Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2020, 10(2), 289-293, doi: 10.15421/2020_99

ORIGINAL ARTICLE

Efficiency of premixes with Bioplex® microelements in the diets of Holstein cattle

A. Horchanok[1*], O. Kuzmenko[2], L. Lytvyshchenko[1], M. Lieshchova[1], N. Prysiazhniuk[2], O. Bevz[2], O. Slobodeniuk[2]

[1]Dnipro State Agrarian and Economic University, Dnipro, Ukraine
[2]Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine

**Corresponding author E-mail: anna.horchanok@dsau.dp.ua*

Received: 13.04.2020. Accepted 23.05.2020

The feeds grown in the research farm in the Steppe of Ukraine have the composition with a low concentration of vital microelements. Cuprum content in alfalfa haylage harvested in different years ranged from 1.66 to 3.11 mg/kg; in silage it was 0.70-1.17 mg/kg; in hay it was 6.71-11.01 mg/kg, and in semi-sugar beets the cuprum content was 1.17-2.04 mg/kg. In regards to concentrated feeds, the least Cuprum content was registered in corn grain and was 2.26-3.93 mg/kg. The insignificant cuprum amount was reported for the barley and pea grain: 3.93-7.41 and 2.83-5.50 mg/kg, respectively, while the most abundant amount was in sunflower meal - about of 18.64–29.33 mg/kg. The article presents the results of effect of organic minerals Bioplex Mn, Bioplex Cu and Bioplex Zn on milk productivity and quality of Holstein cattle in the Steppe Zone of Ukraine. Replacement of Mn sulphate with Bioplex Mn increased the productivity of Holstein cows by 8.52%, replacement of Cu increased the productivity by 5.72%, and replacement of Zn with Bioplex Mn increased the productivity by 11.08%. During cumulative effect of Bioplex Mn, Cu and Zn in the diets of cows demonstrated the best results in productivity; this was by 19.30% more compared with the control group. We also found that the chemical composition of milk did not differ from the control by density, content of protein, lactose and ash. The fat content in the milk of cows in the experimental groups increased by 0.05-0.13%, the number of somatic cells was also decreased.

Keywords: Organic microelements Bioplex Mn; Bioplex Cu and Bioplex Zn; Milk productivity; Milk quality indicators

Introduction

The most important task of dairy farming is to provide the population with ecologically safe dairy products. To solve this problem, many farms in Ukraine, including Dnipropetrovsk region, have created highly productive herds of cows, in particular Black-Pied Holstein breed, where milk yield per cow is 6-9 and even can amount 10-12 thousand kg of milk per lactation (Khavturina, 2015; Horchanok & Kuzmenko, 2018). A number of authors claim that to increase the milk productivity of high-producing cows, it is necessary to balance diets not only for energy and protein value, but also for mineral (Ashry et al., 2012; Horchanok et al., 2019). And to obtain ecologically safe dairy products enriched with all the necessary nutrients, it is preferable to use mineral supplements of organic origin in the feeding of dairy cows (Hassan et al., 2011; Gayathri, 2018; Horchanok et al., 2019). Microelements (Cuprum, Zinc, Manganese, Ferrum and Selenium) play an important role in the functioning of immune system, in reproduction and normal metabolism. Microelements interact with each other in the digestive tract, forming soluble complexes, thus, for example, Sulphur, Molybdenum and Ferrum reduce the availability and absorption of Cuprum. Intensive cultivation of feed and grain crops leads to a decrease of microelements in their composition. Zoohygienic conditions affect the consumption of micronutrients by animals (Sviezhentsov, 1998). That's why the various experimental researches to justify the formula of advanced zonal premixes for high-producing Holstein breed cows with organic mineral complexes (like for instance Bioplex Cu, Zn and Mn) and a comprehensive study of their impact on milk productivity are extremely important and relevant for each Ukrainian region.

