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Influence of chelates on pigs productivity and quality

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Feeding Zinc in the form of an organic chelate in the mixed feed for young Large White pigs in fattening causes improved metabolic processes in the organism, which positively affects the indices of pigs' laughter. The intervention of zinc chelate in mixed feed promotes an increase in the morphological composition of the carcass and an improvement in the chemical composition of meat and lard. It was established that in the process of fattening young Large White pigs with a zinc chelate dose of 83.2 g/t in mixed feed, a slaughter yield is higher by 1.2% compared with analogs of control. Pigs exceeded analogs by 6.6% in meat yield and by 0.9% in protein content in meat.
Keywords: Pigs, Zinc chelate, Mixed feed, Slaughter weight, Slaughter yield, Morphological composition of carcasses, Chemical composition of meat, Lard, Internal organs

Introduction

Ukraine has sufficient genetic potential of pig breeds which can be effectively used in the hybridization system to produce young animals for fattening. With sufficient and balanced feeding, the nutrient transformation level from mixed feed into the substance of product during fattening maybe 45-50%. The primary method of reaching the transformation is to organize a balanced feeding that means the use of diets that suit them best to the needs of animals in containing the essential nutrients and biologically active substances (Mavromichalis et al., 2001; Wang et al., 2013; Smetanina et al., 2017).
Previous studies have found that among the substances that play an essential role in the vital activity of the animal organism, recently, great attention has been paid to microelements, i.e., chemical elements contained in the body in deficient concentrations. Most microelements are indispensable for the organism. The lack or excess of them can cause significant pathological changes in the animal organism (Borisevich et al., 2008; Pal et al., 2010). Zinc is also an essential microelement. Zinc is required for the functioning of more than one hundred enzymes, such as carboxypeptidase, oxidoreductase, transferase, alcohol dehydrogenase, which are related to protein and carbohydrate metabolism, energy metabolism, nucleic acid synthesis, haem biosynthesis, CO2 transport, and others (El Ashry et al., 2012).
The issue of mineral supplements development in the diets of animals aimed for reducing the level of heavy metals and their excretion into the environment and increasing their digestion is worked out by several scientists (Hackbartet al., 2010; Dyachenko et al., 2017), they offer the use of organic microelements, especially the chelate compounds of microelements and amino acids. Therefore, most studies are currently focused on examining the effects of metal chelates on animal productivity (Saripinar Aksu et al., 2010; El Ashry et al., 2012; Kuzmenko O. et al., 2020). Presently carbonate, chloride, and sulfate of zinc, which have good water solubility, are an effective source of enrichment for diets. Therefore, these elements are rapidly excreted and have little absorption (Sethy et al., 2012; Bomko et al., 2015).
Previous studies have proved that with sulfates introducing into premixes, the crystalline water contained in their molecules can be released during storage under the influence of various factors, which results in the intensification of the destruction of both vitamins and microelements. Therefore, sulfates are more dangerous for the stability of vitamins than other compounds.
Scientists say that the Zinc effect on the animal body is multifaceted, and the optimization of diets with this microelement affects the normalization of various metabolic processes (Nagalakshmi et al., 2018; Horchanok A.V. et al., 2019).
The purpose of the research was to set the optimum dose of zinc chelate in mixed feed for young Large White pigs in the process of fattening, which can provide maximum meat productivity.

Materials and Methods

The doses of the drug did not influence the composition and general nutrition of mixed feed. During fattening with complete mixed feed, pigs of the 1st control group received 355 g of zinc sulfate containing 79.9 g of this metal, pigs of the 2nd experimental group consumed mixed feed where the same dose of sulfate was replaced entirely by zinc chelate. Its amount was 665,8 g of metal in chelate (100%), pigs of the 3rd experimental group consumed the dose of chelate reduced by 50% from the indicator of the 2nd experimental group, and it amounted to 335.9 g. Young animals of the 4th and fifth experimental groups consumed doses of chelate reduced by 75% and 87.5%, respectively, and amounted to 166.4 g and 83.2 g, respectively. The scientific experiment was carried out in the conditions of LLC "Elita" of the Kyiv region with young Large White pigs in the process of fattening. According to the principle of analogs, five groups of pigs of 18 heads in each were formed. Feeding pigs for the meat was carried out with mixed

