БІОТЕХНОЛОГІЇ ТА БІОІНЖЕНЕРІЯ

UDC 631.894:598.2:616.995.1

Cultivation of worms on a substrate containing poultry droppings fermented with addition of biodestructors

Merzlov S., Osipenko I., Merzlova H.

Bila Tserkva National Agrarian University

E-mail: Merzlov S. serhii.merzlov@btsau.edu.ua; Osipenko I., innaosipenko1987@gmail.com;
Merzlova H. halyna.merzlova@btsau.edu.ua

OPEN ACCESS

Мерзлов С.В., Осіпенко І.С., Мерзлова Г.В. Вирощування черв'яків на субстраті з вмістом посліду птиці ферментованого за участі біодеструкторів. Збірник наукових праць «Технологія виробництва і переробки продукції тваринництва», 2022. № 2. С. 51–57.

Merzlov S., Osipenko I., Merzlova H. Cultivation of worms on a substrate containing poultry droppings fermented with addition of biodestructors. «Animal Husbandry Products Production and Processing», 2022. № 2. PP. 51–57.

Рукопис отримано: 21.09.2022 р.
Прийнято: 05.10.2022 р.
Затверджено до друку: 27.12.2022 р.

doi: 10.33245/2310-9289-2022-175-2-51-57

Significant accumulations of poultry droppings near large poultry enterprises are a problem both in Ukraine and abroad. An urgent issue is the search for rational methods of disposal of these wastes with the involvement of natural, ecologically safe methods such as composting with the use of microorganisms and vermiculture. The use of microorganisms during the fermentation of broiler chicken droppings with litter (in the form of sawdust of non-coniferous trees) leads to a reduction of time for preparation of organic biomass for vermiculture. However, it is of scientific and practical interest to establish the effectiveness of growing worms on a substrate containing broiler chicken droppings fermented with various doses of microorganism preparations compared to the option where the droppings were fermented in the traditional way during 18 months.

During the research, 4 groups were formed with 4 micro-beds in each. The weight of the compost and the volume of the micro-beds were identical. In the control version, the compost contained 92.0 % (by weight) of broiler chicken manure fermented during 18 months and 8.0 % of shredded wheat straw. In the experimental micro-beds, the ratio of manure to straw was identical by mass, however, the manure was fermented during 180 days using 143, 1430 and 2860 mg of bio-destructors per ton of biomass. The influence of broiler chicken droppings on the number of sexually mature and immature worms, their mass and the number of laid cocoons was studied for 100 days. The content of protein, biotic metals, and toxic metals in vermiculture biomass was studied.

It was proven experimentally that the inclusion of broiler chicken droppings with a litter of fermented droppings in the amount of 2860 mg/t of bio-destructors leads to an increase in the number of sexually mature and immature worms in the micro-bed and their mass by 45.5 and 29.3 % respectively, and 63.9 and 56.7 % relatively to the control where the litter was fermented during 18 months. Cultivation of vermiculture on compost with manure fermented for 180 days (III experimental group) makes it possible to obtain 41.4 % more cocoons and 17.1 % more cocoons compared to the control group. The biomass of worms grown on compost containing manure fermented with the highest dose of bio-destructors probably did not differ by the content of biotic metals and toxic metals.

Key words: worm cocoons, protein, biotic metals, toxic metals, bio-destructors, vermiculture, compost.

Problem statement and analysis of recent researche. The dynamic development of poultry farming in most countries of the world leads to the accumulation of significant volumes of litter with and without bedding in limited areas [1, 2]. In Ukraine, the issue of the accumulation of poultry droppings in limited areas is also quite relevant. Poultry droppings, especially of broiler chickens, are a source of soil, air and water pollution, while at the same time it contains a significant amount of nutrients for microorganisms, invertebrates, insects and plants. Among the nutrients of poultry droppings there is a certain concentration of proteins, carbohydrates, lipids, macroelements and microelements [3, 4]. Promising methods of rational disposal of broiler chicken droppings are its active composting under the action of a conglomerate of microorganisms and vermiculture [5–7]. Therefore, conducting research aimed at accelerating biotechnological methods of disposal of broiler chicken droppings with the use of bio-destructors and vermiculture is of important scientific and practical importance.

