Effect of fodder ingredient on meat productivity and development of internal organs of broilers

E I Amiranashvili¹, N V Kolokolnikov¹, E A Chaunina² and A V Yatsishin²

¹ LLC "Morozovskaya poultry farm", 1, Yubileinaya, Morozovka, 644555, Russia
² FSBEI HE Omsk SAU, 1, Institutskaya sq., Omsk, 644008, Russia

E-mail: amiranashvili.e@mail.ru

Abstract. Annually, there is an increase in the cost of soybean components of feedstuffs, which negatively affects the profitability of poultry farming. The use of cheaper alternative feeds in poultry diets such as rapeseed flour, as well as sunflower kernels and seeds, brings novelty to fodder production and broiler feeding. The purpose of these studies was to determine the impact of unconventional fodder ingredients on meat productivity and the development of internal organs of broilers. The results of the experiment on the use of rapeseed flour in the diets of turkeys show that its introduction into the diets reduces their pre-slaughter living weight and the weight of the ripped carcass. Development of the internal organs of the experimental groups was comparable to those of the control group. The inclusion of sunflower kernel and seeds in the diet contributed to increased meat productivity and better development of internal organs in broiler chickens. Compared to the sunflower core, broilers receiving sunflower seeds and the enzyme preparation Ronozim tended to increase the weight of internal organs, while the greatest differences were established by the relative weight of the gizzard (when using 5% of fodder ingredients - by 0.05%, and when using 7.5% - by 0.03%).

1. Introduction

The formation of meat productivity is influenced by breed (cross), conditions of maintenance and feeding. In the process of ontogenesis, there is an increase in the weight of broilers, but also in the weight of their internal organs, the development of which characterizes the physiological parameters of the bird. Therefore, the study of the development of internal organs is also important in assessing the meat productivity of broilers.

Growth (weight) of internal organs is largely determined by feeding conditions: feeding mode (period) [1], restriction in feed [2], form of feed (physical structure) [3], food (fodder) additives [4-5].

The high cost of traditional energy sources and protein in the production of poultry feed (corn, fish flour, full-fat soybean, soybean cake) led to an increase in the cost of a unit of production. And the cultivation of broilers on alternative feed ingredients is very promising and inexpensive [6-7].

In the region of Western Siberia, the problem of protein deficiency in plant feed is solved by using unconventional feed resources, which include oilseeds and their processed products.

Poultry diets can include ingredients such as rapeseed flour, as well as sunflower kernel and seeds, which is very relevant for practical poultry farming. But the literature presents limited data on the influence of unconventional fodder ingredients on the development (weight) of internal organs of agricultural poultry.
For this, a series of experiments were conducted, the main purpose of which was to determine the influence of various levels of unconventional fodder ingredients (rapeseed flour, kernels and sunflower seeds) on meat productivity and the development of internal organs of broilers.

2. Materials and methods
Experiments were carried out on turkeys and broiler chickens in the conditions of Morozovskaya Poultry Farm LLC. In the first study, 400 heads of turkey poults (Big 6 cross) were used, divided into 4 groups: the control received full-diet combined food with soy extraction cake, the 1st experimental - with 5% rapeseed flour, the 2nd experimental - with 10% rapeseed flour, the 3rd experimental - with 15% rapeseed flour. The rapeseed variety used was low in glucosinolates and erucic acid. The feeding period was 1-119 days.

In the second study, cores and sunflower seeds were used as the feed ingredient for broiler chickens. The study was conducted on 5 groups of cross-country broiler chickens Arbor Acres (groups of n = 100). The poultry of the control group received a combination feed with soybean extraction cake, the 1st and 2nd experimental groups - with 5 and 7.5% of the sunflower core, the 3rd and 4th experimental groups - with 5 and 7.5% of sunflower seeds and the enzyme preparation Ronozim VP 250 g/t. The duration of the test was 1-35 days.

The conditions of maintenance, feeding and singing front in all groups were the same and corresponded to the methodological recommendations for working with poultry of the corresponding cross. Broilers were kept on the floor on a deep litter.

