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THE INFLUENCE OF REGENERATED LITTER ON THE PRODUCTIVE PERFORMANCE AND WELL-BEING OF REARING YOUNG CHICKENS

Ryabinina Elena, Ph.D., Senior Researcher, https://orcid.org/0000-0003-3803-0195
Melnyk Volodymyr, Ph.D., https://orcid.org/0000-0003-3571-7872
State poultry research station NAAS of Ukraine

Due to the shortage and high cost of bedding materials, the regeneration of used reinforcement and its repeated use is an urgent problem in modern poultry farming. However, at the same time, there is a threat of the negative impact of such litter on poultry. Several studies have proved the possibility of raising broiler chickens on regenerated bedding. Less studied is the option of using regenerated waste in the cultivation and maintenance of poultry with a long production cycle rearing young stock or adult birds. In the State Experimental Poultry Station National Academy of Agrarian Sciences of Ukraine (SEPS NAASU), the regeneration technology of used litter has been improved. In this study, the impact of the use of litter regenerated according to the developed technology in the rearing of young chickens on the microclimate of the poultry house, well-being, and zootechnical indicators of poultry was studied. The research was carried out on the experimental farm of the SEPS NAASU. According to the results of the investigation, although the initial moisture content of the regenerated litter was higher than the new one ($p<0.05$), after ten weeks of rearing young animals, the litter moisture content in both variants no longer had significant differences. During the growing period, the content of ammonia and carbon dioxide in the air of the experimental premises did not exceed the maximum permissible concentrations. Still, in the practical room, it was higher than in the control room, especially in the initial cultivation period. The leading difference was 4.4 mg/m3 for ammonia and 0.05% for carbon dioxide. In terms of ammonia content, the difference between the experimental and control variants was statistically significant up to 8 weeks of age ($p<0.05$) and carbon dioxide content up to 6 weeks of age ($p<0.05$). There was no negative impact of regenerated litter on the well-being indicators (condition of feather cover, knee joints, and paw feet) and zootechnical indicators of rearing young stock (safety, body weight, and feed conversion). This indicates the possibility of using regenerated litter in the rearing of young chickens without a negative impact on poultry.

Keywords. Litter, regeneration, multiple use, rearing chickens, microclimate, poultry welfare, zootechnical indicators.

ВПЛИВ РЕГЕНЕРОВАНОЇ ПІДСТИЛКИ НА ПРОДУКТИВНІ ПОКАЗНИКИ І БЛАГОПОЛУЧЧЯ РЕМОНТНОГО МОЛОДНЯКА КУРЕЙ

Рябініна О. В., к. с. - г. н. , с. н. с., https://orcid.org/0000-0003-3803-0195
Мельник В. О., к. с. - г. н., https://orcid.org/0000-0003-3571-7872
Державна дослідна станція птахівництва НААН

У зв'язку з дефіцитом та високою вартістю підстилкових матеріалів регенерація використаної підсилки та багатократне її використання є актуаль-

ною проблемою в сучасному птахівництві. Однак при цьому існує загроза негативного впливу такої підстилки на птицю. Можливість вирощування курчат-бройлерів на регенерованій підстилці була доведена низкою досліджень. Менш вивчена можливість застосування регенерованої підстилки при вирощуванні та утриманні птиці з тривалим виробничим циклом-зокрема ремонтного молодняку або дорослої птиці. В ДДСП НААН удосконалено технологію регенерації використаної підстилки. У цьому дослідженні вивчали вплив використання регенерованої за розробленою технологією підстилки при вирощуванні ремонтного молодняку курей на мікроклімат пташника, благополуччя та зоотехнічні показники птиці. Дослідження були проведені на експериментальній фермі ДДСП НААН. Як засвідчили результати досліджень, хоча початкова вологість регенерованої підстилки була більшою, ніж нової ($p<0,05$), після 10 тижнів вирощування молодняку вологість підстилки в обох варіантах вже не мала істотних відмінностей. Впродовж періоду вирощування вміст аміаку і вуглекислого газу в повітрі дослідних приміщень не перевищував гранично допустимих концентрацій, однак в дослідному приміщенні він був більший, ніж контрольному, особливо в початковий період вирощування. Максимальна різниця досягала: за вмістом аміаку 4,4 мг/м^3, вуглекислого газу 0,05%. За вмістом аміаку різниця між дослідним і контрольним варіантом була статистично вірогідною до 8-тижневого віку ($p<0,05$), вмістом вуглекислого газу до 6-тижневого віку ($p<0,05$). Не встановлено негативного впливу застосування регенерованої підстилки на показники благополуччя (стан пір'яного покриву, колінних суглобів та стоп лап) та зоотехнічні показники ремонтного молодняку (збереженість, живу масу та конверсію корму). Зазначене свідчить про можливість використання регенерованої підстилки при вирощуванні ремонтного молодняку курей без негативного впливу на птицю.