Ukraine has a number of geochemical regions which are characterized by a lack of certain microelements in soils, feeds, livestock products and animals (Sviezhentsov, 1998). Lack of microelements in the diet leads to disturbance in metabolism in animal organisms, reducing their productivity, product quality, immunity and the contraction of diseases (Gowda et al., 2014). However, recent studies have convincingly shown that the use of a single standard premix formula throughout Ukraine is impossible because it cannot equally supply the needs of animals in each nutrient as different feeds used in the cow diets have different content of these elements depending on natural and climatic factors, soil composition, harvesting technology, preparation and use within the diet. The organization of a complete mineral nutrition of animals is impossible without taking into account the peculiarities of each region of Ukraine (Khavturina & Sviezhentsov, 2008).

Recently, several categories of organically bound microelements Mn, Cu, Zn have appeared on the European market. These chelated forms have one common feature associated with organic molecules (ligands). Previous researches have shown that micronutrient sols, especially sulphates and chlorides, destroy vitamins, therefore micronutrients are introduced into premixes in the form of chelated compounds. Chelated compounds of the element with glycine, methionine or histidine have greater bioavailability (Hassan et al., 2011; Sethy et al., 2018). Chelates are complex organic compounds of microelements. They have many advantages over soluble sols of microelements used before. When ordinary microelements are digested by 30–40%, microelements in chelated form are digested almost by 95% and only 5% is excreted from the body (Ebbinhe, 2007; Pal, Gowda, 2015). The formation of

chelated compounds is the basis of the reactive molecules presentation, the transformation of biosubstrates into structurally organic specific systems, the formation of immunity and biodynamic processes in the body (Fremaut, 2003).

One method to improve the use of micronutrients by the animal body is to increase the use of micronutrients in organic form such as Bioplex of foreign production in animal husbandry. Due to the organic form of microelements Bioplex (Mn, Cu, Zn) is easily digested without antagonistical interactions with other microelements and nutrients. It has advantages in comparison with inorganic sources of minerals in feeding and metabolism (Kinal et al., 2007). Minerals of Bioplex are used for rapid absorption and digestion and can replace inorganic additives in the diet, reducing the excretion of minerals (Nollet et al., 2008; Faulkner et al., 2016).

It is known that Manganese, Cuprum and Zinc are essential elements that play a key role in all physiological processes of synthesis and disintegration, absorption and excretion of substances; could create a favourable environment for the normal action of enzymes, hormones and vitamins; are involved in the reproductive functions of animals. However, at present there is a deficiency of these microelements in the feeds of the Steppe Zone of Ukraine. Despite the positive results of the inorganic sols of microelements use, many researchers confirm the high effectiveness of the stimulating influence of chelated compounds of microelements with amino acids and vitamins on the processes of growth, development, preservation, productivity and reproductive capacity of animals. Among the nutritional factors, mineral substances are important, the lack or excess of them causes significant damage to livestock. Scientists prove that microelements Ferrum, Cuprum, Zinc, Iodine, Cobalt, and Manganese play a significant role in increasing the biological full value of feeding dairy cowbanes (Ashry et al., 2012; Horchanok et al., 2019). Since mineral substances are closely related to vitamins in the metabolism of nutrients and biologically active agents, a great attention should be paid to the vitamin nutrition in the feeding of highly productive cows. Mineral supplements should be fed taking into account the productivity and physiological state of the animals (Faulkner et al., 2016; Gayathri, 2018). Thus, appending of chelated compounds into premixes can be used to influence various metabolic links in order to obtain maximum animal productivity and environmentally safe products.

The purpose of the research was to substantiate the formula of improved zonal premixes for high-producing Holstein breed cows using mineral supplements of organic form Bioplex Mn, Cu, Zn and to investigate their impact on productivity, product quality and economic efficiency.

Material and Methods

To determine the chemical composition of feeds and the content of nutrients including microelements, 95 samples of feeds were studied. Feeds for studying were selected from LLC "Agrofirma named after Gorky" in Dnipropetrovsk region.

Taking of average samples of feeds and forage crops and their preparation for analysis was carried out according to generally accepted methods (Kozyr & Svezhencov, 2002). Determination of the chemical composition of feeds and their nutritional value was carried out in the Laboratory of Zootechnical Analysis of Feed, Feed Technology and Animal Feeding Department, Dnipro State University of Agriculture and Economics.