Slaughter and anatomical cutting of turkeys were carried out at 105 and 119 days of age (females and males, respectively), and broiler chickens at 35 days of age, 6 heads from each group (3 heads of each sex with an average living mass characteristic of each group) and internal organs (liver, heart, gizzard, lungs, kidneys) were weighed. Before slaughter, the bird was not fed for 8 hours with free access to water, then it was weighed before and after slaughter, slaughter was carried out, followed by cutting of carcasses. The weight of internal organs was determined by weighing on electronic scales.

Numerical data were processed using parametric analysis methods using Student-Fisher validity criteria. Statistical processing was carried out on a personal computer in the Microsoft Excel program. Differences between groups was considered reliable in R≤0.05; R≤0.01; R≤0.001.

3. Results and Discussion
The introduction of rapeseed flour into diets reduced some of the meat productivity of turkeys (table 1). Compared to the control group, females and males who received 5% rapeseed flour had a lower pre-slaughter living weight - less by 0.4 and 2.4% (R≤0.001) and the weight of the ripped carcass - by 0.2 and 0.9% (R≤0.05), but more slaughter yield by 0.2 and 1.3% (R≤0.05). The inclusion of 10 and 15% of the studied fodder ingredient in the diet further reduced the pre-slaughter live weight by 5.8-9.4 and 5.0-6.2% (R≤0.001) and the ripped carcass by 4.8-8.0 and 4.7-5.2% (R≤0.01), and the slaughter yield increased by 0.8-1.3% and 0.2-0.8%. When 5 and 10% of rapeseed flour is introduced into combined feed, the weight of thoracic muscles in females and males increased by 3.9-8.4 (R≤0.05 and R≤0.01) and 0.5-4.4%, and when 15% of flour is introduced, it decreased by 2.3 and 1.5%. In general, it should be noted that an increase in the proportion of rapeseed flour in the composition of compound feed reduces the meat qualities of turkeys. The decrease in pre-slaughter living weight and ripped carcass weight is probably due to the reduced digestibility of nutrients due to the higher content of anti-nutrients in rapeseed flour, which was included in the diet of turkeys instead of soybean extraction cake.

Our studies in experimental groups also noted changes in both absolute and relative weight of internal organs. On day 105 in females and day 119 in males of experimental groups, the relative liver weight was increased to 0.18 and 0.07%, gizzard - to 0.06 and 0.08%, heart and lungs - to 0.03%, kidneys - to 0.04% compared to turkeys, which received combined feed without rapeseed seed flour. However, when the percentage of rapeseed flour added to the feed is increased, these changes are less noticeable.
Table 1. Meat efficiency of turkey poults and weight of internals at introduction in a diet of rapeseed meal (age of slaughter of females 105 days, males – 119 days) (M ±SEM).

