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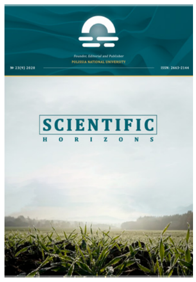

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Dynamics of Some Mineral Elements Content in the Muscle, Bone and Liver of Quails under the Apimin Influence

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Abstract. In the system of full-fledged poultry feeding, particular importance is attached to providing them with mineral substances. The purpose of this study was to determine the effect of the Apimin mineral additive based on bee podmore on the content of zinc, copper, magnesium, and iron in the meat, liver, and bone tissue of quails. During the study, the following methods were used: zootechnical (to analyse the productivity of quails), physiological (to determine the digestibility of nutrients in the poultry diet), biochemical (to analyse the content of minerals in muscles, liver, and tubular bones), morphological (to determine the meat qualities of quails: mass of edible parts, meat carcasses), statistical (to determine the presence or absence of a substantial difference between the values). Justification of the effectiveness of feeding the Apimin additive was carried out based on a comprehensive study on the chemical composition of Apimin, retention of minerals, meat indicators, dynamics of zinc, copper, iron, magnesium content in muscle, bone, and liver tissues of quail. The research was conducted on Pharaoh meat quail from 1 to 56 days of age and quails from 60 to 120 days. Apimin contains calcium, magnesium, iron, zinc, manganese, phosphorus, silicon, and selenium. Feeding Apimin increases metabolism, the digestibility of copper was higher by 21.7%, zinc – by 5.9%, iron – by 8.9%, and magnesium – by 12.9%. Including the additive in the diet influenced increasing muscle mass, the ratio of pulp to bone was higher by 0.26. The content of zinc in pectoral muscles increased by 15.6%, in femoral and lower leg muscles by 2.6%, in the liver – by 5.3%; in pectoral muscles iron increased by 5.1%, in liver– by 13.1%. The copper content was 8.0% higher in the thigh and lower leg muscles, 3.2% higher in the liver, and 14.0% higher in the pectoral muscles. No effect of Apimin on magnesium content was found. With age, the content of ash in the bones of quail fed with Apimin decreased by 3.87%, the content of copper increased by 18.3%, and zinc by 27.6%

Keywords: young quails, trace elements, mineral additive, meat qualities, mineral compositioncarcasses, growth, mass

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INTRODUCTION

Poultry farming is one of the most profitable production sectors in the world. Its main task is to increase the production of meat and eggs. Livestock breeders and consumers are interested in food products that contain plenty of wholesome bioactive components. In recent decades, a promising branch of poultry farming – quail farming – has been successfully developing. Quails have several advantages over other poultry species, one of which is that their growth rate is considerably higher than that of chickens (Khvostik & Bondarenko, 2021; Shelton & Southern, 2006). Therefore, to ensure this biological characteristic, they must be provided with nutritious food, and quite high requirements are imposed on poultry diets.

In Ukraine, poultry farmers breed quails of specialised egg and meat breeds. In terms of the efficiency of using feed in meat production, quails of meat breeds are not inferior to broilers. In the production of poultry products, safety and quality are important. Poultry meat is characterised by high nutritional, dietary, culinary, and technological value (Orkusz, 2015). Quail meat is a source of complete animal protein, low in fat and cholesterol (Moawad *et al.,* 2018). Quail meat is considered a valuable source of protein due to its good amino acid composition (Genchev *et al.,* 2008). Poultry meat contains an increased amount of polyunsaturated fatty acids, and it is more nutritious than chicken meat due to the content of various vitamins (B, A, E) (Khalifa *et al.,* 2016). Various minerals have also been found in quail meat, including calcium, phosphorus, sodium, potassium, magnesium, iron, copper, and zinc (Genchev *et al.,* 2008; Cullere *et al.,* 2018). In sufficient quantities, these minerals contribute to the formation of the skeletal system and animal health, given that various elements are involved in metabolism and maintaining the body's acid-base balance (Ravindran, 2014). Quail meat is also characterised by aroma and taste, it is tender and juicy (Genchev *et al.,* 2008).