For the implementation of vermiculture, dung worms or a hybrid of the red California worm are used. Worms (vermiculture) belong to the oligochaete group and are hermaphrodites. The alimentary canal of worms runs throughout the body. Worms breathe takes place through the skin, which has a large number of blood capillaries. The mass of a sexually mature individual is from 0.35 to 1.4 g. Sexual maturity of worms occurs in 90–95 days. After mating, each individual forms a cocoon with eggs in the middle (up to 15–22 eggs), and after 15–24 days a new generation appears. Under optimal conditions, worms mate every 8–9 days. The substrate for vermiculture is pre-prepared organic mass [4, 7, 8].

Various prepared (composted) organic wastes are used for the cultivation of vermiculture: crop production (straw, chaff, spoiled hay, spoiled hay, silage, etc), livestock production (poultry droppings, animal manure, and waste from slaughterhouses), industrial and food waste [7, 9, 10, 11].

Vermicomposting involves mesophilic biooxidation of organic waste [12]. The use of worms contributes to the active improvement of soil fertility, increasing the content of humus in them, and increasing the yield of agricultural crops. This is achieved due to the ingress of worm coprolites (biohumus) into the soil. Vermiculture coprolites are an effective organic fertilizer. With coprolites, the soil is enriched with humic, fulvic acids, useful microorganisms, polysaccharides, proteins and nitrogenous substances. The greater the number of earthworms per unit area of the soil, the higher its aeration and fertility is. Water penetration into compacted soils increases. As a result of the action of worms, the mineralization of Nitrogen, Phosphorus and other chemical elements is accelerated, thereby increasing bioavailability for plants [13–16].

It is forbidden to use fresh manure of cattle, horses, pigs, and especially poultry droppings for vermiculture. Before using manure and droppings for worms, it is necessary to ferment them. Traditional fermentation of poultry droppings lasts up to 12–18 months. The use of bio-destructors accelerates the processes of manure fermentation by 2 times [17].

During vermicomposting, worms and microorganisms simultaneously act on organic waste [12, 18]. Studying the possibilities of reducing the production time of organic fertilizer from poultry droppings and increasing the biomass of worms by combining vermicomposting with composting under the action of a conglomerate of microorganisms has economic, ecological and practical significance.

The aim of the study is to establish the effectiveness of growing vermiculture on compost containing broiler chicken droppings fermented with different doses of bio-destructors.

Material and methods of research. The study of the influence of the substrate containing broiler chicken droppings with litter (sawdust of non-coniferous trees) fermented under different conditions was carried out in the vivarium of the Biological and Technological Faculty of Bila Tserkva National Agrarian University. The air temperature in the room was maintained at the level of 22–23 °C. Both in the control and in the experimental groups, 4 micro-beds were formed. For the experiment, sexually mature worms (hybrid red California worms) were used, the average weight of which was 0.72±0.01 g. After mixing the litter of broiler chickens with straw, the humidity of the substrate in all groups was adjusted to 67±0.5 %. Once every two days, aeration of the substrate was carried out in micro-beds. The duration of the experiment was 100 days. At the end of the experiment, sexually mature worms, young and cocoons were counted in each micro-bed (Table 1).

Before determining the content of protein and trace elements in the biomass of vermiculture, worms were cleaned of compost, washed with distilled water and placed in desiccators with crushed, moistened filter paper for 36 hours in order to clean the gastrointestinal tract from humus and coprolites.

The protein content in the biomass of worms was determined by the method of O. Lowry. For this, a homogenate was made from worms [19]. The content of biotic metals (Copper, Zinc, and Ferrum) and toxic metals (Plumbum and Cadmium) in vermiculture biomass was determined using atomic absorption spectroscopy [20]. The mass of worms and their cocoons was determined using techno-chemical and analytical scales.