feeds of own production, which consisted of wheat grain, barley grain, corn grain, sunflower meal, and soybean meal; mineral mix Landmix, specially developed for mixed feeds, was added according to the needs of animals in the mineral substance.
The pigs had free access to feed and water to ensure optimal feed intake. The feed nutrition was the same for the animals of all the experimental groups and complied with detailed feeding standards; it was different only in Zinc content. Animals consumed feed with relish, and any changes in the behavior of the experimental pigs were overlooked. At the end of the scientific and commercial experiment, slaughtering of pigs (3 heads from each group) was carried out, followed by boning of half-carcasses to determine morphological and physicochemical parameters of slaughter products. Slaughtering criteria and meat quality were determined using general methods (Petukhova et al., 2010).
Biometric processing of the obtained results was carried out on the PC using MS Excel software and built-in statistical functions. The probability of difference between the indicators was evaluated by Student's criteria (Melnichenko et al., 2006).

Results and Discussions

In the experiment, the consumption of mixed feed by Large White pigs was controlled, which provided pigs optimal growth and development (Table 1).

Table 1. Feed consumption by experimental Large White pigs.

Index	Group				
	control	experimental			
	1	2	3	4	5
Consumed feed for the entire period of the experiment, kg/head	269	271	271	272	273
Consumed feed for the entire period of the experiment, feed unit/head	320.1	322.5	322.5	323.6	324.8
Consumed feed for the main period of the experiment, kg/head	223	225	225	226	227
Consumed feed for the main period of the experiment, feed unit/head	265.4	265.4	267.8	268.9	270.1

As shown in Table 1, pig groups with different zinc content in the feed had differences in the amount of consumed mixed feed. Thus, Large White pigs ate from 269 to 273 kg of mixed feed for the whole experiment period. The 5th experimental group pigs consumed the most significant amount of feed, by 1.5% more than in the control group. An increase in feed consumption was also observed in the second, third, and fourth experimental groups, which exceeded the control group by 0.7%, 0.7%, and 1.1%, respectively. Large White pigs consumed from 223 to 227 kg of feed during the main experimental period, which is 265.4-270.1 feed unit. Thus, the intervention of different levels of zinc chelates into the mixed feed did not cause significant changes in feed consumption of experimental pigs.
Important indicators which can measure productivity level are the dynamics of live weight and feed consumption. Having identified these two indicators, the reasonability of using one or other supplement in the diet of pigs when growing them for meat can be evaluated more accurately. Studies have shown that the live weight of older age pigs in the experimental groups depended on the level of zinc chelate consumed in the mixed feed and differed from the mass of the pigs from the control group (Table 2).
The data in table 2 indicate that different levels of zinc chelate had a positive effect on the growth of Large White pigs.
According to the research design, the livestock's live weight was defined throughout the experiment every 30 days. Pigs at 71-90 days had approximately the same live weight with variations not exceeding 1.6%. At the age of 91-120 days, the live weight of the experimental pigs varied within 1%; the difference was not significant.
However, at the age of 121-150 days, pigs from the 4th experimental group had the indicator exceeded the control by 1.9% ($p \leq 0.05$), pigs from the 5th experimental group by 2.2% (p≤0, 05). Moreover, at the age of 151-180 days, the average live weight of young pigs from the 2nd group exceeded the control by 1.4%, 3rd by 1.7 ($p \leq 0.05$), 4th by 2,4 (p≤0,01), and 5th by 3,0% (p≤0,001).

Table 2. Dynamics of live weight of experimental pigs, kg, X±Sx (n=18).