Research of using effect of organic-mineral complexes Bioplex Mn, Bioplex Cu and Bioplex Zn of foreign production in the feeding of Holstein breed cows was conducted in LLC "Agrofirma named after Gorky" in Dnipropetrovsk region.

Cows for the experiment were selected on the 10-15th day after calving on the principle of analogues by age (number of lactations), date of last calving, live weight and milk productivity during the last lactation and the actual daily milk yield and fat content in it. All selected analogue cows were purebred, had similar maternal performance and average fattening, and were clinically healthy and kept in the same conditions. The animals were kept tied, watering was supplied by stock founts, roughage and succulent fodders were distributed three times a day, concentrated feeds 6 times and not more than 2 kg per serving. Milking was carried out twice in the milk line.

Since the cows were on the 2nd-3rd weeks after the calving and had to be milked, two feed units were added to additional feeding of 2 kg of fodder to the daily norm of energy nutrition. The diet of the equalization period included oat-hay, alfalfa haylage, corn silage, feed molasses and fodder. Table salt and dicalcium phosphate were used as mineral supplements. The duration of the equalization period of scientific and economic experiment was 15 days. After the equalization period, control milking was performed, which allowed to equalize the experimental groups of cows. Control and experimental groups of cows were determined by randomization.

During the equalization period, experimental Holstein breed cows received the basic diet (BD), which included feeds that are typical for the Steppe Zone of Ukraine: hay, oat-hay, alfalfa haylage, green corn silage, semi-sugar beets, feed molasses and fodders, which included corn, barley, pea, sunflower meal, table salt, dicalcium phosphate and premix.

The nutritional value of the diet at the end of the equalization period and at the beginning of the experimental period was as follows: exchange energy - 303 MJ; crude protein - 4093.4 g; lysine - 151.65 g; methionine + cystine - 119.0 g; tryptophan - 41.6 g. The dry substance content per 100 kg of live weight was 4.65 kg; the percentage of crude fibre from dry substance was 18.96. The sugar-protein ratio was 1.1: 1; carbohydrate-protein was 2.5: 1. The ratio of Calcium to Phosphorus was 1.8: 1; the sparingly soluble fraction of protein from crude protein was 40.7%.

Results and Discussion

The use of organic microelements in the diets of experimental cows helped to increase their consumption of roughage, succulent and concentrated feeds. The nutritional value of 1 kg of dry substance of the diet was 1.01-1.03 of feed units or 11.10-11.16 MJ of metabolic energy, the protein-energy ratio was 114.3-115.4 g.

The concentration of microelements in consumed feeds with using Bioplex Mn, Bioplex Cu and Bioplex Zn is shown in Figure 1.

In the researches we studied the content of Cuprum (Cu), zinc (Zn) and Manganese (Mn) in feeds which are widely used in the diets of cattle in the Steppe Zone of Ukraine. Totally 95 feed samples were examined, including: 26 samples of oat-hay feed, 31 samples of green corn silage, 8 samples of alfalfa haylage (budding period), 6 samples of semi-sugar beet feed, 18 samples of cereals and legumes, 6 samples of sunflower meal. The results of research to determine the content of microelements in feeds grown in the experimental farm of the Steppe of Ukraine show that the content of Cuprum in the alfalfa hay harvested in different years ranged from 1.66 to 3.11 mg/kg; in silos 0.70-1.17 mg/kg; in hay 6.71-11.01 mg/kg, in semi-sugar beets 1.17-2.04 mg/kg. Regarding concentrated feeds, the least Cuprum content was in corn grain ranged 2.26-3.93 mg/kg, slightly more in barley and peas: 3.93-7.41 and 2.83-5.50 mg/kg, respectively, the most in sunflower meal: 18.64-29.33 mg/kg.

An important assessment of the effect of Bioplex Manganese, Copper and Zinc on the productivity of experimental cows and the efficiency of nutrient use in diets is in the results obtained by scientific and economic experiment (Table 1).