The obtained research data were processed using standard methods of variation statistics using the Statistica program.

Results and discussion. On the hundredth day of the experiment, it was established that there were an average of 132 sexually mature worms in the control micro-beds. This means that in the first 10 days after settlement, only 3–4 cocoons were formed. Worms hardly mated during this period. When using the litter of broiler chickens fermented with the use of 143 mg/t of bio-destructors for 6 months (I experimental group-micro-beds), the number of sexually mature individuals was 13.6 % higher than in the control one. The fastest adaptation of worms was found in the III experimental group. During the first 10 days, the most cocoons were formed there. Therefore, the number of sexually mature worms was 45.5 % higher than in the control one (Table 2).

The average weight of one sexually mature worm in the control group is 0.71 g. In the first experimental group, this indicator was 5.6 % higher than the control value. The weight of one individual in the II and III experimental groups was the same and amounted to 0.8 g each, which is 12.7 % more than in the control group.

Analyzing the number of worms that had not reached sexual maturity, it was found that the lowest rate was recorded in the control group. Under the cultivation of vermiculture on a substrate fermented with the use of a bio-destructors in the amount of 1430 mg/t (II experimental group), the number of worms was greater than in the control group by 25.4 %. In the III experimental group, the growth of the population was established. The number of immature individuals was 29.3 % higher compared to the data in the control group.

The average weight of worms in the control group that had not reached sexual maturity was 0.033 g. When growing worms on compost fermented with the use of a bio-destructors (I experimental group), the average weight of one individual increases by 12.1 %. The highest average weight of one immature worm was recorded in the III experimental group. The difference with the control one constituted 21.2 %.

Based on the obtained indicators of the number of sexually mature and immature individuals for 100 days of the experiment, it was calculated that for the processing of 1 ton of compost in the control group, it is possible to obtain 41.5 kg of worm biomass. It was calculated that the use of compost obtained by the accelerated method (III experimental group) makes it possible to obtain 28.6 % more of vermiculture biomass.

Table 1 **– Study scheme**

Group of micro-beds	The number of introduced worms in one micro-bed, units	The mass of the substrate in one micro-bed, kg	Characteristic of the substrate
Control group	100	15,0	Fermented litter of broiler chickens for 18 months without the addition of bio-destructors (92.0 % by weight) + crushed wheat straw (8.0 % by weight)
I experimental group	100	15,0	Fermented litter of broiler chickens for 180 days with the addition of bio-destructors – 143 mg/t (92.0 % by weight) + crushed wheat straw (8.0 % by weight)
II experimental group	100	15,0	Fermented litter of broiler chickens for 180 days with the addition of bio-destructors – 1430 mg/t (92.0 % by weight) + crushed wheat straw (8.0 % by weight)
III experimental group	100	15,0	Fermented litter of broiler chickens for 180 days with the addition of bio-destructors – 2860 mg/t (92.0 % by weight) + crushed wheat straw (8.0 % by weight)

Table 2 – **Indicators of growth and development of worms on the 100th day of the experiment,** M±m, n=6

Group-micro-beds	Mature worms in the micro-bed		Immature worms in one micro-bed		Mass of worms, which is grown under processing a ton of the studied substrate, kg
	quantity, units.	mass, g	quantity, units.	mass, g	
Control group	132±2,3	93,7±0,86	3866±56,3	127,6±3,77	41,5
I experimental group	150±3,5	112,5±0,69	4799±74,2	177,6±5,18	45,5
II experimental group	185±2,8	148,0±0,74	4850±65,5	194,0±7,33	50,2
III experimental group	192±4,5	153,6±1,33	5000±70,7	200,0±4,11	53,4

It is possible to judge the intensity of mating of sexually mature worms by the number of cocoons. The lowest number of mating was observed in the control group, where worms were grown on compost containing fermented broiler chicken droppings, for 18 months, on the 100th day of the experiment, the number of cocoons constituted 145 units. The established pattern was that the higher the concentration of the bio-destructors in the litter of broiler chickens, the greater number of cocoons in the micro-bed was. In the III experimental group, the number of cocoons was greater by 41.4 % compared to the control indicators (Fig. 1).