Feeding is a vital component of livestock production technology, which provides animals and poultry with energy, nutrients, and biologically active components (Skoromna *et al.,* 2019). The availability of full-fledged feed, balanced in all nutritional indicators, largely determines the level of development of poultry farming. Among the main factors of nutrition, trace elements play a vital role, which take part in all physiological processes and are considered indispensable substances (Lemesheva & Yurchenko, 2016). Partial mineral deficiency causes particularly great losses to poultry farming, and the optimal content of trace elements in the diet ensures the normal state of poultry health, safety, and high productivity (Kyryliv *et al.,* 2017; Gutyj *et al.,* 2019). During the growth and development of birds, the content of mineral elements in their body increases, the mineralisation of skeletal bones increases, and the need for macro- and microelements increases (Shelton & Southern, 2006; Dozier *et al.,* 2003). Recently, animal husbandry has begun to use a variety of feed additives to enrich the diets of animals with mineral elements, which should enter their bodies in optimal quantities and proportions (Chudak *et al.,* 2019; 2020; Poberezhets *et al.,* 2021). They regulate the body's metabolism, provide optimal conditions for the activity of digestive enzymes in various parts of the gastrointestinal tract, and contribute to improving productivity and product quality (Yefimov & Masiuk, 2016; Nys *et al.,* 2018; Vargas-Sánchez *et al.,* 2019). Trace elements such as copper, iron, zinc, and manganese are essential for poultry growth and are involved in many digestive, physiological, and biosynthetic processes in the body (Milanović, 2008; Sunder, 2008). additiveation of the basic diet of broilers with trace elements affects the colour and moisture retention of the pectoral and thigh muscles (Yang *et al.,* 2011).

Given the above, there is a constant need to search for new feed additives. In many countries, numerous non-conventional feeds with low biological usefulness and nutritional value are used for feeding poultry. Non-conventional feed additives of natural origin are of considerable interest to scientists and practitioners. The use of feed additives from non-conventional plant raw materials in feed increases the slaughter weight of broiler chickens, provides an increase in the content of zinc, manganese, and iron in muscle and bone tissues (Gunchak *et al.,* 2016). Scientists and practitioners are interested in non-conventional feed additives of natural origin, which are by-products of industry, to replenish feed resources for animals and poultry (Plyska & Ibatullin, 2020; Bittencourt *et al.,* 2019). Among non-conventional feed additives, beekeeping waste is of particular interest, namely bee podmore, which is unique in its biochemical composition (Razanova, 2018). In beekeeping, its reserves are still completely unused. Bee podmore is a source of protein (up to 50%), fat, fibre, vitamins, and mineral elements. It also includes a chitosan-melanin complex, which, due to its radioprotective and sorption properties, can bind and remove toxic substances (Razanova *et al.,* 2018).

Scientists have investigated the beneficial properties of bee podmore on rabbits, gobies, pig breeding, and beekeeping (Razanova *et al.,* 2018; Gevlich *et al.,* 2013). The introduction of preparations and feed additives from the bee podmore contributed to an increase in metabolic processes, animal productivity, an increase in the number of red blood cells, haemoglobin content within the physiological norm, and an increase in the total protein level.

Recently, there has been an increase in poultry meat consumption all over the world. The growing level of demand for meat is affected by the quality of products. The use of various additives in poultry farming contributes not only to increased production of meat products, but also affects their quality, which requires monitoring the safety and quality of meat (Nawaz *et al.,* 2016;

Sałek *et al.,* 2020). Therefore, research on the impact of new additives in poultry feeding on the meat qualities and chemical composition of quail meat is relevant and of practical importance.

The purpose of this study was to investigate the effect of the Apimin mineral additive based on bee podmore on the content of zinc, copper, magnesium, and iron in quail meat and liver.

MATERIALS AND METHODS

When conducting research on quails, international and national biotic provisions on animal experiments were observed – the European Convention for the protection of vertebrates used for research and other scientific purposes of 1986, and the Law of Ukraine No. 3447-IV "On the Protection of Animals from Ill-Treatment".

200 meat quail (Coturnix coturnix Pharaoh) aged 1 day, including males and females, were used for the study. Poultry was divided into 2 groups of 100 heads using the method of balanced groups (Ibatullin *et al.,* 2017). When forming the groups, the age and live weight of the bird were considered. Quail were raised from one day to 56 days of age. For the further influence of the additive under study, at the age of 60 days, 2 groups of quail (25 heads each) were selected, which were raised until the age of 120 days. In the first series of quail studies, the duration of the experiment was 56 days (from 1 to 56 days), in the second – 60 days (from 60 to 120 days). Experimental studies were conducted by using a mineralized additive from bee podmore – Apimin – in feeding quails. Birds of the control group were fed the basic diet. Experimental quail of the second group were added to the diet with the addition of Apimin at a dose of 1.1 g/kg of mixed feed. The additive was thoroughly mixed with compound feed.