Ключові слова: підстилка, регенерація, багатократне використання, ремонтний молодняк курей, мікроклімат, благополуччя птиці, зоотехнічні показники.

Entry. Due to the shortage of bedding materials and the increased cost, poultry farmers are increasingly interested in their repeated use after appropriately carrying out regeneration. The main renewal task is the destruction or inactivation of pathogenic microflora (Merino, 2018; Roll et al., 2011; Oliveira et al., 2015).

The most common way to regenerate used litter is to disinfect it by biothermal composting in piles (Wang, 2019; Schmidt et al., 2013). This regeneration technology involves raking litter in poultry houses during the period of their sanitation into piles with a height of 0.3-1.7 m and keeping them in piles for 3-8 days. In the process of composting, the used litter is heated to a temperature of 55-70 °C, which ensures its disinfection. During the composting period, it is possible to turn the piles over to move the outer layers of the piles into their middle for better disinfection.

Methods of disinfection of used litter, such as adding quicklime to the litter, shallow fermentation, or processing in special bioreactors, are also known (Lopes et al., 2013; Vaz et.al., 2017; Benedet et.al., 2021).

Poultry farmers are also concerned about the possible negative impact of the use of regenerated litter on the microclimate of poultry houses, production indicators, and well-being of poultry since its physical, mechanical, and thermal properties, moisture absorption capacity are significantly different from those of fresh litter (Cressman, 2014; Dornelas et al., 2020; Dornelas et al., 2023).

The effect of using regenerated litter compared to fresh litter on the leading indicators of broiler chicken rearing has been studied in several studies.

Abougabal and Taboosha (2017) and Abougabal (2019) raised broilers on fresh litter, a mixture of fresh and regenerated litter, regenerated litter, and regenerated alum-treated litter. The results of the experiment showed that the differences between the variants in most indicators (live weight of poultry, feed intake, feed conversion rate, safety, European Production Efficiency Index, slaughter yield and carcass characteristics, behavior patterns, overall economic efficiency of production) were insignificant and statistically unreliable. However, numerically, some advantages favored the variant using fresh litter. More significant differences ($P<0.05$) were observed with different types of litter in terms of dermatitis of the soles of the feet and the condition of the feather cover, which were worse with the use of regenerated litter. Adding alum to compostable re-used litter helped improve them.

Kyoung et al. (2017) studied ammonia emissions when poultry were kept on single and reusable litter. It was found that, as a rule, in the latter case, an increase in the emission of this gas by 1.3 – 2.0 times was recorded; however, in most cases, the total content of ammonia in the air of the poultry house did not exceed the maximum permissible concentration.

In an experiment by Garces-Gudino et al. (2018), broiler chickens reared on litter regenerated after cycles 2 and 3 had higher live weight, daily weight gain, feed intake, preservation, and European production efficiency factor ($P<0.05$) than chickens raised on new litter. The authors concluded that regenerating used litter is an excellent option to reduce bird droppings production and improve the productivity of broiler chickens.

Kalita et al. (2012) conducted three experiments in which broiler chickens were raised on new, regenerated after two and three use cycles, and mixed (50%:50%) litter. In broiler chickens raised on mixed litter and used for 2 and 3 cycles, there was a tendency to increase live weight. At the same time, in the 3rd experiment, the live weight of chickens raised on mixed litter was statistically significantly ($P<0.05$) higher than the live weight of chickens raised on fresh and regenerated used litter. In all three experiments, the authors did not note a statistically significant difference between the variants regarding feed conversion, preservation, and yield of gutted carcass. During the research, an organoleptic assessment of broiler meat was also carried out. Meat from chickens raised on mixed and used litter had an advantage in tenderness and juiciness ($P<0.05$) compared to broilers raised on new bedding. However, no significant difference was found between the samples regarding "flavor" and "overall acceptability" of meat.