The mass of cocoons correlates with the number of individuals that develop in them. The average mass of cocoons in the 1st experimental group was 7.8 % greater than in the control one. The largest mass of one cocoon was in the III experimental group. The difference with the control one constituted 17.1 % (Fig. 2).

In addition to the influence of different compost on the technological parameters of vermiculture, the chemical composition of worm biomass was also studied. In vermiculture biomass from the control group, the protein content constituted 683 g/kg of dry matter (Fig. 3). Cultivation of worms on compost containing broiler chicken droppings probably did not affect the increase of protein in their biomass. The difference with the control group was within 0.4–1.0 %.

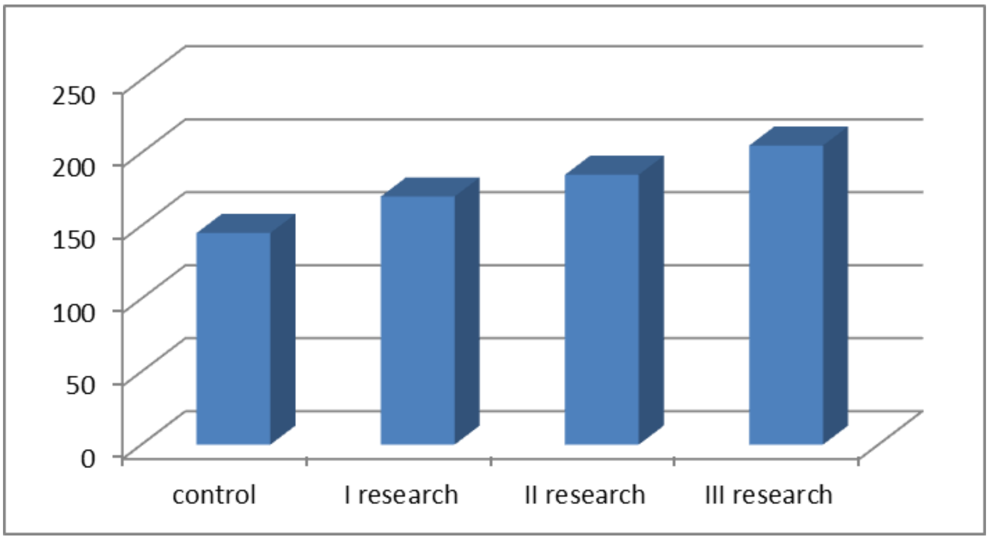

Fig. 1. **Number of cocoons, units.**

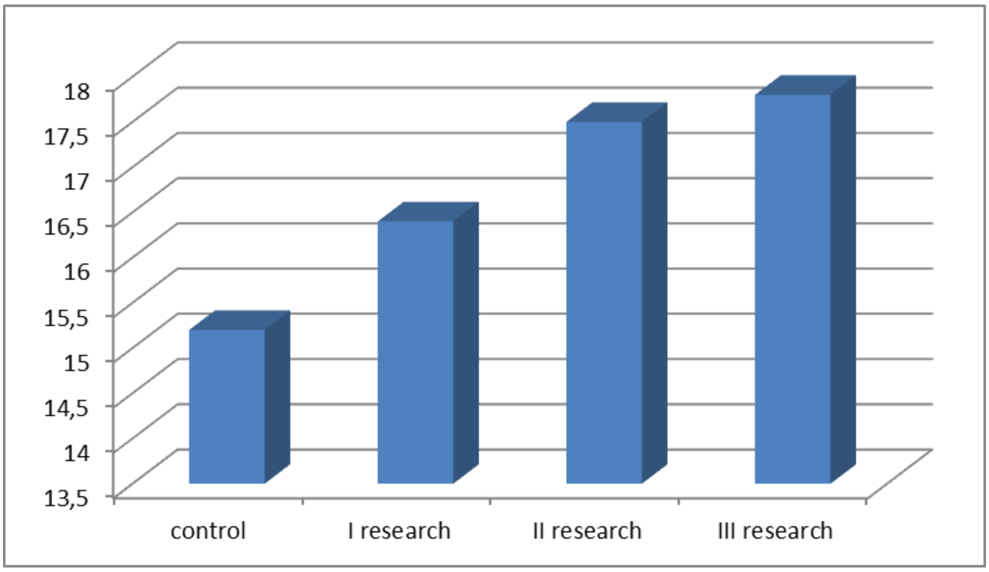

Fig. 2. **Mass of cocoons, mg.**

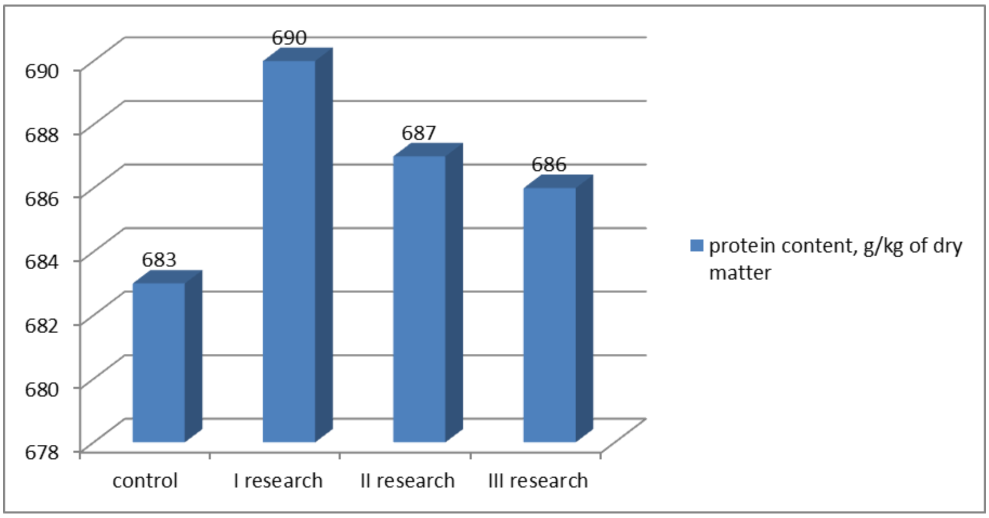

Fig. 3. **Protein content in vermiculture biomass, g/kg of dry matter.**

Among biotic metals, the content of Ferrum, Copper and Zinc in the biomass of worms was determined. The content of copper in worms from the control group was 7.9 mg/kg of dry matter. The lowest metal content was found in vermiculture biomass from the 1st experimental group. The indicator was 12.6 % lower than in the control group, but it was not significantly different from the control. In worms from the II and III experimental groups, the copper content was lower than in the control one by 5.1–7.6 %. The difference had the nature of a trend (Table 3).

Investigating the content of Zinc in the biomass of worms, it was established that the highest rate was recorded in the control group. It has been observed a pattern in the research groups that with an increase in the content of the bio-destructors in the litter of broiler chickens, the content of zinc in worms increases.

The content of Ferrum in vermiculture biomass from the control group constituted 875.5 mg/kg of dry matter. When growing worms on compost with broiler chicken droppings, which was fermented with the highest dose of bio-destructors (III experimental group), the content of Ferrum was lower than in the control group by 1.63 %. The difference was within the margin of error.

Studying the content of Lead it was found that the highest concentration of this toxic metal was in vermiculture biomass from the control group. The lowest content of Lead was recorded in worms from the 1st experimental group. The difference with the control group was 11.6 % and was not probable. It was revealed that with the increase of the destructor during the fermentation of broiler chicken droppings, which is the part of the compost, the metal content increases within the margin of error (Fig. 4).

