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THE WAY FOR BISMUTH NANOPARTICLES USAGE IN THE TECHNOLOGY OF BROILER-CHICKENS GROWTH

The article presents results of estimation of experimental spherical 40 nm BiNP usage in the technology of broiler chickens growth in compare with traditional scheme of the growth technology. Cross Cobb-500 broiler chickens have been used for investigation. It has been revealed that usage of experimental BiNP substance in the broiler chickens growth technology enhance growth and survival value of the poultry during all period of the feeding and stimulate increase in body weight under the conditions of absence of antibiotics' and hormones' use in the chicken growth technology. Experimental BiNP substance has been characterized as safe for broiler chickens as well as for potential consumers: content of bismuth was not fixed in the organs and tissues.

Keywords: *bismuth nanoparticles, Cross Cobb-500, broiler chickens, growth technology, survival value, body weight increase.*

Introduction. The modern market of poultry products in Ukraine as well as in the world is characterized by increasing supply and demand for poultry meat [1]. Poultry meat is a dietary and cheaper compared to other protein products. These features characterize poultry as economically attractive and promising area of livestock.

According to the statistical data in Ukraine the poultry farms in different ownership had about 126.0 million heads at the beginning of 2000. At the corresponding period in 2013 this index exceeded the 230.3 million heads [2].

The growth of this industry is observed also in the major producing countries – the USA, China, EU and Brazil, where the volume of poultry meat production is estimated at an average of 15–20 million tons per year [3].

The advantage of poultry species is given to chickens growing. The average part of chickens is about 80–90% [4].

The development of broiler industry is associated with broilers' high dietary, nutritional quality and economic advantages in compare with other types of the poultry meat production. Broilers are characterized by precocity, efficient use of feed,

relatively low cost of feed per unit of production, rapid reversibility of circulating assets as well as high profitability of the production [3, 4].

However, in spite of the positive trends in the poultry market, some constraints of its development exist. In most cases, it is concerned to increase production costs.

It is difficult to achieve the desired economic effect even using modern growth technologies for poultry breeding. In poultry industry the costs first of all depend on feed costs.

Significant threat for the profitability of poultry production is provoked by various diseases of young birds. Infectious diseases of the broiler chickens can cause significant loss of head number [5, 6].

This leads to the necessity to use the large number of different stimulators and growth factors based on antibiotics throughout the all production cycle of broiler chickens growth.

At the same time, the spread of pathogen strains, which are resistant to the traditional antimicrobial agents, spreading of cross-resistance microorganisms and accumulation of antibiotics in poultry products lead to the search of new effective alternative biostimulators, which could enhance growth and natural resistance of chickens' organism, could be used for prevention of vitamin and mineral insufficiency and for stimulation of feed assimilation-dissimilation, and have high antimicrobial activity against wide spectrum of pathogens – causative agents of the most widespread infectious diseases in poultry.

Only the introduction of new evidence-based rational technological approaches in growing and keeping of broiler chickens will provide along with safety of products at all stages from «farm to fork» obtaining of high indexes of poultry productivity with a minimum cost of material and labour resources.

The usage of nanotechnologies developments, in particular – metal nanoparticles – in the industrial poultry can be one of these approaches. Taking into account high antimicrobial activity of the synthesized spherical 40 nm bismuth nanoparticles [7] they can possess high potential in this area.

The goal of the work was investigation of the way for bismuth nanoparticles usage in the technology of broiler-chickens growth.

Materials and methods of research. In this study, spherical bismuth nanoparticles (BiNP) with average particle size 40±2.0 nm and 100% of Bi content in the particle have been used. BiNP have been synthesized by the method of chemical condensation in water medium according to the original protocol developed in F.D. Ovcharenko Institute of biocolloidal chemistry. The concentration of obtained BiNP was 77.5 mg/ml. BiNP are possessed by high bactericidal action against wide spectra of pathogen microorganisms including *Salmonella*, *Escherichia*, *Pasteurella* etc. Along with high antimicrobial effectiveness, BiNP is characterized as biosafe according to the parameters of cytotoxicity, genotoxicity, mutagenicity and LD_{50}.

Effectiveness of the experimental BiNP substance usage in industrial poultry has been investigated in the technology of cross Cobb-500 broiler chickens growth. 150 daily chickens from Hungary breeding farm have been used in experiments.