Bucher et al. (2020) and Pepper et al. (2021) note that with repeated use of litter, a microbe is formed in it, which negatively affects harmful microflora and is characterized by a probiotic effect in the intestines of poultry, which ultimately has a positive effect on the safety and productivity of poultry.

Grimes et al. (2003) regenerated used turkey litter by heat treatment in a screw system at 95 °C or 220 °C. No significant differences were found in live weight, feed conversion, and safety of turkey poults reared on new heat-treated bedding.

About 13% of farmers in Canada raise turkeys on reclaimed litter (Staaveren et al., 2020). However, the effect on poultry performance of the use of regenerated litter compared to fresh litter is not reported by the authors.

Despite the generally positive results of using regenerated litter when growing poultry abroad, poultry farmers in Ukraine still have concerns about its disinfection in the process of biothermal treatment in the traditional way and the possible negative impact of repeated use of litter on the production performance of poultry. Both abroad and in Ukraine, the possibility of using regenerated litter in the cultivation and maintenance of poultry with a long technological cycle – rearing stock or parent flock of chickens and turkeys – has not been sufficiently studied.

The State Experimental Station of Poultry Farming of the National Academy of Agrarian Sciences of Ukraine (DSSP NAAS) has improved the regeneration technology of used litter. The improved technology involves adding a special microbiological preparation to the litter and, in addition, irradiating the surface of compost piles with ultraviolet radiation of the bactericidal range or disinfecting it with ozone. The developed experimental methods ensured the intensification of the process of its biothermal treatment by 1 – 9.4°C, a decrease in ammonia emission by 1 – 17 mg/m2 per 1 hour, seeding with enterobacteria by 1.1 log10, fungal microorganisms by 2-5 times (Ryabinina & Melnik, 2022).

Purpose of research. To study the effect of litter regenerated according to improved technology on the productive performance and well-being of rearing young chickens.

Materials and methods.

The study was carried out on the experimental farm "Conservation of the State Poultry Gene Pool" of the Children's Agricultural Enterprise of the National Academy of Agrarian Sciences of Ukraine in the period from July 10 to November 16 in a poultry house for raising young chickens in two isolated sections measuring 4x5 m with an area of 20 m3 each with separate independent ventilation systems. In one section, new bedding (a mixture of pine shavings and sawdust) was used. In another section, regenerated litter made of the same materials was used after one rearing cycle of Chickens. The initial moisture content of the new reinforcement was 15.6%, and the regenerated 25.7%. In quantitative terms, at the induced humidity, the mass of the regenerated litter exceeded the mass of the new litter by 4.7 times, and in terms of dry matter content by 4.1 times, since during the first cycle of use, poultry excrement was added to the bedding material.

The regeneration of the used litter was carried out according to the previously developed experimental method, which involved the addition of the microbiological preparation Bioseven (Vetolac) manufactured by PE "BTU-Center" to the litter, its biothermal treatment for ten days in a pile 70 cm high and irradiation of the pile surface with bactericidal ultraviolet radiation (UVB wavelength 253.7 nm) according to the regime: daily once a day for 20 minutes. Microbiological preparation Bioseven (Vetolak) contained microorganisms of probiotic action not less than 1x10 10 CFU/l: Lactobacillus acidophilus, Lactobacillus plantarum, Lactobacillus delbrueckii subsp. bulgaricus, Lactobacillus fermentum, Lactobacillus rhamnosus, Bifidobacterium bifidum, Enterococcus faecium, whey. The estimated dose of UVB was 50 J/m2.

Each section housed 150 heads. Day-old young chickens of the G-2 line of the Plymouth Rock white breed with a stocking density of 7.5 heads/m2. The standard temperature and air exchange was maintained in the sections (according to VNTP-APK-04.05). Also, the norms of feeding poultry of both groups were the same, following the Recommendations on rationing of feeding of poultry (IP et al., 2014). During the research period, the following indicators were studied and determined in both sections:

– litter moisture – according to GOST 26713−85 (once every two weeks, five samples from each section)

- the content of harmful gases (ammonia and carbon dioxide) in the air: using a portable 3-component gas analyzer Dozor S-M - once every two weeks at the same time - 5 measurements at the level of poultry in each section;

- mortality of poultry and causes of death – according to the data of daily registration and autopsy of carcasses;