Cadmium content in the biomass of worms from the control group was at the level of 0.15 mg/kg. In the worms from the experimental groups, the metal content was lower by 6.7–13.3 % compared to the control group. The difference was with in the margin of error.

Table 3 – **The content of biotic metals in the biomass of worms**, mg/kg of dry matter

Group-micro-beds	Metals		
	Copper	Zinc	Ferrum
Control group	7,9±0,48	75,1±2,55	875,5±18,12
I experimental group	6,9±0,52	73,4±3,45	845,2±22,45
II experimental group	7,3±0,39	74,2±1,99	857,4±35,53
III experimental group	7,5±0,37	74,7±4,15	861,2±17,69

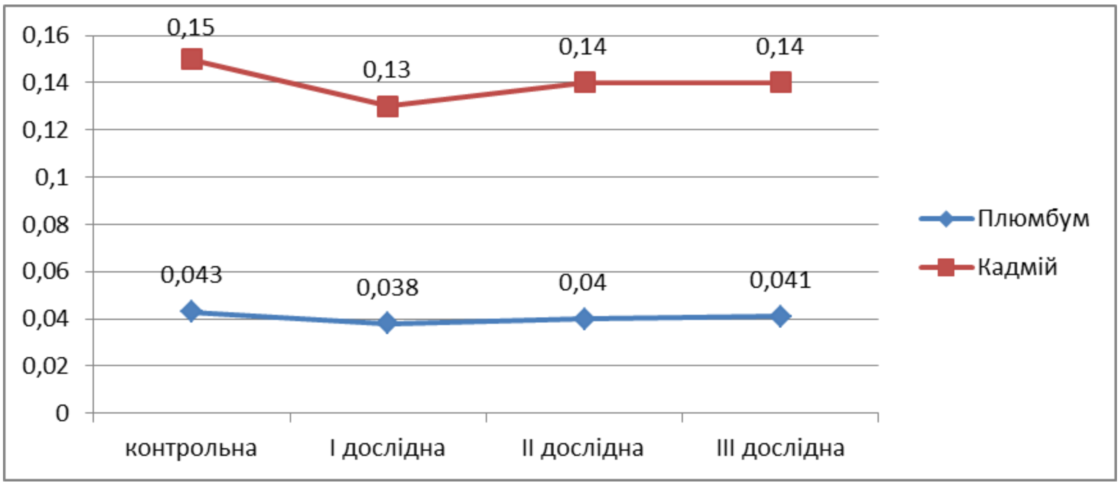

Fig. 4. **Content of toxic metals, mg/kg of dry matter.**

Conclusion. 1. The use of 92.0 % by mass of broiler chicken droppings fermented for 180 days with the use of bio-destructors at the rate of 2860 mg/t as a substrate makes it possible to increase the productivity of vermiculture. This regularity is confirmed by an increase in the number of sexually mature worms and worms that have not reached sexual maturity and their mass, respectively, by 45.5 and 29.3 % and 63.9 and 56.7 % relatively to the technology where poultry droppings, which was fermented for 18 months, were used.

2. Broiler chicken droppings fermented with the highest dose of bio-destructors in the composition of compost contributes to an increase in the number of formed cocoons of worms and their weight, respectively, by 41.4 and 17.1 % compared to the control group.

3. The use of broiler chicken droppings fermented with the use ofbio-destructors in the composition of compost revealed an increase within the margin of error of protein and a decrease in biotic metals and toxic metals in vermiculture biomass.

REFERENCES

1. Hepperly, P. (2009). Compost, manure and synthetic fertilizer influences crop yields, soil properties, nitrate leaching and crop nutrient content. Compost Sci Util., 17, pp. 117–126.