The maintenance and care of experimental quails during the experiment were the same. The parameters of the microclimate of the room corresponded to zoohygienic standards adopted for poultry. The quails were fed with a full-fledged compound feed, which was complete in terms of the content of macro- and microelements. The frequency of feeding was twice a day (morning and evening). After the end of the experimental periods, 4 birds from each group were slaughtered according to the methods of T. Polivanova (1988) and A. Genchev *et al.* (2008). Live weight of quail at slaughter, at 56 days of age, averaged 285.0 g in the control group and 297.5 g in the experimental group.

To obtain the Apimin mineralised additive, winter bee podmore was used, which was harvested in the spring in apiaries of the Vinnytsia Oblast. During the conducted research, an innovative method for solving the scientific problem of justification for the use of beekeeping waste to produce feed additives was proposed, which consisted in developing an appropriate technological solution for its production (mineralised additive) and an experimental study of its use in poultry feeding. To obtain the Apimin mineral additive, the bee podmore was first selected, then it was burned in a muffle furnace at 300°C. As a result, the Apimin additive was obtained. The yield of Apimin was 27 g per 100 g of bee podmore.

Apimine, according to the results of its mineral composition, contains macronutrients: calcium, magnesium, phosphorus, silicon, and trace elements – iron, magnesium, selenium, copper, and zinc (Table 1).

***Table 1**. Mineral composition of Apimin*

Indicator	Content	Indicator	Content
Silicon, g/kg	27.705	Iron, g/kg	8.059
Calcium, g/kg	22.164	Magnesium, mg/kg	302.24
Magnesium, g/kg	25.186	Selenium, mg/kg	11.08
Phosphorus, g/kg	47.854	Copper, mg/kg	151.12
Sodium, g/kg	16.623	Zinc, mg/kg	50.37

Apimine contains a considerable amount of silicone, which plays an important role in the absorption of mineral elements such as calcium, phosphorus, magnesium, sulphur, potassium, and sodium.

The research materials were samples of meat, bones, liver, feed, and droppings. Samples of average muscle, bone, and liver tissue were taken during anatomical disassembly of quail carcasses.

In the samples under study, the content of magnesium, copper, zinc, and iron was determined by atomic absorption spectrophotometry (Lebedev & Usovych, 1976).

Biometric processing of the obtained research data was performed using MS Excel software with built-in statistical functions. Conventional symbols are used in the tables to show the level of probability: * – $p<0.05$; ** – $p<0.01$; *** – $p<0.001$.

RESULTS AND DISCUSSION

One of the priority tasks of poultry farming is to increase poultry productivity and expand the range of feed products with the use of mineral additives in feeding. In world practice, a considerable number of studies have been conducted on the use of additives in feeding various poultry species and areas of productivity (Bao *et al.,* 2007; Gutyj *et al.,* 2019; Nys *et al.,* 2018).

Y. Nys et al. (2018) analysed the role of essential trace elements (zinc, copper, iron, manganese, iodine, and selenium) in feeding broilers and laying hens, determined the need for trace elements, bioavailability of trace element sources. The data obtained are consistent with the results of Y. Bao et al. (2007), who investigated the use of copper, zinc, iron, and manganese from organic sources in broiler diets. B. Kyryliv et al. (2017) obtained positive results in increasing the productivity of quail and improving the products obtained by introducing the "Belo-Akt" additive with minerals of copper, manganese, and zinc into the poultry diet. They established that when the supplement was introduced into the diet of quail, the live weight increased by 12.67%, the laying capacity by 7.37%, and the content of mineral elements in the eggs increased. Studies by P. Sałek et al. (2016) confirm the feasibility of introducing organic zinc additives with amino acids into the broiler diet, which improved the quality of the carcass and pectoral muscles. J. Shelton & L. Southern (2006) did not establish the effect of mineral additives on the growth rate of chickens, but the removal of trace element additives from the diet adversely affected the bone strength of poultry. G. Kim et al. (2011) investigated the effect of copper chelate supplementation on productivity, blood parameters, and mineral content in the liver of broiler chickens. They found that the concentration of copper in the liver increased with increasing levels of supplementation of this element. B. Gutyj et al. (2019) found that feeding laying hens with cadmium sulphate contributed to a decrease in the number of red blood cells, haemoglobin levels, and an increase in the number of white blood cells. The use of the Apimin feed additive in the diet of young quail contributed to an increase in their lifetime indicators of meat productivity. The bird of the experimental group grew more intensively and at the end of the experiment the live weight was 277.9 g against 267.2 g in the control group. That is, the advantage in the group of quail that were given the Apimin mineral additive in the diet was 4.0%.