During the experiment, all poultry have been divided into 3 groups:

1 group – 50 heads – control – chickens which have been grown under standard technology: from the 1 to 3 day young birds obtained with water antibiotic enrofloxacin 20%. From 5 to 7 day chickens obtained with water vitamin «Miksovit»;

2 group – 50 heads – experiment 1 – during the growth cycle chickens in this group obtained experimental substance of BiNP with initial concentration 77.5 mg/ml with 3 ml water content in the substance per 1 L of water every day from the 1st day during 25 days. Terminal concentration of bismuth nanoparticles in water was 0.23 mg/ml by the metal. From 5 to 7 day chickens also obtained vitamin «Miksovit» with water;

3 group – 50 heads – experiment 2 – during the growth cycle chickens in this group obtained experimental substance of BiNP with initial concentration 7.75 mg/ml with 3 ml water content in the substance per 1 L of water every day from the 1st day during 25 days. Terminal concentration of bismuth nanoparticles in water was 0.023 mg/ml by the metal. From 5 to 7 day chickens also obtained vitamin «Miksovit» with water.

All poultry had free access to the water and obtained feed with the same composition: from 1 to 10 day of feeding – feed Start PK-5-1; from 11 day before the end of feeding – feed «Growth».

All feed was free from hormones and synthetic growth stimulators.

For estimation of experimental BiNP effectiveness usage in the technology of broiler-chickens growth the below parameters have been analysed:

- survival value of the poultry – everyday control;
- increase in body weight – control once per 3 days;
- BiNP distribution and accumulation in the organs and tissues of the experimental groups of chickens – on the 30st day of the growth cycle in compare with control group (by the method of atomic absorption spectrometry of the mineralized tissues according to the standard protocol).

Results of research and discussion. Estimation of analyzed parameters of the broiler chickens in both experimental groups (both studied BiNP concentrations) showed high efficacy of the BiNP usage in growth technology of broiler chickens compared to the traditional scheme (control).

Chickens from both experimental groups, which got BiNP with water in terminal concentrations 0.23 mg/ml by metal (experiment 1) and 0.023 mg/ml by metal (experiment 2) during all period of the observation are characterized by significant improvement in vital signs: appetite, mobility, quality of fluff in compare with the control group.

Figure 1 shows the 10-days old chickens of the experimental groups.

Fig. 1. The 10-days Cobb-500 broiler chickens from the experimental groups obtained the BiNP experimental substance with water.

Survival value of the poultry during all period of the observation was 100% for both control and experimental groups.

It is necessary to note that in the control group improvement of survival value has been shown due to the use of antibiotics in the first critical days of chickens' growth.

100 % of «Survival value» parameter in experimental groups has been achieved due to the use of experimental BiNP in the chickens' growth technology.

Increase of the «average increase in body weight» parameters of chickens in experimental groups has been revealed compared with control (table 1).

Obtained data shown that during the 1st 10 days of the feeding, the average increase in chickens' body weight of the both experimental groups was on the level of control (standard technology using antibiotic enrofloxacin 20%).

During the last period of feeding it has been observed more expressed gradual increase in average body weight of broiler chickens from both experimental groups compare with the control.

Finally, after 29 days of growth, average body weight of the chickens was by 23.5% higher in the 1st experimental group and by the 22.4% higher in the 2nd experimental group compare with such parameter for the Control group, which was grown using the traditional scheme (table 1).

Thus, the usage of experimental BiNP substance in the broiler chickens growth technology enhance growth and survival value of the poultry during all period of the feeding and stimulate increase in body weight under the conditions of absence of antibiotics' and hormones' use in the chicken growth technology. The BiNP usage with water in terminal concentration 0.23 mg/ml by the metal can be recommended based on the obtained results.

Table 1

Increase in body weight and Survival value of the Cobb-500 broiler chickens, which have been grown under standard technology (using antibiotic enrofloxacin 20%) and using BiNP experimental substance

Age, days	Control - standard technology of growth				Experiment 1 –BiNP usage with water – terminal concentration 0.23 mg/ml by the metal				Experiment 2 –BiNP usage with water – terminal concentration 0.023 mg/ml by the metal			
	Average body weight, g	Survival value, %	Increase in body weight, g	Increase in body weight, %	Average body weight, g	Survival value, %	Increase in body weight, g	Increase in body weight, %	Average body weight, g	Survival value, %	Increase in body weight, g	Increase in body weight, %
1	34,57	100	-	-	33,56	100	-	-	33,48	100	-	-
3	41,5	100	6,93	20,0	38,30	100	4,74	14,1	38,58	100	5,1	15,2
5	49,39	100	7,89	19,0	47,12	100	8,82	23,0	45,94	100	7,36	19,0
7	54,0	100	4,61	9,3	53,65	100	6,53	13,9	51,77	100	5,83	12,7
9	66,53	100	12,53	23,2	66,59	100	12,94	24,1	65,2	100	13,43	25,9
11	81,39	100	14,86	22,3	76,65	100	10,12	15,2	77,39	100	12,19	18,7
14	127,36	100	45,97	56,5	127,5	100	50,85	66,3	128,35	100	50,96	65,8
16	164,73	100	37,37	29,34	176,3	100	48,8	38,3	168,66	100	40,31	31,4
18	208,06	100	43,33	26,3	225,42	100	49,12	27,9	237,13	100	68,47	40,6
20	301,76	100	93,7	45,0	309,58	100	84,16	37,3	321,56	100	84,43	35,6
22	365,58	100	63,82	21,1	403,8	100	94,22	30,4	413,28	100	91,72	28,5
24	479,2	100	113,62	31,0	502,35	100	98,55	24,4	510,97	100	97,69	23,6
29	**729,5**	100	250,3	52,2	**901,17**	100	398,82	79,4	**892,65**	100	381,68	74,7