2. Merzlov, S.V., Melnichenko, O.M., Mashkin, Yu.O., Bilkevych, V. V. (2017). Biomass growth of California worms and accumulation of Cobalt in it at different concentrations of the metal in the nutrient medium. Technology of production and processing of livestock products. (5), pp. 10–12. (in Ukrainian)

3. Shen, X. (2015). Compositional characteristics and energy potential of Chinese animal manure by type and as a whole, Appl. Energy. 160, pp. 108–119. DOI:10.1016/j.apenergy. 2015.09.034

4. Jessica, K.L., David, C.V. (2013). Improving Waste management strategies for small livestock farms, Sci. Technol., 47, pp. 11940–11941. DOI:10.1021/es40 4078b

5. Zhahg, H. (2016). Influence of aeration on volatile sulfur compounds (VSCs) and NH3 emissions during aerobic composting of kitchen waste. Waste Manage, 58, pp. 369–375. DOI:10.1016/j.wasman.2016.08.022

6. Nasiru, A., Ismail, N., Ibrahim, M.H. (2013). Vermicomposting: Tool for Sustainable Ruminant Manure Management. Journal of Waste Management, Vol. 2013, Issue 2013 (31 Dec. 2013), pp. 1–7, 7 p. DOI:10.1155/2013/732759

7. Vovkogon, A.G., Merzlov, S.V. (2014). Influence of different sources and doses of Iodine on biomass growth of hybrid red California worms. Technology of production and processing of animal husbandry products. Scientific bulletin of NUBiP of Ukraine. no. 202, pp. 63–67. Available at:http://nbuv.gov.ua/UJRN/nvnau_tevppt_2014_202_50. (in Ukrainian)

8. Mashkin, Yu.O., Merzlov, S.V., Karkach, P.M., Fesenko, V.F. (2021). The effect of cobalt concentration in the nutrient medium on the growth of the biomass of California worms and the accumulation of the metal in it. Collection of scientific works "Technology of production and processing of animal husbandry products". no. 2, pp. 101–106. DOI:10.33245/2310-9289-2021-166-2-101-106 (in Ukrainian)

9. Ismayana, A. (2012). Faktorrasio C/N awaldanlajuaerasipada proses co-composting bagasse danblotong (Factor of initial C/N ratio and aeration rate in co-composting processof bagasse and filter cake). J. Teknologi Industri Pertanian, 22(3), pp. 173–179.

10. Karak, T. (2014). Composting of cow dung and crop residues using termite mound as bulking agent, Bioresour. technjl. 169, pp. 731–741. DOI:10.1016/j.bior tech.2014.06.110

11. Merzlov, S.V., Mashkin, Yu.O. (2015). Growth of worm biomass at different concentrations of Ferrum in the substrate. Technology of production and processing of animal husbandry products. no. 1, pp. 103–106. (in Ukrainian)

12. Nasiru, A. (2013). Vermicomposting: Tool For Sustainnable Ruminant Manure Management. Hindawi Publishing Corporation. Journal of Waste Management, Vol. 2013, ID732 759, 7 p. DOI:10.1155/2013/732759

13. Rajiv, K.S., Valani, D., Chauhan, K., Agarwal, S. (2010). Embarking on a second green revolution for sustainable agriculture biotechnology using earthworms: Reviving the dreams of Sir Charles Darwin. Journal of Agricultural Biotechnology and Sustainable Development, Vol. 2(7), pp. 113–128.

14. Kangmin, L., Peizhen, L. (2010). Earthworms helping economy, improving ecology and protecting heals; Int. J. Environ. Eng. (Special Issue on Vermiculture Technology), Vol. 10, no. 3–4, pp. 354–365. DOI:10.1504/IJGENVI.2010.037276

15. Kumar Yadav, S., Md. Faruque, M., Ali Makin, A., Kanak Kh.Z. (2014). Small-Scale Compost Production through vermiculture Biotechnology. International J. of research in Agriculture and Forestry, Vol. 1, pp. 7–12. Available at:http://www. ijraf.org/pdf/v1-i2/2.pdf

16. Coyne, K., Knutzen, E. (2008). The Urban Homestead: YourGuideto Self-Sufficient Livingin the Heart of the City. Port Townsend: Process Self Reliance series. 307 p.