Age (days)	Group				
	control	experimental			
	1	2	3	4	5
71–90	30.78±0.207	31.26±0.302	31.22±0.185	31.00±0.282	31.14±0.306
in % with control	-	101.6	101.4	100.7	101.2
91–120	51.67±0.384	51.91±0.521	52.11±0.425	52.18±0.428	52.03±0.460
in % with control	-	100,5	100.8	101.0	100.7
121–150	77.18±0.375	77.87±0.818	78.19±0.810	78.66±0.887	78.86±0.689
in % with control	-	100.9	101.3	101.9*	102.2*
151–180	102.8±1.48	104.3±1.74	104.5±2.68	105.3±2.20	105.9±3.54
in % with control	-	101.4	101.7*	102.4**	103.0***

Note: * – p≤0.05; ** – p≤0.01; *** – p≤0.001 compared with the control group

Pigs from the 2nd experimental group showed the slightest difference in indices of live weight compared with the control; the feed they consumed contained zinc chelate in the amount of 665.8 g/t of feed. The highest difference of live weight compared to the control was determined in the 5th experimental group, which consumed feed with zinc chelate in 83.2 g/t.
Feeding different levels of zinc chelate to experimental pigs during fattening affected feed costs per 1 kg of growth (Table 3).
The data in table 3 indicate that a slight increase in feed consumption by pigs of the experimental groups and an increase in absolute growth contributed to a decrease in feed consumption per unit of production.

Table 3. Feed consumption per 1 kg of pigs live weight gain.

Index	Group				
	control	experimental			
	1	2	3	4	5
Consumption of feed per 1 kg gain, kg	3.29	3.26	3.25	3.23	3.22
Consumption of feed per 1 kg gain, feed unit	3.91	3.88	3,87	3.85	3.84
Consumption of digestible protein per 1 kg gain, g	336	333	332	329	328

Thus, for the whole experiment period, pigs from the 2nd experimental group consumed mixed feed less by 0.9% per1 kg of live weight gain compared with young animals of the control group. Animals from the third, fourth, and fifth experimental groups consumed less by 1.2%, 1.8, and 2.1% feed, respectively, per 1 kg of live weight gain compared to the control group. The consumption of mixed feed per 1 kg of pig lived weight gain in the 5th experimental group and was 3.84 feed units, which is less by 1.8% compared with the index of animals in the control group. Consumption of digestible protein per 1 kg of growth was the lowest in the 5th experimental group and amounted to 328 g, which is less by 2.4% compared to the control group.
Pork has a high content of easily digestible complete protein and essential amino acids, and pork fat is a source of essential fatty acids, including arachidonic acid. Therefore, the basis of proper feeding is to increase animal productivity and to raising slaughter weight to obtain products of high biological value. To study the effect of the different levels of zinc chelate on the quality of meat and lard and its chemical composition, slaughtering of animals was performed (Table 4).
Studies have shown that the biological role of zinc is related to the activity of the endocrine glands where it mainly concentrates. At present, it is proved that zinc is necessary for endocrine function; its involvement in the mechanism of cell fission has been proved (Huntington et al., 2002; Merzlov et al., 2009; Khalak, V. et al., 2020). An analysis of the animal control slaughter results showed that the effect of different doses of zinc chelate on the slaughter quality of pigs was positive. Pigs whose live weight was attributable as closely as possible to the average values in the group were selected for slaughter. Thus, the pre-slaughter weight of pigs from the 2nd experimental group exceeded the control by 1.7%, the 3rd by 1.8, 4th by 2.7, and 5th by 3.2%. Studies have established the high bioavailability of trace elements in cows' bodies, depending on the forms and sources of income. Different doses of Manganese, Copper, and Zinc in inorganic and organic forms as sources of trace elements for Holstein cows change the digestibility of nutrients and their absorption (Horchanok A.V. et al., 2018).
The slaughter weight of animals from the 2nd group was exceeded control analogs by 2.2%, 3rd by 2.6, 4th by 4.1 ($p \le 0.05$), and 5th by 5.1% ($p \le 0.01$). Animals from the control group were inferior to the analogs from the experimental groups in slaughter output. The value of this indicator in the 2nd experimental group was higher than control by 0.3%, in 3rd by 0.5, in 4th by 0.9, and in 5th by 1.2%.
The results of internal fat weighing showed that its highest weight was observed in the fourth and fifth experimental groups, which is more by 4.8% and 6.7% compared with the control. There is no significant difference between the control and experimental animals.