The typical photo of 30-days Cobb-500 broiler chickens from the experimental groups obtained with water experimental BiNP substance is presented on figure 2.

Fig. 2. 30-days Cobb-500 broiler chicken from the experimental group that obtained experimental BiNP substance with water.

Analysis of the BiNP distribution and accumulation in the organs and tissues of the experimental groups of chickens has been done by atomic absorption spectrometry on 30th day of the growth cycle compare with control. Obtained results shown that BiNP accumulation was not registered in organs and tissues of the chickens from experimental groups: content of bismuth was not detected. So, experimental BiNP substance can be characterized as safe for broiler chickens as well as for potential consumers.

Conclusions and prospects for further research. Results of estimation of experimental spherical 40 nm BiNP usage in the technology of Cross Cobb-500 broiler chickens growth in compare with traditional scheme shown that usage of BiNP substance enhance growth and survival value of the broiler chickens during all period of the feeding and stimulate increase in body weight under the conditions of absence of antibiotics' and hormones' usage in the chicken growth technology.

Experimental BiNP substance has been characterized as safe for broiler chickens and for potential consumers of poultry products: bismuth nanoparticles were not accumulated in organs and tissues of the poultry.

These investigations open new perspectives in the area of development of novel biosafe feed additives for chicken growth technology with high antimicrobial action toward wide spectrum of pathogenic microorganisms, which stimulate survival and growth enhancement.

REFERENCES

1. Ukraine Poultry and Products Annual Report (2014). *thepoultrysite.com.* Retrieved from http://www.thepoultrysite.com/reports/?id=4322.

2. Vinichenko, I., & Makhovsky, D. (2015). Problems and development prospects of poultry farming in Ukraine. *Technology audit and production reserves*, 3/5(23), 62-66.

3. Van Horne, P.L.M. & Bondt, N. (2013). Competitiveness of the EU poultry meat sector. *LEI Report 2013-068*.

4. Poultry Development Review (2013). Food and Agriculture Organization (FAO) of the United Nations. *fao.org.* Received from www.fao.org/docrep/019/i3531e/i3531e.pdf.

5. Lutful Kabir, S.M. (2010). Avian Colibacillosis and Salmonellosis: A Closer Look at Epidemiology, Pathogenesis, Diagnosis, Control and Public Health Concerns. *Int. J. Environ. Res. Public Health*, 7, 89-114.

6. Calnek, B. W. et al. (1991). *Diseases of Poultry.* Iowa State University Press, Ames, Iowa.

7. Rieznichenko, L.S., Gruzina, T.G., & Dybkova, S.M. et al. (2015). Investigation of bismuth nanoparticles antimicrobial activity against high pathogen microorganisms. *American Journal of Bioterrorism Biosecurity and Biodefense*. 2(1):id10045.

СПОСОБ ИСПОЛЬЗОВАНИЯ НАНОЧАСТИЦ ВИСМУТА В ТЕХНОЛОГИИ ВЫРАЩИВАНИЯ ЦЫПЛЯТ БРОЙЛЕРОВ / Резниченко Л.С., Дыбкова С.Н., Рыженко Г.Ф., Нычик С.А., Горбатюк О.И., Андриящук В.А., Жовнир А.М., Грузина Т.Г.

В статье представлены результаты оценки использования экспериментальной субстанции сферических наночастиц висмута 40 нм в технологии выращивания цыплят бройлеров в сравнении с традиционной схемой. Для исследований использованы цыплята-бройлеры кросса Кобб-500. Показано, что использование экспериментальной субстанции BiNP в технологии выращивания цыплят-бройлеров повышает выживаемость и стимулирует рост птицы, а также прирост массы тела цыплят на протяжении всего периода выращивания в условиях отсутствия использования антибиотиков и гормонов. Экспериментальная субстанция BiNP характеризуется как безопасная как для цыплят-бройлеров, так и для потенциального потребителя: содержание висмута не фиксировалось в органах и тканях птицы.