The content of mineral elements in the bird's body depends on the intensity of metabolic processes (Kim *et al.,* 2011; Dozier *et al.,* 2003). Mineral mobilisation depends on the amount of food intake, the level of assimilation and distribution in the body (Bao *et al.,* 2007).

The highest level of assimilation of certain mineral elements was found in quail when feeding the Apimin mineral additive as part of the diet. In quail of this group, the absorption of copper was higher, compared with poultry of the control group, by 21.7%, zinc – by 5.9%, iron – by 8.9% and magnesium – by 12.9% at ($p<0.001$) (Table 2).

The mass of edible parts of quails increased most in the group of quails when they were fed the Apimin mineral additive as part of the diet (Table 3).

***Table 2**. Digestibility of feed trace elements by quails (M±m, n=4)*

Indicator	Group	
	Control	Experimental
Copper	41.9±0.38	67.4±0.54***
Zinc	77.3±0.34	89.9±0.13***
Iron	69.2±1.84	78.1±1.33***
Magnesium	59.5±2.11	72.4±1.27***

***Table 3**. Quail meat qualities (M±m, n=4)*

Indicator	Group	
	Control	Experimental
Output of edible parts, %	58.8±0.60	61.1±0.24*
Including femoral and tibial muscles	9.2±0.13	9.5±0.14
Pectoral muscles	15.1±0.07	16.8±0.23***
Liver	2.01±0.11	2.48±0.1*
Meat content of the carcass, %	61.4±0.28	63.5±0.38
Breast meatiness, %	24.0±0.06	26.6±0.26
Meatiness of the thighs and lower leg, %	14.6±0.19	15.2±0.06

Quail of the experimental group fed with the additive under study according to the results of the slaughter had a higher yield of edible parts of the carcass, namely, by 2.3% ($p<0.05$) compared to the analogues of the control group. Poultry of this group showed higher indicators in building muscle mass. Thus, the output of the femoral and tibial muscles was higher by 0.3%, and the pectoral muscles – by 1.7% ($p<0.001$).

Higher indicators were found in the experimental group of quail in terms of meat content of carcasses by 2.1%, breasts – by 2.6%, thighs and shins – by 0.6%. The most valuable thing in carcasses is muscle tissue. Carcass in which the ratio of muscle tissue to bone is 4–4.5:1 is considered more valuable. According to the results of studies in the experimental group, a slightly higher indicator was obtained – 4.07:1 against 3.81:1 in the control group. That is, the difference between the indicator in the experimental groups was 0.26 in favour of the experimental group.

Minerals mainly accumulate in the muscles and liver (Zakharenko *et al.,* 2004). The liver is the main tissue depot where most minerals accumulate. Therefore, the liver plays an important role in the exchange of bioelements. Through it, mineral elements enter the blood and individual organs and tissues.

Analysis of the mineral content in the muscles and liver of quails showed certain changes in the introduction of Apimin into the diet (Table 4).

Table 4. *Mineral composition of quail muscles and liver (M±m, n=4)*

Group	Trace elements			
	Copper, mg/kg	Zinc, mg/kg	Iron, mg/kg	Magnesium, g/kg
Pectoral muscles				
Control	5.56±0.017	10.95±0.144	24.33±0.687	0.57±0.014
Experimental	4.78±0.020***	12.65±0.104***	25.57±0.444	0.57±0.015
Femoral and tibial muscles				
Control	3.86±0.025	18.03±0.125	21.17±0.147	0.44±0.019
Experimental	4.17±0.020***	18.50±0.129*	21.16±0.155	0.43±0.020
Liver				
Control	8.96±0.091	103.0±0.18	543.1±10.11	54.0±0.08
Experimental	9.25±0.011	108.5±0.19	614.4±1.08	54.2±0.12

Zinc is an essential trace element for all living organisms. This element performs vital functions in the maintenance and development of the skeleton, is a structural component, a catalytic factor of enzymes, and part of vitamins and hormones (Bao *et al.,* 2007; Zakharenko *et al.,* 2004). The zinc content in the pectoral muscles significantly increased in the experimental group by 15.6% (p<0.001), in femoral and tibial muscles – by 2.6% (p<0.05), in the liver – by 5.3%.