Table 4. Indices of pigs slaughter, X±Sx (n=3).

Index	Group				
	control	experimental			
	1	2	3	4	5
Ante live mass, kg	102.4±1.37	104.1±1.82	104.3±2.05	105.2±1.77	105.7±1.64
Slaughter mass, kg	68.9±0.86	70.4±1.12	70.7±1.27	71.7±0.98*	72.4±1.24**
Slaughter gain, %	67.3±0.45	67.6±0.64	67.8±1.05	68.2±0.85	68.5±0.99
Mass of internal fat, kg	1.05±0.122	1.05±0.164	1.08±0.251	1.10±0.223	1.12±0.176
Head mass, kg	5.10±0.314	5.12±0.342	5.17±0.236	5.18±0.327	5.21±0.338
Legs mass, kg	0.84±0.055	0.84±0.048	0.85±0.075	0.87±0.023	0.88±0.062
Skin mass, kg	5.85±0.277	5.85±0.465	5.87±0.306	5,88±0.231	5.92±0.262
The thickness of the fat above 6-7 thoracic vertebra, mm	35.1±0.36	35.1±0,31	35.2±0.42	35.2±0.35	35.1±0.29
Rib eye area, sm^2	29.8±0.82	30.2±0.74	30.4±0.65	30.5±0.58	30.5±0.73

Note: * – $p \le 0.05$; ** – $p \le 0.01$ compared with the control group

The larger the rib eye area means, the more valuable meat content the carcass. The analysis rib eye area of the animals from the experimental groups was 30.2-30.5 cm^2; it was higher by 1.3-2.3% compared to the control analogs.
Morphological composition analysis of the carcasses showed that the meat yield in the experimental groups was high (Figure 1).

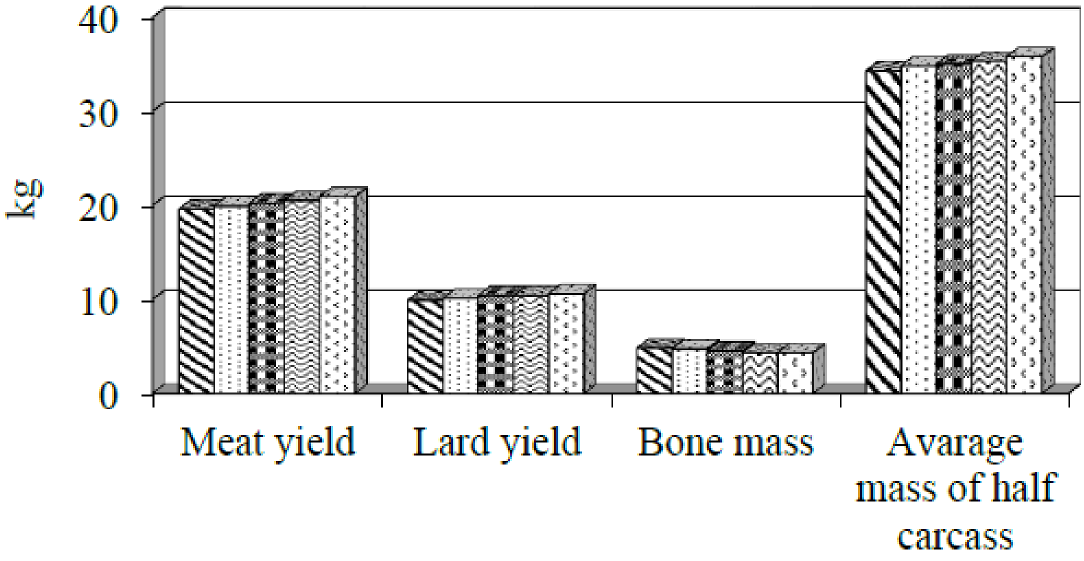

Fig. 1. Morphological composition of carcasses of Large White pigs, kg.