Ключевые слова: *наночастицы висмута, кросс Кобб-500, цыплята-бройлеры, технология выращивания, выживаемость, прирост массы тела*

СПОСІБ ЗАСТОСУВАННЯ НАНОЧАСТИНОК ВИСМУТУ У ТЕХНОЛОГІЇ ВИРОЩУВАННЯ КУРЧАТ-БРОЙЛЕРІВ / Рєзніченко Л.С., Дибкова С.М., Риженко Г.Ф., Ничик С.А., Горбатюк О.І., Андріящук В.А., Жовнір О.М., Грузіна Т.Г.

Вступ. *Висока біологічна активність наноматеріалів робить перспективним їх використання у технологіях вирощування молодняку тварин і птиці.*

Мета роботи. *дослідження шляхів використання наночастинок вісмуту (BiNP) в технології вирощування курчат-бройлерів.*

Матеріали та методи досліджень. *Експериментальна субстанція BiNP 40 нм, використана в роботі, є біобезпечною і виявляє високу бактерицидну активність відносно широкого спектру збудників інфекційних хвороб птиці.*

Дослідження ефективності застосування BiNP у технології вирощування курчат-бройлерів проведено на 150 добових курчатах кросу Кобб-500. Під час експерименту уся птиця була поділена на 3 групи по 50 голів: 1 група (контроль) курчата утримувалась за традиційною схемою: молодняку випоювали з водою антибіотик енрофлоксацин 20%; 2 група (дослід 1) курчата отримували BiNP за кінцевої концентрації у воді 0.23 мг/мл за металом; 3 група (дослід 2) курчата отримували BiNP за кінцевої концентрації у воді 0.023 мг/мл за металом.

Уся птиця отримувала комбікорми однакового складу без гормонів та штучних стимуляторів росту.

Аналізували наступні показники: виживаність поголів'я, приріст маси тіла, розподіл та накопичення вісмуту в органах і тканинах птиці дослідних груп.

Результати досліджень та їх обговорення. *Показано, що застосування експериментальної субстанції BiNP в технології вирощування курчат-бройлерів сприяє стимуляції росту та підвищенню виживаності поголів'я за умов відсутності застосування антибіотиків та гормонів у технології вирощування. При цьому, субстанція є безпечною як для курчат, так і для потенційних споживачів продукції: BiNP не накопичуються в органах і тканинах птиці.*

Висновки та перспективи подальших досліджень. *Виявлена висока ефективність застосування субстанції BiNP у технології вирощування курчат-бройлерів з першої доби. Ці дослідження відкривають перспективи в області розробки нових біобезпечних кормових добавок з високою антимікробною активністю, що стимулюють виживаність та ріст птиці.*

Ключові слова: *наночастинки вісмуту, крос Кобб-500, курчата-бройлери, технологія вирощування, виживаність, приріст маси тіла.*

СПИСОК ЛІТЕРАТУРИ

1. Ukraine Poultry and Products Annual Report. – 2014. – http://www.thepoultrysite.com/reports/?id=4322

2. Vinichenko I. Problems and development prospects of poultry farming in Ukraine / I. Vinichenko, D. Makhovsky // Technology audit and production reserves. – 2015. – No. 3/5 (23). – P. 62–66.

3. Van Horne P.L.M. Competitiveness of the EU poultry meat sector / P.L.M. van Horne, N. Bondt // LEI Report 2013-068. – 2013. – 65 p.

4. Poultry Development Review. Food and Agriculture Organization (FAO) of the United Nations. – 2013. – http://www.fao.org/docrep/019/i3531e/i3531e.pdf

5. Lutful Kabir S.M. Avian Colibacillosis and Salmonellosis: A Closer Look at Epidemiology, Pathogenesis, Diagnosis, Control and Public Health Concerns / S.M. Lutful Kabir // Int. J. Environ. Res. Public Health. – 2010. – Vol. 7. – P. 89-114

6. Calnek B. W. Diseases of Poultry / B. W. Calnek, et al. – Iowa State University Press, Ames, Iowa. – 1991. – 929 p.

7. Rieznichenko L.S. Investigation of bismuth nanoparticles antimicrobial activity against high pathogen microorganisms / L.S. Rieznichenko, T.G. Gruzina, S.M. Dybkova [et al.] // American Journal of Bioterrorism Biosecurity and Biodefense. – 2015. – 2(1):id10045.