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Cluster Chelates Based on Microelements (Fe, Co, Cu) and Natural Raw Materials

I.Beshkenadze, N.Zazashvili, M.Gogaladze, N. Klarjeishvili, M.Chichakua, M.Chikaidze,

***Abstract*— The methods of the synthesis are demonstrated, and cluster chelate compounds of Fe, Co, and Cu are synthesized based on the metals acetates and plant-derived (complex of biologically active materials, nucleoplasmic and nano-cytoplasmic compounds of plant stem (embryonic, germ) cells) substance "DAS". Depending on the synthesis conditions, different amounts of metals are combined in the synthesized compounds. The individuality of synthesized compounds is studied using the microelement analysis, radiographic and melting temperature methods. The qualitative solubility of compounds in various solvents has been studied as well.**

To estimate the biological activity of synthesized cluster chelates in rabbits, preliminary research was carried out.

For the experiment, 30-day-old rabbits were selected by the principle of analogs. For the testing purposes were formed two groups of rabbits: I - experimental (feeding by combined food was balanced with a premix containing cluster chelates) and II - control (feeding by farm food). In each group were 10 animals. The rabbits were firstly weighed after 15 days since grouping at the age of 45 days, and the next weighing were at the age of 60; 90; and 120 days.

The study of live weight dynamics showed that the growth and development rates of the experimental group had an obvious advantage over the control group. Based on the analysis of the obtained results, we can conclude that supplementation of cluster chelates in the combined feed premixes of rabbits has a positive effect on the growth and development of their live weight and resistance. The optimal amounts of chelated microelements in the premix calculated on 100 kg of food are found as well.

The expediency of carrying out the main experiment to determine the rabbits average weight gain, feed uptake, and compensation during the growing is supposed.

***Index Terms*— Cluster, Chelate, Nucleoplasmic, "DAS", Germ cells, Rabbit, Microelement, Premix.**

I. INTRODUCTION

Obtaining environmentally safe agricultural products with high quantitative and qualitative indicators is a current problem. Farm poultry and animal provision with the feed containing defined qualitative, quantitative composition and optimal ratio of the microelements is one of the important issue for this challenge. It is possible by creating and using premixes containing chelated microelements.

It is known that the role of microelements for a living organism is significant and the rate of their absorption by the organism depends not only on its quantity, but mostly on the chemical form of the substance to be assimilated.

Premixes contain chelated or non-chelated microelements. Non-chelated microelements are not eco-safe, are toxic, have a low degree of assimilation (7-10%), while microelements in chelated form are eco-safe, are not toxic, have a high degree of assimilation (60-70%). The superiority of the chelated form is confirmed by the researches of our scientific group [10–15] along with scientists working in this field [1–9]. For the reason of the positive factors (such as diversity of the composition of natural raw materials and consequently high biochemical activity, cheapness and availability), as a research object, we have selected complex of absolutely different, completely new biologically active substances of plant derivation, obtained from cereals on the basis of the Research Center for Biorational Technologies, nucleoplasmic and nano-cytoplasmic compounds of plant stem (embryonic, germ) cells, referred to in this article as "DAS". It is distinguished by its diversity of heterocyclic compounds, different classes of organic substances, and accordingly, high biological and chemical activity [16–19].

Considering the factors mentioned above, our scientific team has obtained "DAS" and metals (manganese, zinc, and chromium) based cluster-type chelates and studied a number of their physical-chemical properties. In order to study their biological activity, experiments have been carried out on earthworms and broiler chickens [20].

II. COMPUTATIONAL METHOD

✓ Microelement analysis - to determine the percentage of metal in synthesized compounds;
✓ Determination of melting temperature and radiographic studies - to determine the individuality of chelates;
✓ Solubility - to determine the qualitative solubility of chelate compounds in various solvents;
✓ Weighing method - to study the dynamics of a live weight of rabbits.