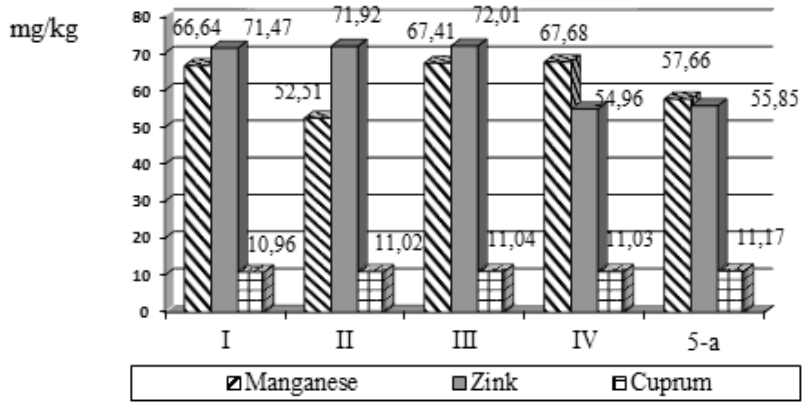

Figure 1. Concentration of microelements in 1 kg of dry substance.

Table 1. Average productivity of cows during 170 days of experiment (M ± m; n=10).

Index	Group				
	control	experimental			
	1	2	3	4	5
	Gross milk yield per cow, kg				
Natural fat milk	5768.1 ± 47.30	6259.4 ± 90.99**	6097.9 ± 92.51*	6407.3 ± 48.84***	6881.6 ± 107.43**
%, From the control	100	108.52	105.72	111.08	119.30
Milk of 4% fat	5479.1 ± 55.16	6023.1 ± 82.20**	5730.7 ± 118.57	6213.5 ± 44.83**	6760.9 ± 107.50**
%, From the control	100	109.92	104.59	113.40	123.39

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001 compared with the control

According to Table 2, the replacement 650 mg of inorganic manganese by 300 mg of organic in the diet in the 2nd group ensured the intake of this element into the organism of animals with actually consumed feed only by 77.4% of norm, but the milk productivity of cows in general during the experiment increased by 9.92% (p ≤ 0.01) compared with the control group. Cuprum supply was by 4% higher of the norm, and Zinc supply was by 6.02% higher. Furthermore, a significant increase in milk yield (per milk of 4% fat) was observed in the second period of the experiment.

In the 3rd group the inorganic Cuprum was replaced by organic in the compound of Bioplex (0.065 g per 1 cow per day). As a consequence, the milk productivity of cows in the 3rd group increased by 4.59% compared to the control group, but this increase was inconsiderable. The diet for cows of the 4th group included 450 mg of Zn-Bioplex, i.e. 53% of inorganic Zinc was replaced by organic. Dairy productivity of cows in the 4th group was taken as a whole during the experiment increased by 13.40% (p ≤ 0.01) compared with the control group.

However, the highest productivity in general for both periods of the experiment was in the 5th group, in the diets of which Bioplex Manganese, Bioplex Copper and Bioplex Zinc were introduced. 6760.9 kg of milk of 4% fat content were milked per 1 cow from cows of this group on average for 170 days of the experiment; it is by 23.39% (p ≤ 0.001) more in comparison with the control. Thus, with consumed feeds Manganese supply was 88.84%; Copper supply was 109.39%; Zinc supply was 86.03% of the norm. Along with the study of milk productivity, the chemical composition of milk of experimental cows depending on the level of Bioplex Mn, Cu and Zn in the diets was also investigated (Table 2).

Table 2. Chemical composition of milk (M ± m; n=10).

Index	Group				
	control	experimental			
	1	2	3	4	5
Water, %	86.70 ± 0.045	86.64 ± 0.020	86.69 ± 0.059	86.64 ± 0.047	86.56 ± 0.043
Protein, %	3.18 ± 0.031	3.17 ± 0.027	3.17 ± 0.027	3.18 ± 0.036	3.21 ± 0.030
Fat, %	3.80 ± 0.013	3.85 ± 0.013*	3.76 ± 0.034	3.88 ± 0.023**	3.94 ± 0.020**
Lactose, %	5.55 ± 0.018	5.58 ± 0.014*	5.59 ± 0.011*	5.54 ± 0.012	5.54 ± 0.014
Ash, %	0.78 ± 0.004	0.77 ± 0.003*	0.79 ± 0.004	0.77 ± 0.006	0.75 ± 0.005**
Density of milk, g/sm^3	1.029	1.029	1.029	1.029	1.029

*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001 compared with the control

The study of the milk chemical composition showed that the density, protein, lactose and ash content of the test samples did not differ from the control. The fat content in milk of cows in the experimental groups increased by 0.05-0.13%, as a result the intergroup difference in milk yields of 4% fat milk increased. At the same time, a definite decrease in the number of somatic cells in

milk was found (Figure 2).