- the live weight of birds: by weighing 50 of the same birds once a month on electronic scales with an accuracy of + 1 g;
- feed consumption by groups – by daily accounting;
- feed conversion – by calculation;
- plumage condition was assessed in the entire population of the experimental bird at the end of the experimental period visually on a point scale from 0 to 3, where 0 meant very clean and 3 - very dirty (De Jong et al., 2011).
- frequency and severity of foot lesions by pododermatitis: visually in the entire population of experimental birds at the end of the experimental period on a point scale from 0 to 4, where 0 points meant no lesions, and 4 points meant half of the foot area was affected (Hocking et al., 2011);
- the condition of the knee (hock) joints was assessed visually in the entire population of the experimental bird at the end of the experimental period in 3 categories, where category 01 meant no lesions, 02 – more than 25% of the hock area was affected, 03 – more than 50% of the hock area was affected (Bignon et al., 2015);
- the quality (structure) of the litter was assessed visually once a month on a 4-point scale (from 0 to 3): 0 – dry and loose; 1 - slightly damp, with a small degree of caking; 2 – moister and caked; 3- wet, with a high degree of caking (Kheravii et al., 2017);
– statistical processing of research results was carried out using application software for OS Windows - Microsoft Excel;
- The European Factor Efficiency Index (EPEF) was determined according to the generally accepted formula:

$$EPEF = \frac{live\ weight, kg\ \times\ conservation, \%}{growing\ period, days \times forage\ conversion, kg/kg} \times 100$$

Research Results

Dynamics of humidity and quality (structure) of litter. As mentioned above, the initial moisture content of the new reinforcement was 15.6%, and the regenerated 25.7%. That is, the difference was 9.1% ($p<0.05$). Subsequently, the moisture content of both the new and the regenerated litter increased. At the same time, the difference in humidity between them decreased (Fig. 1) since the moisture content of the new litter increased faster than that of the regenerated litter, primarily due to its much lower total amount. After ten weeks of rearing young animals, the moisture content of the litter in both variants no longer had significant differences. At the end of the growing period, the litter moisture content in the control section was 32.3%, and in the experimental section, 31.1%.

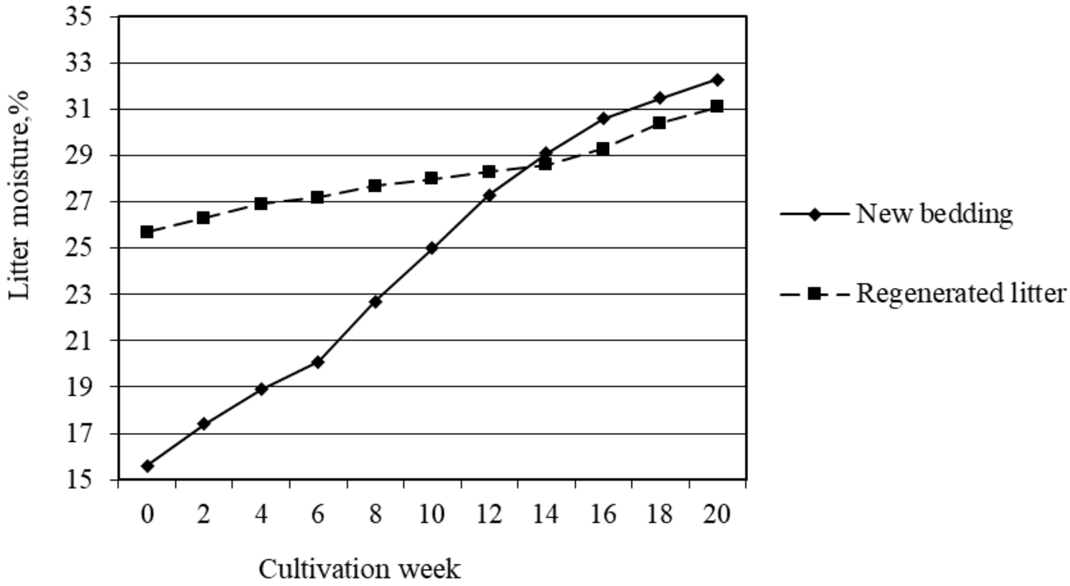

Fig. 1. **Moisture dynamics of new and regenerated litter**

The dynamics of litter quality (structure) in both sections is shown in Table 1.