Iron is an essential element for oxygen transport, the respiratory chain of mitochondria and cell proliferation, facilitates the survival of young animals and contributes to an increase in live weight (Bao *et al.,* 2007; Milanović *et al.,* 2008). Iron in the pectoral muscles of experimental quails was 5.1% more, and the content of this element in the femoral and lower leg muscles was not affected by feeding Apimin as part of the diet. The liver of quails of the experimental group contained 13.1% more iron (p<0.001). An increase in the content of this element in the liver of the experimental group of poultry indicates a high bioavailability of iron from the Apimin mineral additive.

Copper is involved in haemogenesis and promotes the formation of haemoglobin in the blood, is necessary for the normal development of the skeleton and increases meat productivity (Zakharenko *et al.,* 2004). In the femoral and tibial muscles of the poultry of the experimental group, the copper content was higher by 8.0% (p<0.001), in the liver – by 3.2%, and in the chest muscles, on the contrary, less – by 14.0% at (p<0.001) compared to the control group.

Magnesium is a calcium antagonist and is involved in many processes that occur in the muscles. Feeding quail as part of the diet of the Apimin mineral additive had almost no effect on the magnesium content in the muscles and liver.

Summarising the obtained research results, it is possible to state the positive effect of the Apimin additive based on bee podmore on the mineral composition of pectoral, femoral and lower leg muscles and liver.

According to the degree of metabolism in the skeleton of the bird's limbs, mineral metabolism can be traced both in the bones themselves and in the body as a whole. The bone tissue of tubular bones reacts to changes in the mineral composition of poultry diets (Pasnichenko, 2017).

In the group of quails that were fed the Apimin mineral additive as part of the diet, a higher yield of tubular bone ash was found (Table 5).

Table 5. *Dynamics of zinc and copper content in quail tubular bones*

Indicator	Poultry age					
	60 days			120 days		
	ash, %	Copper, mg/kg	Zinc, mg/kg	ash, %	Copper, mg/kg	Zinc, mg/kg
Control	43.73±0.15	1.38±0.036	23.50±0.255	39.49±0.175	1.64±0.031	25.05±0.222
Experimental	46.55±0.14***	1.53±0.019**	23.78±0.293	42.68±0.20	1.81±0.02	30.35±0.171

Thus, in the bones of quail of the experimental group at the age of 60 days, ash was 2.82% more, at the age of 120 days – by 3.19%, compared to the control group. The ash content decreased with age in quail of the control group by 4.24%, in the experimental group – by 3.87%.

Copper and zinc also play a significant role in bone development. Zinc is involved in the renewal of bones and cartilage. Zinc and copper provide the strength of collagen. Copper is essential for the formation and functioning of elastin (Zakharenko *et al.,* 2004; Shelton & Southern, 2006).

Analysis of the content of copper and zinc in tubular bones shows that the introduction of Apimin into the poultry diet has a positive effect. Therewith, the copper content in the experimental group of quails of 60 days of age increased by 10.8%, 120 days of age – by 10.4% compared to the control group. With age, the amount of copper in the bones increased in the control group by 18.8%, the experimental group – by 18.3%.

There were also changes in the zinc content both with age and with the action of the mineral additive. Thus, zinc in the bones of quails of the experimental group aged 60 and 120 days was higher by 1.2% and 21.1%, respectively. In laying hens, the concentration of zinc increases during egg-laying: in the control group by 6.6%, in the experimental group – by 27.6%.

CONCLUSIONS

Studies have shown that the use of a mineral additive based on bee podmore (Apimin) increases the body's absorption of copper by 21.7%, zinc – by 5.9%, iron – by 8.9% and magnesium – by 12.9%.

Feeding young quail as part of the Apimin diet increased their live weight by 4.0%, meat content of carcasses – by 2.1%, breasts – by 2.6%, thighs and shins – by 0.6%, the ratio of pulp and bones – by 0.26.

The ash content of the pectoral muscles in the experimental group of quails increased with a higher content of some biogenic elements: zinc – by 15.6%, iron – by 5.1%, and copper – less by 14.0%, femoral and tibial muscles: zinc – by 2.6%, copper – by 8.0%, liver: zinc – by 5.3%, iron – by 13.1%, copper– by 3.2%. The additive had no effect on the magnesium content in the muscles and liver. With age, the amount of copper in quail bones increased in the control group – by 18.8%, the experimental group – by 18.3%, and zinc – by 6.6% and 27.6%, respectively.