It should be noted that the pre-slaughter live weight of pigs from the experimental groups exceeded analogs from the control group. In the half-carcasses of pigs from the experimental groups, the meat yield was more by 1.5%, 3,1, 4.6 ($p \leq 0.05$), and 6.6% ($p \leq 0.01$), respectively. The part of lard in the half-carcasses of animals from the 2nd experimental group exceeded the control by 2.0%, thi rd and 4th by 5.1% ($p \leq 0.05$), and 5th group by 7.1% ($p \leq 0.05$). The smallest amount of bones was in the carcasses of pigs from the 4th and fif th experimental groups; this indicator was less by 10.4% ($p \leq 0.05$) than the control; in the 2nd and thi rd groups by 2.1% and 6.2%, respectively. Thus, the enrichment of mixed feed for young Large White pigs of the experimental groups with zinc chelate contributes to the increase of slaughter indices and improves the morphological composition of the carcasses. The highest rates were found in the 5th experimental group of animals. The chemical composition of meat and lard of pigs fed with different levels of zinc chelate is shown in Table 5. An analysis of the meat chemical composition showed that its moisture content ranged from 72.4 to 73.4%. The difference was statistically insignificant. A similar pattern is established for the dry matter content. Protein, which increases the biological value of meat, was the highest in the 4th and fif th experimental groups of animals; it was higher by 0.9% compared with the control analogs. The value of this indicator in the second and third experimental groups of pigs was higher by 0.2% and 0.3%, respectively, compared to the control. The highest fat content from the longest muscle of the back was found in the first control group of animals and was 4.84%. This indicator was slightly lower in the second, third, fourth, and fifth experimental groups of pigs; it was lower by 0.54%, 1.06, 1.89 ($p \leq 0.05$), and 2.01% ($p \leq 0.05$), respectively.

Table 5. Chemical composition of pigs meat and lard, X±Sx (n=3)

Index	Group				
	control	experimental			
	1	2	3	4	5
		Meat			
Moisture, %	72.4±0.44	72.7±0.28	73.1±0.34	73.3±0.48	73.4±0.25
Dry matter, %	27.6±0.40	27.3±0.51	26.9±0.37	26.7±0.58	26.6±0.42
including protein, %	20.8±0.36	21.0±0.41	21.1±0.64	21.7±0.30	21.7±0.32
fat, %	4.84±0.152	4.30±0.12	3.78±0.08	2.95±0.17*	2.83±0.12*
ash, %	1.96±0.018	2.00±0.11	2.02±0.04	2.05±0.14*	2.07±0.08*
		Lard			
Moisture, %	5.86±0.235	5.86±0.422	5.81±0.291	5.75±0.384	5.75±0.417
Protein, %	1.54±0.122	1.59±0.173	1.67±0.154	1.88±0.094	1.93±0.091*
Fat, %	92.6±0.49	92.6±0.68	92.5±0.67	92.4±0.55	92.3±0.91

Note: * – p≤0,05 compared with the control group

A significant difference was seen in the ash content in the meat of the control and experimental groups, which can be explained by better absorption of zinc chelate. The highest ash content was determined in the 5th group of animals; it was 2.07% ($p \leq 0.05$). In the second, third and fourth groups of animals, this index exceeded the control by 0.04%, and 0.06, and 0.09%. Lard of the animals from the control and experimental groups differed insignificantly in chemical composition from the control. Protein content was highest in the lard of animals from the 5th experimental group and amounted to 1.93%, which is more by 0.39% ($p \leq 0.05$) than analogs from the 1st control group. There is no significant difference between the mass of the internal organ of pigs in the groups (Table 6). The results of the studies indicate a positive effect of the addition of organic-mineral origin of the mixed-ligand complex of Copper on the growth and development of young pigs on fattening. The animals had the highest live weight, which fed the Copper bathrobe in the amount of 21.2 and 15.4 g/t of compound feed, which covered the Copper deficit in the diet by 55 % and 40 %. Animals at the age of 150 days had a live weight of 2.3 % and 1.9 % more, respectively, compared to the same indicator in the control group (Podkhaliuzina O.M. et al., 2020).
Our research is consistent with the research of other scientists, so we can say that zinc chelate has a positive effect on the productive qualities of pigs for fattening.