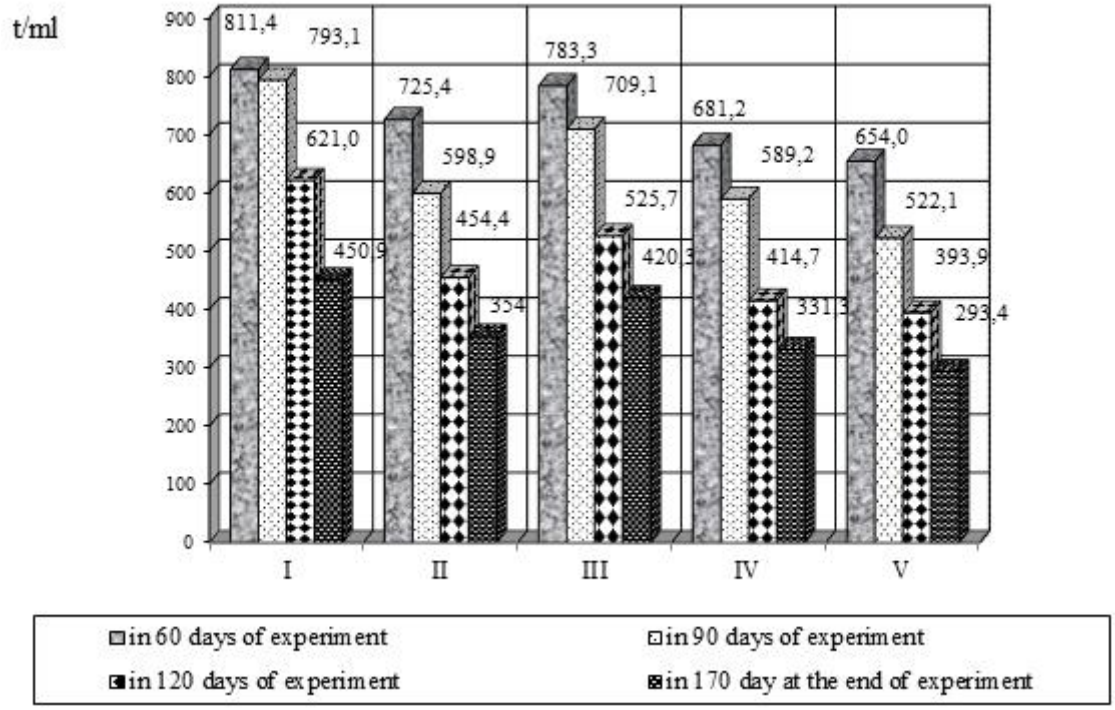

Figure 2. Changes in the dynamics of somatic cells in the milk.

Particularly it refers to cows been given Bioplex Mn, Bioplex Zn and simultaneously Bioplex Mn, Bioplex Cu and Bioplex Zn. It can be affirmed that the decrease in the number of somatic cells occurred gradually during the scientific and economic experiment and this was (in thousand/ml) 450.9 in the 1st control group, 354.0 in the 2nd experimental group, 420.3 in the 3rd experimental group, 331.3 in the 4th experimental group, and 293.4 in the 5th experimental group. We established that the decrease in the number of somatic cells was less by 44.4% in control group, by 51.2% in group related to Bioplex Mn, by 46.3% in group with Bioplex Cu, by 51.4% in group with Bioplex Zn, and by 55.1% in group with Bioplex Mn, Cu and Zn. According to the control, the content of somatic cells in the milk decreased by 6.8 in the 2nd group, by 1.9 in the 3rd group, by 6.9 in the 4th group, and by 10.7% in the 5th group. The introduction of organic microelements Bioplex Mn, Cu and Zn in the cattle diet in sufficient quantity is extremely important for health maintenance of cows. The balance of microelements Manganese, Cuprum and Zinc in the organism can protect a lactating high-producing cow from the detrimental effect of acute inflammation caused by mastitis pathogens. The use of organic microelements is one of a number of feeding factors to improve udder health and reduce SCC (somatic cell count) which ultimately affects the constant production of milk quality.