REFERENCES

[1] Bao, Y.M., Choct, M., Iji, P.A., & Bruerton, K. (2007). Effect of organically complexed copper, iron, manganese, and zinc on broiler performance, mineral excretion, and accumulation in tissues. *Journal of Applied Poultry Research*, 8, 448-455. doi: 10.1093/japr/16.3.448.

[2] Bittencourt, T.M., D'Avila, Lima, H.J., Valentim, J.K, da Silva Martins, A.C., Moraleco, D.D., & Vaccaro, B.C. (2019). Distillers dried grains with solubles from corn in diet of Japanese quails. *Acta Scientiarum Animal Sciences*, 41(1). doi: 10.4025/actascianimsci.v41i1.42749.

[3] Chudak, R.A., Poberezhets, Y.M., Vozniuk, O.I., & Dobronetska, V.O. (2019). Echinacea pallida extract effect on quils meat quality. *Ukrainian Journal of Ecology*, 2(9), 151-155.

[4] Chudak, R.A., Ushakov, V.M., Poberezhets, Y.M., Lotka, H.I., Polishchuk, T.V., & Kazmiruk, L.V. (2020). Effect of Echinacea pallida supplementation on the amino acid and fatty acid composition of Pharaoh Quail meat. *Ukrainian Journal of Ecology*, 10(2), 302-307. doi: 10.15421/2020_101.

[5] Cullere, M., Tasoniero, G., Giaccone, V., Acuti, G., Marangon, A., & Dalle Zotte, A. (2018). Black soldier fly as dietary protein source for broiler quails: Meat proximate composition, fatty acid and amino acid profile, oxidative status and sensory traits. *Animal*, 12, 640-647. doi: 10.1017/S1751731117001860.

[6] Dozier, W.A., Davis, A.J., Freeman, M.E., & Ward, T.L. (2003). Early growth and environmental implications of dietary zinc and copper concentrations and sources of broiler chicks. *British Poultry Science*, 44, 726-731. doi: 10.1080/00071660310001643714.

[7] European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes. (1986, March). Retrieved from https://rm.coe.int/168007a67b.

[8] Genchev, A., & Mihailov, R. (2008). Slaughter analysis protocol in experiments using Japanese quails (Coturnix Japonica). *Trakia Journal of Sciences*, 6(4), 66-71.

[9] Genchev, A., Mihaylova, G., Ribarski, S., Pavlov, A., & Kabakchiev, M. (2008). Meat quality and composition in Japanese quails. *Trakia Journal of Sciences*, 6, 72-82.

[10] Gevlich, O.A., Trukhachev, V.I., & Marynich, A.P. (2013). The effectiveness of the use of biologically active feed additive "BIOKHIT" from the larvae of drones and dead bees in feeding young pigs. *Bulletin of the Stavropol Agro-Industrial Complex*, 3(11), 21-26.

[11] Gunchak, A.V., Sirko, Y.M., Kirillov, B.Ya., Kistsev, V.O., Lisna, B.B., Koretchuk, S.I., Stefanishin, O.S., Kaminska, M.V., & Martyniuk, U.A. (2016). Influence of plant extracts on digestive processes in poultry, productivity and product quality. *Animal Biology*, 18(2), 25-35.

[12] Gutyj, B.V., Ostapyuk, A.Y., Sobolev, O.I., Vishchur, V.Ja., Gubash, O.P., Kurtyak, B.M., Kovalskyi, Y.V., Darmohray, L.M., Hunchak, A.V., Tsisaryk, O.Y., Shcherbatyy, A.R., Farionik, T.V., Savchuk, L.B., Palyadichuk, O.R., & Hrymak, K. (2019). Cadmium burden impact on morphological and biochemical blood indicators of poultry. *Ukrainian Journal of Ecology*, 9(1), 235-239.