III. RESULTS AND ANALYSIS

As the Laboratory of Agrarian Chemistry carrying out studies for creating and testing premixes of a new generation in the frame of synthesis special conditions, so-called homogeneous cluster-type chelate compounds of Fe, Co and Cu according to the conditions of synthesis, were obtained based on metal acetates and "DAS", where different numbers of metal atoms are related to each other following the appropriate terms of synthesis (Tab. 1).

I.Beshkenadze, M.Gogaladze, N. Klarjeishvili, L.Gogua, iv. javakhishvili tbilisi state university, P. Melikishvili Institute of Physical and Organic Chemistry , Tbilisi Georgia
N.Zazashvili, M.Chichakua, M.Chikaidze, Biorational Technology and Research Centre, Tbilisi Georgia
L.Gogua, Tbilisi State Medical University, Tbilisi Georgia

Table 1

Metal percentage in cluster chelates		
Ratio of Reacting Components	Synthesis conditions	Metal
		%
0.02 mole $Fe(CH_3COO)_2 \cdot 4H_2O$+20ml. Ds*	Evapor. in water bath	11.00–24.07
	Separation	39.04–46.48
0.02 mole $Co(CH_3COO)_2 \cdot 2H_2O$+20ml. Ds	Evapor. in water bath	16.09–30.24
	Separation	33.30–47.09
0.03 mole $Cu(CH_3COO)_2 \cdot H_2O$+20ml. Ds	Evapor. in water bath	16.19–30.03
	Separation	33.64–47.46
Ds* -"DAS"		

As the tab.1, in the ratio of 0.02mole $Fe(CH_3COO)_2 \cdot 4H_2O$+20ml.Ds of reacting components, the percentage of iron in the compounds obtained by evaporation on a water bath varies between 11.00-24.07%, and in the compounds obtained by separation, it is in the range of 39.04 - 46.48%. In the ratio of 0.02mole $Co(CH_3COO)_2 \cdot 4H_2O$+20ml.Ds, the percentage of cobalt in the compounds obtained by evaporation on a water bath varies in the range of 16.09-30.24%, and in the compounds obtained by separation, it varies between 33.30-47.09%. In the ratio of 0.03mol $Cu(CH_3COO)_2 \cdot H_2O$+20ml.Ds, the percentage of copper in the compounds obtained by evaporation on a water bath varies in the range of 16.19-30.03%, and in the compounds obtained by separation, it is in the range of 33.64 - 47.46%.

Tab.2 demonstrates some of the physical-chemical properties of cluster chelating compounds. The melting temperature of the compounds of Fe, Cu, and Co obtained by the separation method is $>300^0$c. As for the compounds obtained by evaporation of the same metals, they are sticky and melt at a much lower temperature ranging between about $70\text{-}120^0$c. Some regularity is observed with the solubility of compounds obtained by separation and evaporation methods in various solvents. In particular, the compounds obtained by the evaporation method are characterized by good solubility in water, while the compounds obtained by separation are practically insoluble. Compounds obtained using any above mentioned methods are characterized by low or poor solubility in organic solvents.

Table 2

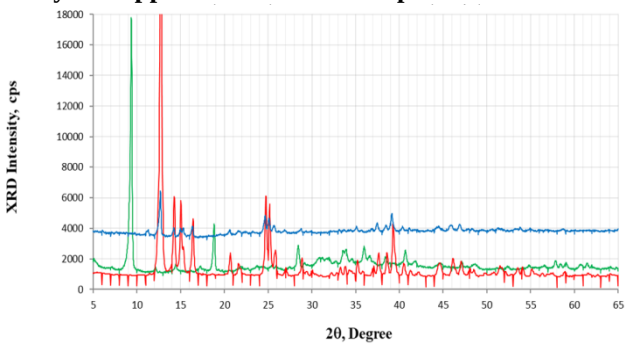
Some Physico-chemical Properties of Cluster Chelates						
Chelates	Color	Melting	Solubility			
		T °c	Water	EtOH	Acetone	DMFA*
Fe·Ds(by evaporation)	Light brown	120	+	Poor sol.**	Poor sol.	Poor sol.
Fe·Ds (by separation)	Brown	> 300	-	-	-	-
Co·Ds(by evaporation)	Light pink	80	+	Poor sol.	Poor sol.	Poor sol.
Co·Ds (by separation)	Dark pink	> 300	-	-	-	-
Cu·Ds (by evaporation)	Light blue	70	+	Poor sol.	+t	Poor sol.
Cu·Ds (by separation)	Dark bluish-green	> 300	+t	Poor sol.	Poor sol.	Poor sol.