| Performance variable | control | 1-experiment | 2-experiment | 3-experiment |
|----------------------|---------|--------------|--------------|--------------|
| Live weight, g:       |         |              |              |              |
| males                | 17250.0±26.66 | 16828.0±28.74*** | 16391.0±29.62*** | 16183.0±27.64*** |
| females              | 11280.0±26.29 | 11230.0±33.69 | 10629.0±21.83*** | 10216.0±17.92*** |
| on average            | 14265.0    | 14029.0      | 13510.0       | 13199.5      |
| Weight of a gutted   |         |              |              |              |
| carcass, g:           |         |              |              |              |
| males                | 13710.0±22.83 | 13591.0±25.72* | 13070.0±24.74*** | 12992.0±24.81*** |
| females              | 8968.0±19.41 | 8953.0±23.42 | 8537.0±18.46*** | 8255.0±17.65*** |
| on average            | 11339.0    | 11272.0      | 10803.5       | 10623.5      |
| Carcass yield, %:     |         |              |              |              |
| males                | 79.5±0.38  | 80.8±0.23*   | 79.7±0.33     | 80.3±0.68    |
| females              | 79.5±0.38  | 79.7±0.23    | 80.3±0.33     | 80.8±0.68    |
| on average            | 79.5       | 80.3         | 80.0          | 80.6         |
| Weight of pectoral   |         |              |              |              |
| muscles, g:           |         |              |              |              |
| males                | 3640.0±20.72 | 3800.0±10.58 | 3660.0±25.36  | 3584.0±6.77  |
| females              | 2150.0±10.87| 2330.0±20.73**| 2233.0±15.49*| 2100.0±15.03|
| on average            | 2895.0     | 3065.0       | 2946.5        | 2842.0       |
| Absolute weight of organs (g) |
| Liver: males          | 216.0±3.17 | 199.0±2.75*  | 210.0±2.32    | 202.0±3.96   |
| females              | 152.0±1.02 | 154.0±1.45   | 156.0±1.11    | 154.0±1.09   |
| on average            | 184.0      | 176.5        | 183.0         | 178.0        |
| Heart: males          | 62.0±1.14  | 60.0±0.66    | 62.0±1.52     | 63.0±0.85    |
| females              | 30.0±0.56  | 31.0±0.55    | 28.0±0.44*    | 30.0±0.22    |
| on average            | 46.0       | 45.5         | 45.0          | 46.5         |
| Gizzard: males        | 118.0±2.01 | 120.0±1.59   | 121.0±1.45    | 119.0±1.74   |
| females              | 69.0±0.67  | 68.0±0.68    | 68.0±0.55     | 67.6±0.62    |
| on average            | 93.5       | 94.0         | 94.5          | 93.3         |
| Lights: males         | 92.0±1.57  | 93.0±0.79    | 90.0±1.65     | 90.0±2.01    |
| females              | 34.0±0.42  | 32.0±0.21*   | 32.0±0.34*    | 33.0±0.43    |
| on average            | 63.0       | 62.5         | 61.0          | 61.5         |
| Kidney: males         | 60.0±0.98  | 62.0±1.05    | 60.0±1.14     | 61.0±1.74    |
| females              | 24.0±0.41  | 24.0±0.41    | 24.0±0.21     | 24.0±0.36    |
| on average            | 42.0       | 43.0         | 42.0          | 42.5         |
| Relative organ weight (%) of pre-slaughter live weight |
| Liver: males/females  | 1.25/1.35 | 1.18/1.37    | 1.28/1.47     | 1.25/1.51    |
| on average            | 1.29       | 1.26         | 1.35          | 1.35         |
| Heart: males/ females | 0.36/0.27 | 0.36/0.28    | 0.38/0.26     | 0.39/0.29    |
| on average            | 0.32       | 0.32         | 0.33          | 0.35         |
| Gizzard: males/ females | 0.68/0.61 | 0.71/0.61    | 0.74/0.64     | 0.74/0.66    |
| on average            | 0.66       | 0.67         | 0.70          | 0.71         |
| Lights: males/females | 0.53/0.30 | 0.55/0.28    | 0.55/0.30     | 0.56/0.32    |
| on average            | 0.44       | 0.45         | 0.45          | 0.47         |
| Kidney: males/females | 0.35/0.21 | 0.37/0.21    | 0.37/0.23     | 0.38/0.23    |
| on average            | 0.29       | 0.31         | 0.31          | 0.32         |

Hereinafter * - P≤0.05; ** - P≤0.01; *** - P≤0.001 there is a criterion of reliability of distinctions of indicators between control and skilled groups.

As reported (Zhu et al.), in ducks consuming diets with 5, 10, 15 or 20% rapeseed extraction cake during the growing period 7-14 days (1st experiment) or 5, 10, 15, 20 or 25% rapeseed extraction cake during the growing period 15-42 days (2nd experiment), growth rates also decreased linearly as the
level of extraction cake inclusion increased. In addition, the inclusion of rapeseed extraction cake in the diet induced an increase in liver and kidneys in ducklings on the 21st and 42nd days [8].