[13] Ibatullin, I.I., Zhukorskyi, O.M., & Bashchenko, M.I. (2017). *Methodology and organization of scientific research in animal husbandry*. Kyiv: Agrarian Science.
[14] Khalifa, A.H, Omar, M.B, Hussein, S.M., & Abdel-Mbdy, H.E. (2016). Nutritional value of farmed and wild quail meats. *Assiut Journal of Agricultural Sciences*, 47(6-1), 58-71. doi: 10.21608/ajas.2016.2574.
[15] Khvostik, V.P., & Bondarenko, Yu.V. (2021). Growth intensity of the meat and egg chickens of different genetic origin. *Bulletin of Sumy National Agrarian University. Series*: *Livestock*, 3(46), 91-94.
[16] Kim, G.-B., Seo, Y.M., Shin, K.S., Rhee, A.R., Han, J., & Paik, I.K. (2011). Effects of supplemental coppermetionate chelate and Copper-soy proteinateon the performance, blood parameters, liver mineral content, and intestinal microflore of broiler chickens. *Journal of Applied Poultry Research*, 20, 21-32.
[17] Kyryliv, B.Ya., Hunchak, A.V., & Sirko, Ya.M. (2017). Productivity and quality of quail products under the influence of biologically active additives. *Scientific Messenger of LNU of Veterinary Medicine and Biotechnology*, 19(74), 229-235.
[18] Law Of Ukraine No. 3447-IV "On the Protection of Animals from Cruelty". (2006, February). Retrieved from https://zakon.rada.gov.ua/laws/show/3447-15#Text.
[19] Lebedev, P.T., & Usovych, A.T. (1976). *Methods for the study of feed, organs and tissues of animals*. Moscow: Rosselkhozizdat.
[20] Lemesheva, M., & Yurchenko, V. (2016). The using of different forms of minerals in poultry feeding. *Science and Technology Bulletin of SRC for Biosafety and Environmental Control of Agro-Industrial Complex*, 4(1), 121-124.
[21] Milanović, S., Lazarević, M., Jokić, Ž., Jovanović, I., Pešut O., Kirovski, D., & Marinković, D. (2008). The influence of organic and inorganic Fe supplementation on red blood picture, immune response and quantity of iron in organs of broiler chickens. *Acta Veterinaria*, 58, 179-189.
[22] Nawaz, H., Irshad, M., & Mubarak, A. (2016). Effect of probiotics on growth performance, nutrient digestibility and carcass characteristics in broilers. *The Journal of Animal and Plant Sciences*, 26(3), 599-604.
[23] Nys, Y., Schlegel, P., Durosoy, S., & Jondreville, C. (2018). Adapting trace mineral nutrition of birds for optimising the environment and Poultry product quality. *World's Poultry Science Journal*, 74(2), 225-238. doi: 10.1017/S0043933918000016.
[24] Orkusz, A. (2015). Factors affecting the quality of gallinaceous poultry meat. A review. *Engineering Science and Technology*, 1, 47-60. doi: 10.15611/nit.2015.1.05
[25] Pasnichenko, O.S. (2017). The dynamics of calcium and phosphorus content in tubular bones of stylopodium of ducks in "blagovarsky" cross in the postnatal period of ontogenesis. *Problems of Zooengineering and Veterinary Medicine*, 34(2), 83-88.
[26] Plyska, A.Ju., & Ibatullin, I.I. (2020). The egg productivity of quails for feeding different levels of dry post-alcohol bard in composition of feed. *Animal Husbandry Products Production and Processing*, 2, 82-87. doi: 10.33245/2310-9289-2020-158-2-82-87.
[27] Poberezhets, J., Chudak, R., Kupchuk, I., Yaropud, V., & Rutkevych, V. (2021). Effect of probiotic supplement on nutrient digestibility and production traits on broiler chicken. *Agraarteadus*, 2, 296-302. doi: 10.15159/jas.21.28.
[28] Polivanova, T.M. (1988). *Methods of scientific research on the physiology and anatomy of poultry*. Moscow: VASKhNIL.
[29] Ravindran, V. (2014). Nutrition of meat animals | Poultry. In M. Dikeman, C. Devine (Eds.), *Encyclopedia of meat sciences. (Second Edition) USA* (pp. 436-470). Oxford: Academic Press.
[30] Razanova, O.P., & Chudak, R.A. (2018). *The effectiveness of the use in animal husbandry of biologically active additives based on bee stings*. Vinnytsia: RVV VNAU.
[31] Razanova, O.P. (2018). Increasing meat quality quails fed by biological active additives based on submerged bees. *Ukrainian Journal of Ecology*, 8(1), 631-636. doi: 10.15421/2017_259.
[32] Sałek, P., Przybylski, W., Jaworska, D., Adamczak, L., Zielińska, D., & Głuchowski, A. (2020). The effects on the quality of poultry meat of supplementing feed with zinc-methionine complex. *Acta Scientiarum Polonorum, Technologia Alimentaria*, 19(1), 73-82. doi: 10.17306/J.AFS.0756.
[33] Shelton, J.L., & Southern, L.L. (2006). Effects of phytase addition with or without a trace mineral premix on growth performance, bone response variables, and tissue mineral concentrations in commercial broilers. *Journal of Applied Poultry Research*, 15, 94-102.
[34] Skoromna, O.I., Razanova, O.P., & Tkachenko, T.Y. (2019). Effect of lysine feeding allowance on growth performance and carcass characteristics of growing pigs. *Ukrainian Journal of Ecology*, 9(4), 204-209. doi: 10.15421/2019_803.
[35] Sunder, G.S., Panda, A.K., Gopinath, N.C.S., Rao, S.V.R., Raju, M., Reddy, M.R., & Kumar, C.V. (2008). Effects of higher levels of zinc supplementation on performance, mineral availability, and immune competence in broiler chickens. *Journal of Applied Poultry Research*, 17, 79-86.
[36] Vargas-Sánchez, R.D., Ibarra-Arias, F.J., del Mar Torres-Martínez, B., Sánchez-Escalante, A., & Torrescano-Urrutia, G.R. (2019). Use of natural ingredients in Japanese quail diet and their effect on carcass and meat quality: A review. *Asian-Australasian Journal of Animal Sciences*, 32(11), article number 1641. doi: 10.5713/ajas.18.0800.