Table 1

Dynamics of litter quality (structure) in the experimental and control sections

Month (week) of cultivation	Quality (structure) of litter	
	Control (new litter)	Experiment (regenerated litter)
0(0)-before planting chicks	0	1
1(4)	0	1
2(8)	0	1
3(12)	1	1
4(16)	1	1
5(20)	2	2

The structure of the litter during the rearing period of the rearing stock varied from dry and loose (new litter in the control section) or slightly moist with a small degree of caking (regenerated litter in the experimental section) before planting the chicks to more moist and caked in both sections at the end of the rearing period.

Dynamics of the content of harmful gases in the air of the experimental and control sections. The content of harmful gases (ammonia and carbon dioxide) in the air of the experimental and control sections during the entire period of cultivation did not exceed the maximum permissible concentrations (MPC) [15]. However, in the experimental section, it was higher than in the control section (Figs. 2 and 3). A more significant difference was observed in the initial cultivation period, for ammonia by 4.4 mg/m3 and carbon dioxide by 0.05% on the first day of cultivation. In terms of ammonia content, the difference between the experimental and control variants was statistically probable up to 8 weeks of age ($p<0.05$) and carbon dioxide content up to 6 weeks of age ($p<0.05$). At the end of the growing period, the content of harmful gases in the air of the experimental and control sections was almost equal.

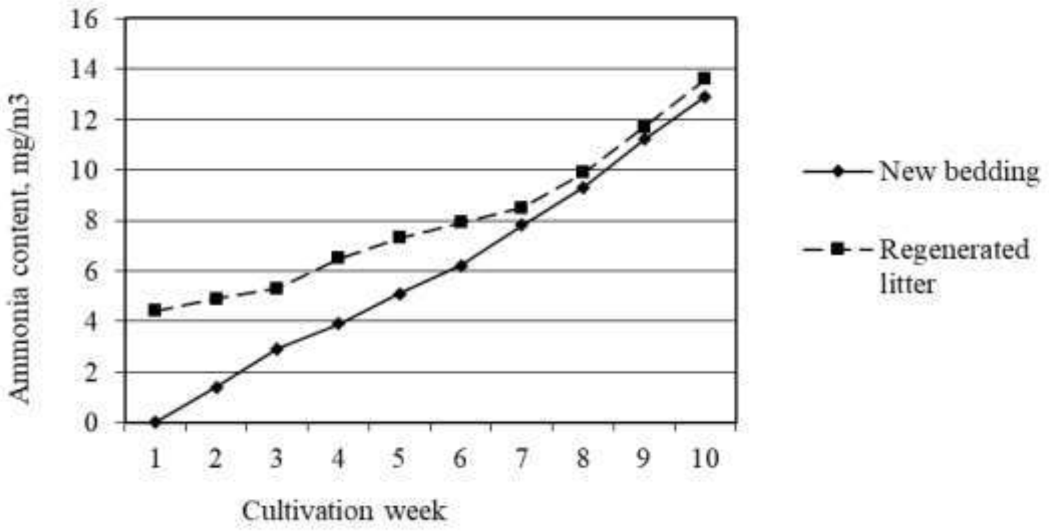

Fig. 2. **Dynamics of ammonia content in the air of premises for rearing young chickens using new and regenerated litter**