DMFA * - Dimethylformamide

Poor sol.** - Poor soluble

Along with melting temperature the X-ray analysis is used to determine individuality as well. X-ray diffractometric study was performed using DRON-4.07 on Cukα (λ=0.154184 nm) radiation. During the exposure, the samples were rotating on their plane through a special device - GP-13. Diffractograms of initial chelates were also taken for comparison. As the figures [Fig. 1–3] show, copper - chelates obtained by separation of "DAS" and evaporation, as well as the diffractograms of their initial salt (copper acetate), are very different from each other (Fig. 1).

X-ray of Copper -DAS chelate compounds

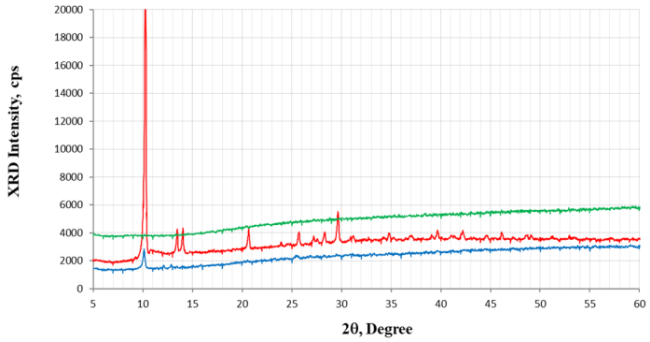


—Cu-acetate, —Cu·Ds(via selection), —Cu·Ds (via evapor.)

Figure 1

Cobalt - diffractograms of chelates obtained by "DAS" evaporation do not contain the diffraction maximums characteristic to the initial compound (cobalt acetate), while the chelate obtained by separation is a solid amorphous substance [Fig. 2].

X-ray of Cobalt -DAS chelate compounds

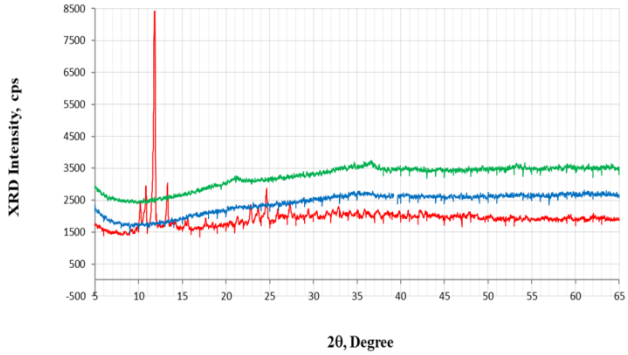


—Co-acetate, —Co·Ds(via selection), —Co·Ds(via evapor.)

Figure 2

Iron acetate diffractogram characterizes by sharply expressed peaks. Whereas iron – "DAS"-containing chelated compounds obtained by both evaporation and separation methods are amorphous, solid substances [Fig. 3].

X-ray of Iron -DAS chelate compounds



— Fe-acetate, — Fe·Ds (via selection), — Fe·Ds (via evapor.)

Figure 3

Based on the diffractograms analysis, it can be conclude that the clusters obtained by the separation and evaporation of copper-"DAS", cobalt-"DAS" and iron -"DAS" are individual compounds.