Table 6. Characteristic of pigs internal organs mass, X±Sx (n=3).

Index	Group				
	control	experimental			
	1	2	3	4	5
Liver, kg	1.97±0.140	1.97±0.121	1.95±0.315	1.95±0.285	1.93±0.347
Heart, kg	0.25±0.042	0.25±0.053	0.23±0.142	0.23±0.047	0.22±0.119
Lungs, kg	0.34±0.05	0.34±0.05	0.34±0.05	0.34±0.05	0.34±0.05
Kidneys, kg	0.23±0.005	0.24±0.007	0.24±0.011	0.23±0.032	0.23±0.026
Spleen, kg	0.13±0.01	0.12±0.02	0.12±0.01	0.11±0.03	0,11±0,02
Stomach, kg	0.75±0.12	0.78±0.08	0.80±0.05	0.83±0.11	0.85±0.07
Small intestine: mass, kg	1.08±0.02	1.14±0.03	1.18±0.05	1.20±0.04	1.22±0.03
length, m	12.0±0.28	11.3±0.15	11.3±0.32	11.6±0.22	11.8±0.25
Large intestine: mass, kg	1.80±0.22	1.85±0.24	1.90±0.20	1.98±0.27	2.05±0.31
length, m	2.28±0.54	2.28±0.34	2.32±0.48	2.32±0.52	2.40±0.41

The experiment results in establishing optimal doses of zinc chelate indicate that this nutritional feed supplement provides animal productivity and has a specific effect on the mass of internal organs. However, there were no deviations from the norm in the experimental groups of pigs than in control. Considering that the liver performs metabolic, antibacterial, antitoxic, regenerative, and other functions, changes in the mass of this organ in the control and experimental groups of pigs ranged at 2.0%. There is an insignificant difference between the animals from the control and experimental groups. Analysis of heart, lungs, kidneys, and spleen mass indicates no significant differences between the control and experimental groups. The mass of internal organs in the experimental groups of pigs was at the level of control, and the differences between animals of different groups during biometric processing were statistically insignificant ($p \geq 0.05$).

Regarding the mass of digestive organs, it should be noted that pigs consumed different levels of zinc chelate had a larger mass of stomach, small and large intestine. The highest index of the mass compared with the control was in the 5th experimental group of pigs which consumed mixed feed containing zinc chelate in 83.2 g/t. Thus, animals from the 2nd-4th experimental groups by mass of the stomach exceeded the control by 4.0-10.7%. In the 5th group of pigs, this indicator was higher by 13.3%. It was compared with the control. By the mass of small intestine animals from the 2nd experimental group exceeded control analogs by 5.6%, and animals from the third, fourth, and fifth groups by 9.3%, 11.1, and 12.9%, respectively; the most significant length of small intestine was11.8 m found in the 5th experimental group of pigs. By the mass of the large intestine, animals from the second experimental group exceeded control analogs by 2.8%, from third by 5.6%, from fourth by 10.0%, and from fifth – by 13.9%. The most considerable length of the large intestine was 2.4 m found in the 5th experimental group of pigs.

Conclusion

During the experimental period, the experimental animals showed a high intensity of growth seen from the dynamics of live weight in each month of fattening. The balance of diets can explain this with the essential nutrients and zinc chelate on the basic life processes: hematopoiesis, growth and development of the body, metabolism of proteins, fats, and carbohydrates, energy metabolism, and maintenance of the organism natural resistance. The best indicators of the growing intensity and conversion of feed were established in the 5th experimental group of pigs, where the zinc chelate in the amount of 83.2 g/t was added into mixed feeds. Feeding zinc in the form of an organic chelate in the mixed feed for young Large White pigs in the process of fattening increases slaughter indices, meat yield, and its chemical composition. It should be noted that the indexes of Large White pigs consumed doses of zinc chelate in the amount of 83.2 g/t in the mixed feed exceeded significantly control.

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