Conclusion

Usage of organic microelements Bioplex Mn, Bioplex Cu and Bioplex Zn in compound concentrate feeds for high-producing cows in the first and second 100 days of lactation had a positive effect on the level of milk productivity and chemical composition of milk, which confirms the reasonability of their use in feeding of Holstein breed cows. Biometals have a positive influence on the physiological status of animals.

Feeding of highly productive cows with Bioplex Manganese, Cuprum and Zinc increased the 4% fat milk yield by 23.4%. The fat content in milk of high-producing cows increased by 0.13% with the use of Bioplex Manganese, Cuprum and Zinc; the number of somatic cells in the milk decreased in the 2nd group by 6.8, in the 3d group by 1.9, in the 4th group by 6.9, and in the 5th group by 10.7%, respectively, compared to the control.

Also, our research proved that Bioplex Manganese has a positive impact on the above mentioned indicators. Thus, with the use of Bioplex Manganese the milk productivity increased by 8.52%, milk fat content increased by 0.05%, while protein decreased by 0.01%, and the number of somatic cells in milk decrease by 157.5 thousand/ml, compared to the control. We testified that the use of Bioplex Mn, Cu and Zn in feeds of high-producing cows in the first and second 100 days of lactation had a positive impact on the level of milk productivity and chemical composition of milk. Our further researches will be aimed at studying the influence of microelements of organic origin on the digestibility of feed nutrients and hematological parameters of high-producing Holstein dairy cattle.

References

Ashry, E.I., Hassan, G.M., Soliman, A.A.M. S.M. (2012). Effect of feeding a combination of Zinc, Manganese and Copper Methionine chelates of early lactation high producing dairy cow. Food and Nutrition Science, 3, 1084-1091. DOI:10.4236/fns.2012.38144

Ebbinhe, B (2007). Peredovyie tekhnologii v kormlenii zhvachnykh zhivotmykh [Advanced technologies in feeding ruminants]. Hlavnii zootekhnik [The main livestock], 5, 25-27. (in Russian).

Faulkner, M.J., Wenner, B.A., Solden, L.M., Weiss, W.P. (2016). Source of supplemental dietary copper, zinc, and manganese affects fecal microbial relative abundance in lactating dairy cows. J Dairy Sci, 100(2), 1037-1044. DOI: 10.3168/jds.2016-11680

Fremaut, D. (2003). Trace mineral proteinates in modern pig production. In: Nutrition Biotechnology in the free and food industries. Alltech 19th Ann / Symp., Nottingham Univ. Press, 171-178.

Gayathri, S. L. (2018). Chelated minerals and its effect on animal production. Agricultural Reviews, 39(4), 314-320. DOI: 10.18805/ag.R-1823

Gowda, N.K.S., Pal, D.T., Krishnamoorthy, P., Verma, Swati, Maya, G. and Prasad, C.S. (2014). Response of chelated copper and zinc supplementation in Rambouillet crossbred lambs under intensive system. The Indian Journal of Small Ruminants, 20(2), 33-37.

Hassan, A.A., El Ashry, Gh. M. and Soliman, S.M. (2011). Effect of supplementation of chelated zinc on milk production in ewes. Food and Nutrition Science, 2(7), 706-713. URL: doi:10.4236/fns.2011.27097

Horchanok, A. V., & Kuzmenko, O. A. (2018). Biologichna dostupnist' mikroelementiv z riznih spoluk v organizmi koriv ta їh vpliv naperetravnist' [Bioavailability of microelements of different compounds in the body of cows and their indigestibility]. Zbirnik naukovih prac' mizhnarodnoї naukovo-praktichnoї konferenciї. Agrarna nauka ta osvita v umovah Evrointegraciї, [Bulletin of scientific and practical conference. Agricultural science and education in the conditions of Eurointegration] 1, 211-213.