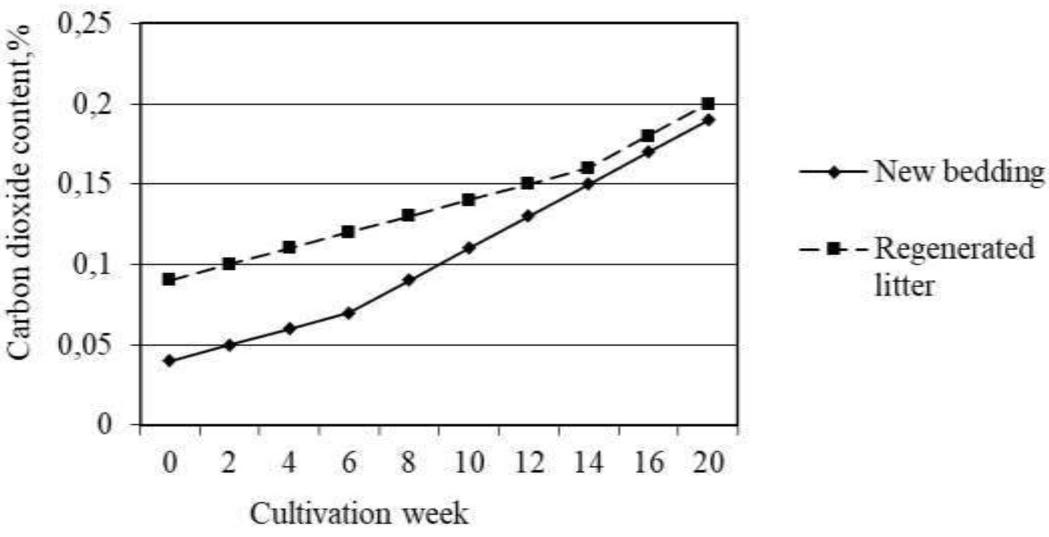

Fig. 3. **Dynamics of carbon dioxide content in the air of premises for rearing young chickens using new and regenerated litter**

Indicators of poultry welfare. Such indicators characterizing the bird's well-being as the state of plumage, the frequency and severity of damage to the feet by pododermatitis, and the condition of the knee (hock) joints were studied. The state of the plumage of young chickens at the end of the experimental period did not have significant differences in the control and experimental groups. Plumage contamination in both groups was minor, and it was also estimated at an average of 1 point (low degree of contamination). The number of birds with lesions of the knee (hocks) and with pododermatitis was also small. The severity of the lesion was also minor (see Table 2).

Table 2

Plumage condition, frequency and degree of damage to hocks and soles of the feet by pododermatitis in rearing young chickens when rearing on fresh and regenerated reinforcement

Indicators	Control (fresh litter)	Experiment (regenerated litter)
Number of birds evaluated	141	142
Assessment of the degree of contamination of the feather cover, points	1 (slight degree of contamination)	1 (low degree of contamination)
Number of birds with lesions of the knee joints, head.	7	6
Incidence of knee joint involvement, %	5,0	4,2
Degree of damage to the knee joints in poultry, points	01	01
Number of birds with lesions of the feet by pododermatitis	12	14
Frequency of manifestations of pododermatitis, %	8,5	9,9
Assessment of the degree of damage to the feet by pododermatitis, points	1	1

Zootechnical indicators. There were no significant differences between the groups of rearing chickens reared on fresh and regenerated litter and in terms of the leading zootechnical indicators (see Table 3). The live weight of the bird corresponded to the characteristics of the G-2 line for chickens of the appropriate age. The safety of young animals was within the permissible standards (VNTP-APK-04.05). The causes of death of the bird were not related to the quality of the litter.

Table 3

The main zootechnical indicators of rearing chickens when grown on new and regenerated litter

Indicators	Control (new litter)	Experiment (regenerated litter)
Duration of the experiment, weeks	20	20
Initial number of chickens, head.	150	150
Preserved to 20 weeks of age, goal.	144	143
Safety, %	96,0	95,3
Average live weight of chickens at the age of one day, g	42,8±1,12	41,7±0,87
Average live weight of birds (g) at age, weeks:		
4	356,5±5,3	345,4±4,5
8	851,8±14,2	839,1±15,9
12	1190,7±17,3	1178,4±19,6

16	1465,2±22,9	1457,2±23,7
20	1843,3±24,1	1835,4±25,9
Average weight gain during the growing period, kg	1,801	1,794
Homogeneity of livestock by live weight, %	72,0	70,8
Received conditioned youngsters, head.	131	130
Yield of conditioned young animals, %: of the number grown of the number planted for cultivation	 91,0 87,3	 90,9 86,7
Feed consumption during the growing period, kg/head	8,8	8,7
Feed conversion rate, kg/kg	4,996	4,849
Feed consumption per 1 grown conditioned pullet, kg	10,1	10,1

European Factor Efficiency Index. The EPEF in the control and experimental groups was 25.30 and 25.77, respectively; that is, there were also no significant differences.