[37] Yang, X.J., Sun, X.X., Li, C.Y., Wu, X.H., & Yao, J.H. (2011). Effects of copper, iron, zinc, and manganese supplementation in a corn and soybean meal diet on the growth performance, meat quality, and immune responses of broiler chickens. *Journal of Applied Poultry Research*, 20, 263-271. doi: 10.3382/japr.2010-00204.
[38] Yefimov, V.H., & Masiuk, D.M. (2016). Biologically active components of the diet – the basis of poultry productivity. *Feeding and Keeping poultry*, 1, 8-10.
[39] Zakharenko, M., Shevchenko, L., Mykhalska, V.M., Maliuha, L.V., & Skyba, O.O. (2004). The role of trace elements in animal life. *Veterinary Medicine of Ukraine*, 2, 13-16.

Динаміка вмісту деяких мінеральних елементів у м'язовій, кістковій тканинах та печінці перепелів за впливу апіміну

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Анотація. У системі повноцінної годівлі птиці важливе значення приділяється забезпеченості їх мінеральними речовинами. Мета дослідження полягала у визначенні впливу мінеральної добавки на основі бджолиного підмору апімін на вміст цинку, міді, магнію та заліза у м'ясі, печінці, кістковій тканині перепелів. Під час виконання дослідження були використані наступні методи: зоотехнічні (для аналізу продуктивності перепелів), фізіологічні (для визначення перетравності поживних речовин раціону птиці), біохімічні (для аналізу вмісту мінеральних речовин у м'язах, печінці та трубчастих кістках), морфологічні (для визначення м'ясних якостей перепелів: маса їстівних частин, м'ясності тушок), статистичні (визначали наявність або відсутність суттєвої різниці між значеннями). Обґрунтування ефективності згодовування добавки апімін здійснювалося на підставі комплексного дослідження з вивчення хімічного складу апіміну, ретенції мінеральних речовин, м'ясних показників, динаміки вмісту цинку, міді, заліза, магнію у м'язовій, кістковій тканинах та печінці перепелів. Дослідження проводили на перепелах м'ясної породи фараон з 1 до 56-денного віку і перепілках з 60 до 120 днів. У складі апіміну містяться кальцій, магній, залізо, цинк, марганець, фосфор, силіцій, селен. Згодовування апіміну сприяє підвищенню метаболізму, засвоюваність міді була вищою на 21,7 %, цинку – на 5,9 %, заліза – на 8,9 % і магнію – на 12,9 %. Додавання до раціону вплинуло підвищувало наростання м'язової маси, співвідношення м'якоті до кісток було вищим на 0,26 %. У грудних м'язах вміст цинку збільшився на 15,6 %, у стегнових і гомілкових м'язах – на 2,6 %, у печінці – на 5,3 %, заліза в грудних м'язах збільшився на 5,1 %, печінці – на 13,1 %. У м'язах стегна та гомілки вміст міді на 8,0 % вищий, у печінці – на 3,2 %, у грудних м'язах – на 14,0 %. Не виявлено впливу апіміну на вміст магнію. Вміст золи з віком в кістках перепілок за годівлі апіміном зменшився на 3,87 %, підвищився вміст міді – на 18,3 %, цинку – на 27,6 %

Ключові слова: молодняк перепелів, мікроелементи, мінеральна добавка, м'ясні якості, мінеральний склад