The inclusion of broiler chickens in the diet of the core or sunflower seeds with the enzyme preparation ensured that they achieved high living weight at 35 days of age (table 2). However, feeding 5% of sunflower seeds with Ronosim VP 250 g/t to chickens in the diet contributed to the highest live weight, which was 4.8% (at R≤0.05) and 2.6% more than in the control group. Differences were established between the groups in the weight of the ripped carcass (6.7 and 4.6% at R≤0.05 and R<0.01), slaughter yield (1.3 and 1.4%) and in the weight of the pectoral muscles (5.1 and 5.3%). There is also a tendency to increase the absolute mass of internal organs, but this difference is not reliable. Feeding both the core and sunflower seeds affected the relative weight of the internal organs. It should be noted that by the relative weight of internal organs, the greatest differences are established by the weight of the gizzard both in cocks (up to 0.12%) and in hens (up to 0.06%), as well as by the weight of the liver in hens (up to 0.09%). There was practically no connection between the inclusion of the core and sunflower seeds and the relative weight of the heart and kidneys.

In a study conducted by M. Zajac et al., it was found that the inclusion in the diets of broiler chickens of 15% sunflower seeds without husk (shell) during the growing period of 21-42 days allows to obtain a higher increase in body weight, breast muscle weight and stomach, but a decrease in liver and heart weight is noted [9].

Miya A et al. (2020) observed similar changes in the weight of internal organs to our results, but using 3 to 15% of Vachellia tortilis leaf flour in the diet [10].

Suchy P et al. (2010) in a study with broilers (1-42 days) found that replacing soy extraction cake with 1/3 and 2/3 lupine slightly reduced the average living mass at the end of the growing period, the weight of the carcass and pectoral muscles. At the same time, in the chickens of the 2nd experimental group compared to the control, a highly significant (P≤0.01) increase in the output of the heart (by 6.7%) and stomach (by 13.1%) was recorded [11].

However, Ciurescu G. et al. (2017) did not observe the dependence between digestive organ sizes (stomach, heart, liver, pancreas, small intestine, blind intestine and small intestine) on diets (feeding) with an increased content of raw lentils seeds (200-400 g/kg). A significant relationship between lentil content was observed for pancreatic mass [12-15].

If we compare the experimental groups with each other, it can be noted that broilers that received sunflower seeds and an enzyme preparation, both in meat qualities and in absolute weight of internal organs, exceeded broilers that received sunflower kernels in their diet. However, by the relative weight of the organs, the difference is noted only by the weight of the gizzard (more by 0.08 and 0.06%). An increase in the mass of the stomach in broilers is most likely due to a moderately high content of raw fiber in the diets, since sunflower seeds were included with the husk, as well as with an additional introduction of an enzyme preparation. These two factors improved the development of the organ and its work, which ultimately led to an improvement in the growth of broiler chickens.

It should also be noted that the increase in creep feed rates for both the core and sunflower seeds is accompanied by a decrease in the weight of internal organs. So, liver weight in cockerels of the 3rd and 4th experimental groups, less than the 1st and 2nd experimental groups by 0.6 and 2.0%, hearts - by 1.4 and 6.3%, gizzard - by 2.2 and 4.3%, lungs - by 1.9 and 0.9%, kidneys - by 1.3%, and for chickens by 1.9 and 0.4%, 1.6 and 3, respectively, 0%, 2.8 and 6.4%, 2.8 and 3.8%, 1.6 and 2.4%, 9.3 and 2.7%.

Chickens- females of experimental groups in terms of relative weight of the liver, gizzard and lungs were superior to males by 0.16-0.19%, 0.02-0.07% and 0.03-0.05%, while they were inferior in weight of the heart and kidneys - by 0.01-0.02% and 0.04-0.07%. The results of studies conducted by E.Tumová and D. Chodová (2018) on broiler chickens also established the superiority at the age of 35 days of chicken-females over males in relative weight of the stomach and the lag in heart weight [2].

4. Conclusion

Studies show that the meat productivity and development of some internal organs depend on the feed ingredient and the amount of its introduction. Turkeys that received rapeseed flour had lower
values for pre-slaughter live weight (less by 0.4-9.4%) and ripped carcass weight (less by 0.2-8.0%), while indicators for slaughter yield were more by 0.5-1.1%, relative liver weight - by 0.02-0.16% and gizzard - by 0.03-0.05%.