Discussion. The moisture content of the litter at the end of the period of rearing and keeping poultry can be up to 45%. According to Karthiga (2018), the optimal moisture content of the litter used for regeneration is 28-32%. Suppose the actual moisture content of the used litter is less than this value. In that case, biothermal processes during its regeneration will not ensure the litter is heated to the temperatures required for pasteurization – 55-70°C (Lopes et al., 2015). This necessitates the addition of water and, as in our case, a higher initial moisture content of the regenerated litter, respectively 25.7%, compared to 15.6% for the new litter ($p<0.05$). Subsequently, the moisture content of both the new and the regenerated litter increased due to the constant supply of excrement. However, due to the 4.7 times greater total initial weight of the regenerated litter or 4.1 times in terms of dry matter, its moisture content increased more slowly than the new one. However, the difference in moisture between the litter variants remained statistically significant until the 10th week of cultivation. After ten weeks of rearing young animals, the litter moisture content in both variants no longer had significant differences and was, in the control section, 32.3%, and the experimental section, 31.1%. A similar trend was observed by Abougabal and Taboosha (2017). The difference in the structure of the new and regenerated litter, which was assessed according to the point system, was also observed only in the initial period of cultivation. At the same time, it must be borne in mind that before regeneration, "cakes" were removed from the litter. Further, this difference decreased, and in the last weeks of cultivation, the condition of the litter was estimated at 2 points - relatively wet and caked.

When rearing young chickens on regenerated litter in the air of the poultry house, an increase in the content of ammonia and carbon dioxide was observed, respectively, by 3.5-1.1 and 2.1-1.1 times compared to their rearing on new litter. In terms of ammonia content in the air, the difference between the cultivation options was statistically significant from the first to the eighth week of cultivation ($p<0.05$), in terms of carbon dioxide in the air from the first to the sixth week of cultivation ($p<0.05$). At the same time, during the entire cultivation period, their concentration in the air did not exceed the maximum permissible. An increase in ammonia emissions from the regenerated litter compared to fresh litter was observed, and Kyong from singing. (2017) and Coufal with Sang. (2006). In all cases, this increase can be explained by a higher amount of organic matter in the regenerated litter due to an overall higher amount of organic matter (in our case, 4.1 times in terms of dry matter) and a greater degree of decomposition. At the same time, the content of these harmful gases in the air of the experimental room did not exceed the maximum permissible concentration at similar (according to the norms of VNTP-APK-04.05) in the experimental and control versions of the levels of air exchange in the premises.

However, the most important criteria determining the possibility of repeated use of litter after properly carried out regeneration, of course, are harmlessness to poultry welfare and productive indicators of poultry compared to the use of new litter. In our study, no significant difference was found between these options when rearing young chickens for indicators that characterize the well-being of poultry as the state of plumage, the condition of the knee joints, and the condition of the soles of the paws. In both variants, these indicators were within acceptable limits. Similar data in the rearing of broiler chickens were obtained by Cressman, M. D. (2014) and Oliveira, M. from Singing. (2015), while Abougabal (2019) observed a negative effect of regenerated litter on the indicated indicators.

In our case, there were no significant differences between the experimental and control groups of rearing young animals, which were reared, respectively, on regenerated and new litter, and in the leading zootechnical indicators: safety, live weight by age and feed conversion, as well as such a generalizing indicator as the European Production Factor Efficiency Index (EPEF). The live weight of the bird corresponded to the characteristics of the G-2 line for chickens of the appropriate age. The safety of young animals was within the permissible standards (VNTP-APK-04.05). The causes of death of the bird were not related to the quality of the litter. When growing broiler chickens, the absence of significant differences in the leading productive indicators of chickens raised on new and regenerated litter was noted by Abougabal (2019) and Kalita with singing. (2012), although Cressman (2014) and Garces-Gudino sang. (2018) The best performance was obtained when broilers were raised on regenerated bedding and Nagaraj sang. (2007) when grown on new litter. This indicates the need to continue research in this direction, in particular, taking into account economic factors.

Conclusions

1. The used litter, regenerated according to the technology improved in the DSP NAAS, can be used in rearing young chickens without adversely affecting the welfare and productive performance of poultry.

2. It was found that the moisture content of the regenerated litter was 1.6-1.2 times higher than the new one ($p<0.05$) from the first to the eighth week of rearing young animals. With further cultivation, the difference in moisture between the types of litter decreased and became insignificant.

3. When rearing young chickens on regenerated litter, there was an increase in the content of ammonia in the air of the poultry house by 3.5-1.1 times and carbon dioxide by 2.1-1.1 times compared to their rearing on new litter. In terms of ammonia content in the air, the difference between the cultivation options was statistically significant from the first to the eighth week of cultivation ($p<0.05$), in terms of carbon dioxide content in the air from the first to the sixth week of cultivation ($p<0.05$). At the same time, during the entire cultivation period, their concentration in the air did not exceed the maximum permissible.

4. Rearing of rearing chickens on regenerated litter did not adversely affect the studied indicators of poultry welfare and zootechnical indicators of rearing.

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