Horchanok, A., Hubanova, N., Bomko, V., Kuzmenko, O., Novitskiy, R., Sobolev, O., Tkachenko, M., Prisjazhnjuk, N. (2019). Influence of chelations on dairy productivity of cows in different periods of manufacturing cycle. Ukrainian Journal of Ecology, 9(1), 231–234.

Horchanok, A.V., Kuzmenko, O.A., Khalak, V.I., Porotikova, I.I. Lunska, A.Yu. (2019) Efficiency of using of the organic mineral mixed ligand cuprum in the pig feeding. Annals of the Faculty of Engineering Hunedoara. International Journal of Engineering, 17(3), 145–148.

Khavturina, H.V. (2015). Vplyv khelatnykh mikroelementiv - biopleksiv na obminni protsesy v orhanizmi koriv na rozdoi [Influence of chelated microelements - bioplexes on metabolic processes in the body of cows at milking]. Naukovo-tekhnichnyi biuleten Naukovo-doslidnoho tsentru biobezpeky ta ekolohichnoho kontroliu resursiv APK [Scientific and technical bulletin of the Research Center for Biosafety and Environmental Control of Agricultural Resources.], 3(1), 135-141.

Khavturina, H.V., Sviezhentsov, A.I. (2008). Vplyv orhanichnykh form deiakykh mikroelementiv na kilkist somatychnykh klityn v molotsi [Influence of organic forms of some microelements on the number of somatic cells in milk]. Novitni tekhnolohii skotarstva u XXI stolitti: materialy mizhnar. nauk.-prakt. konf. Mykol.derzh. ahrar. un-t. [The latest technologies of animal husbandry in the XXI century: materials of the international. scientific-practical conf. Mykhol. state agrarian un-t.]. Mykhovaiv. (in Ukrainian).

Kinal, S., Korniewicz, A., Słupczyńska, M., Bodarski, R., Korniewicz, D., Čermák, B. (2007). Effect of the application of bioplexes of zinc, copper and manganese on milk quality and composition of milk and colostrum and some indices of the blood metabolic profile of cows Czech J. Anim. Sci., 52, (12), 423–429

Kozyr, V. S., & Svezhencov, A. I. (2002). Prakticheskie metodiki issledovanij v zhivotnovodstve [Practical research methods in animal husbandry]. Dnepropetrovsk, Art-Press Publ. (in Russian).

Nollet, L., Huyghebaert, G. and Spring, P. (2008). Effect of different levels of dietary organic (Bioplex) trace minerals on live performance of broiler chickens by growth phases. Journal of Applied Poultry Research, 17, 109-115. doi.org/10.3382/japr.2007-00049

Pal, D. T. Gowda, N. K. S. (2015). Organic trace minerals for improving livestock production. Broadening Horizons No.17, May 2015.

Sethy, K., Behera, K., Mishra, S. K., Gupta, S.K., Sahoo, N., Parhi, S.S., Mahapatra, M. R. and Khadanga. S. (2018). Effect of organic zinc supplementation on growth, metabolic profile and antioxidant status of Ganjam Sheep. Indian J. Anim. Res, 52(6), 839-842. DOI:10.18805/ijar.B-3297

Sviezhentsov, A.I. (1998). Osobennosti biogeokhimicheskoi situatsii na yuge Ukrainy dlia tselei zhivotnovodstva [Features of the biogeochemical situation in the south of Ukraine for livestock purposes]. Migratsiia metallov i radionuklidov v zvene: pochva-rasteniie (korm, ratsion)-zhivotnoie-product zhivotnovodstva-chelovek: sb. materialov mezhdunar.konf. [Migration of metals and radionuclides in the link: soil-plant (feed, diet)-animal-animal product-man. Bulletin of international. conf.]. Novgorod (in Russian).

Citation:

Horchanok, A., Kuzmenko, O., Lytvyshchenko, L., Lieshchova, M., Prysiazhniuk, N., Bevz, O., Slobodeniuk, O. (2020). Efficiency of premixes with Bioplex® microelements in the diets of Holstein cattle. *Ukrainian Journal of Ecology, 10*(2), 289-293.