17. Blazy, V. (2014). Process condition influence on pig slaughter house compost quality under forced aeration. Waste Biomass Valor. 5, pp. 451–468. DOI:10.1007/s12649-013-9251-x

18. Merzlov, S.V., Mashkin, Y.O., Merzlova, G.V., Vovkohon, A.G. (2017). Californian red worm biomass increase and its cobalt accumulation under different concentrations of the metal in nutrient medium. Ukrainian Journal of Ecology, 7(4), 525–528. DOI:10.15421/2017_155 (in Ukrainian)

19. Lowry, O.H., Rosenbrough, N.I., Farr, A.L. (1951). Protein meashurement with the Folin phenol refgent. J. Biol. Chem., Vol. 193, pp. 265–315.

20. Havezov, I., Tsalev, D. (1983). Atomic absorption analysis. Per. from Bulgarian, ed. S.Z. Yakovleva. L.: Chemistry, 144 p.

Вирощування черв'яків на субстраті з вмістом посліду птиці ферментованого за участі біодеструкторів

Мерзлов С.В., Осіпенко І.С., Мерзлова Г.В.

Значні накопичення посліду птиці біля великих птахопідприємств є проблемою як в Україні, так і за кордоном. Актуальним питанням є пошук раціональних методів утилізації цих відходів із залученням природних, екологічно безпечних методів, таких як компостування за участі мікроорганізмів та вермикультури. Застосування під час ферментації посліду курчат-бройлерів із підстилкою (у вигляді тирси нехвойних дерев) мікроорганізмів призводить до скорочення часу підготовки органічної біомаси для вермикультивування. Науково-практичний інтерес представляє встановлення ефективності вирощування черв'яків на субстраті з умістом посліду курчат-бройлерів ферментованого різними дозами препарату мікроорганізмів у порівняні з варіантом, де послід ферментували традиційним способом впродовж 18 місяців.

Під час проведення досліджень формували 4 групи по 4 мікроложів кожній. Маса компосту і об'єм мікролож були ідентичними. В контрольному варіанті компост містив 92,0 % (за масою) посліду курчат-бройлерів, ферментованого 18 місяців, і 8,0 % подрібненої соломи пшениці. У дослідних мікроложах співвідношення посліду до соломи було ідентичне за масою, проте послід ферментували 180 діб, застосовуючи 143, 1430 та 2860 мг біодеструктора на тонну біомаси. Досліджували вплив упродовж 100 діб посліду курчат-бройлерів на кількість статевозрілих, нестатевозрілих черв'яків, їх масу і кількість відкладених коконів. Вивчали вміст у біомасі вермикультури білка, металів-біотиків та металів-токсикантів.

Було доведено, що включення у компост посліду курчат-бройлерів із підстилкою ферментованого посліду за участі біодеструктора в кількості 2860 мг/т призводить до підвищення кількості статевозрілих та нестатевозрілих черв'яків у мікроложі та їх маси відповідно на 45,5 і 29,3 % та 63,9 і 56,7 % відносно контролю, де послід ферментувався 18 місяців. Вирощування вермикультури на компості з послідом, ферментованим впродовж 180 діб (III дослідна група), дає можливість отримати на, 41,4 % більшу кількість коконів та на 17,1 % їх масу у порівняні з контролем. Біомаса черв'яків, вирощених на компості, з умістом посліду ферментованого найбільшою дозою біодеструктора вірогідно не відрізнялась за вмістом металів-біотиків та металів-токсикантів.

Ключові слова: кокони черв'яків, білок, метали-біотики, метали-токсиканти, біодеструктор, вермикультура, компост.

ORCID iD:
Merzlov S. https://orcid.org/0000-0002-9815-4280
Osipenko I. https://orcid.org/0000-0002-0598-0090
Merzlova H. https://orcid.org/0000-0002-2394-9118