To study the biological activity of the synthesized cluster chelate compounds, mixtures based on iron, cobalt, copper cluster chelates, and manganese, zinc, and chromium compounds of the same type previously synthesized by our research team [20] were added to rabbit combined feed premixes. According to the detailed feeding norms for experimental rabbits, the number of chelates in grams per 90 days was calculated:

m(Mn·Ds) = 15.74g	m (Zn·Ds)= 12.87g
m(Fe·Ds) = 30.05g	m(Co·Ds) = 0.4732g
m(Cu·Ds) = 1.83g	m (Cr·Ds)=0.57g

The purpose of the preliminary studies was to observe the growth, development and resistance of the rabbits, as well as to determine the effective and optimal doses of chelate microelements included in the premix.

For the experiment, 30-day-old rabbits were selected by the principle of analogs. For the testing purposes were formed two groups of rabbits: I - experimental (feeding by combined food was balanced with a premix containing cluster chelates) and II - control (feeding by farm food). In each group were 10 animals. The rabbits were firstly weighed after 15 days since grouping at the age of 45 days, and the next weighing were at the age of 60; 90; and 120 days.

Table 3

Dynamics of live weight of Rabbits, kg				
Groups	Dynamics of live weight (kg) Age (day)			
	45	60	90	120
I-experimental	0.96±0.01	1.57±0.02	2.37±0.07	3.85±0.07
II - control	0.95±0.01	1.44±0.01	2.12±0.09	3.00±0.02

At the beginning of the experiment, the live weightes of adolescents were almost equal and ranged from 0.96 to 0.95 kg. In the testing period, the advantage was expressed in the experimental group.

A study of live weight dynamics showed that growth and development rates throughout the testing period were regular, with an obvious advantage of the experimental group over the control one.

Thus, based on the results of the preliminary studies, we can conclude that the inclusion of cluster cheetahs obtained based on "DAS" and microelements (Mn, Zn, Fe, Co, Cu, Cr) in the combined feed premixes has a positive effect on the growth of an animal live mass and its resistance.

The obtained results of the preliminary studies on rabbits, give possibility to provide the number of chelated microelements in the premix prepared by our research team, calculated on the 100 kg of food:

m(Mn·Ds) = 11.83g	m (Zn·Ds) = 9.6g
m(Fe·Ds) = 22.59g	m(Co·Ds) = 0.3558g
m(Cu·Ds) = 1.38g	m (Cr·Ds) = 0.4286g

IV. CONCLUSION

According to the presented research, we can conclude:

- ✓ On the basis of microelements (Fe, Co, Cu) and "DAS" are obtained so-called homogeneous cluster chelating compounds where atoms of the same metals are interconnected, the number of which depends on the conditions of synthesis. The melting temperature and solubility in various solvents depend on the number of atoms in the compounds as well. In atomic clusters, metal atoms are in coordination with the various classes of organic compounds contained "DAS". By the relevant synthesis, it is possible to obtain not only homonuclear, but also heteronuclear clusters with identical and different ligands following to cluster chelated compounds with a planned, desired quantitative/qualitative composition and, consequently, with the required biological activeness in the frame of appropriate synthesis conditions.

By the studies of the biological activity of chelated mixtures of microelements (Mn, Zn, Fe, Co, Cu, Cr) synthesized on the basis of "DAS" has established:

- ✓ The inclusion of cluster cheetahs based on the microelements (Mn, Zn, Fe, Co, Cu, Cr) and "DAS" into combined rabbit food premixes, as a part of food, improves the live weight, growth dynamics and increases resistance because of these ones improve the physiological condition of rabbits, slows down the passage of the food mass in the gastrointestinal tract (prolongation effect), and consequently increase the quality of food absorption, reducing toxicity, increasing the resistance of the immune system, and reducing food consumption.
- ✓ The appropriateness of carrying out the main experiment based on the analysis of the preliminary studies to determine the average weight of rabbits, food uptake, and compensation during the growing period.
- ✓ Recipe for the optimal amount of mixture of cluster chelating microelements (Mn,Zn,Fe, Co,Cu,Cr) in the premix calculated for 100kg of food.
- ✓

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