6,97 %. Відмічено перевагу перепелів 2-ї дослідної групи над контрольної за масою грудних м'язів на 2,5 г або 5,22 %, м'язів лап – на 1,1 г або 3,74 %. Птиця 3-ї дослідної групи випереджала контроль за масою грудних м'язів на 3,5 г або 7,31 %, м'язів лап – на 1,5 г або 5,10 %. Перепели 4-ї дослідної групи за масою грудних м'язів переважали контрольних аналогів на 3,9 г або 8,14 %, за масою м'язів лап – на 1,9 г або 6,46 %. Таким чином, уведення до складу комбікорму перепелів м'ясного напряму продуктивності олії фенхелю у дозі 0,1-0,3 % дозволяє покращити ріст та досягнення кращих показників продуктивності

Ключові слова: фітобіотики; ефірні олії; м'ясне птахівництво; забійні якості; продуктивність; приріст маси тіла