**Table 2.** Meat efficiency of broilers and weight of internals at introduction in a diet of a kernel and seeds of sunflower (age of slaughter of 35 days) (M ±SEM).

| Performance variable                        | control     | 1-experiment | 2-experiment | 3-experiment | 4-experiment |
|---------------------------------------------|-------------|--------------|--------------|--------------|--------------|
| Live weight, g: males                       | 2063.3±19.22| 2120.0±18.93| 2100.0±22.55| 2163.3±17.64*| 2133.3±17.40|
| females                                     | 1855.0±17.64| 1891.7±11.67| 1871.7±15.90| 1903.3±23.15| 1891.7±12.02|
| on average                                  | 1959.2      | 2005.9       | 1985.9       | 2033.3       | 2012.5       |
| Weight of a gutted carcass, g: males        | 1463.4±31.14| 1510.0±30.14| 1491.7±14.81| 1561.7±10.93*| 1530.0±13.23|
| females                                     | 1305.0±10.00| 1341.7±6.01*| 1325.0±10.41| 1365.0±7.64**| 1345.0±10.41|
| on average                                  | 1384.2      | 1425.9       | 1408.4       | 1463.4       | 1437.5       |
| Carcass yield, %: males                     | 70.9±1.15   | 71.2±0.93    | 71.0±0.57    | 72.2±0.26    | 71.7±0.44    |
| females                                     | 70.3±0.41   | 70.9±0.47    | 70.8±0.40    | 71.7±1.00    | 71.1±0.26    |
| on average                                  | 70.6        | 71.1         | 70.9         | 72.0         | 71.4         |
| Weight of pectoral muscles, g: males        | 494.5±13.49 | 510.3±24.51  | 506.8±9.52   | 519.6±30.08  | 513.9±10.75  |
| females                                     | 422.2±7.98  | 434.6±8.03   | 429.8±14.80  | 444.7±20.45  | 441.0±5.11   |
| on average                                  | 458.4       | 472.5        | 468.3        | 482.2        | 477.5        |
| Absolute weight of organs (g)               |             |              |              |              |              |
| Liver: males                                | 48.4±0.60   | 49.7±2.99    | 49.4±2.55    | 50.7±4.42    | 49.7±4.43    |
| females                                     | 45.2±2.17   | 47.8±1.43    | 46.9±2.28    | 47.9±2.75    | 47.7±0.84    |
| on average                                  | 46.8        | 48.8         | 48.2         | 49.3         | 48.7         |
| Heart: males                                | 6.9±0.59    | 7.2±0.12     | 7.1±0.50     | 8.0±0.62     | 7.5±0.23     |
| females                                     | 7.0±0.38    | 6.3±0.07     | 6.2±0.31     | 6.6±0.06     | 6.4±0.23     |
| on average                                  | 6.3         | 6.8          | 6.7          | 7.3          | 7.0          |
| Gizzard: males                              | 17.4±3.34   | 18.6±1.79    | 18.2±1.65    | 20.8±0.64    | 19.9±2.09    |
| females                                     | 17.0±1.39   | 17.9±1.53    | 17.4±1.37    | 18.7±2.70    | 17.5±0.54    |
| on average                                  | 17.2        | 18.3         | 17.8         | 19.8         | 18.7         |
| Lights: males                               | 9.9±0.96    | 10.8±0.15    | 10.6±0.53    | 11.0±0.66    | 10.9±0.55    |
| females                                     | 9.6±0.24    | 10.6±0.37    | 10.3±0.57    | 10.6±0.74    | 10.2±0.26    |
| on average                                  | 9.8         | 10.7         | 10.5         | 10.8         | 10.6         |
| Kidney: males                               | 14.1±1.01   | 15.0±0.85    | 14.8±0.23    | 15.4±0.25    | 15.2±0.21    |
| females                                     | 11.7±0.44   | 12.5±1.25    | 1.3±0.10     | 12.4±0.76    | 12.1±0.37    |
| on average                                  | 12.9        | 13.8         | 13.6         | 13.9         | 13.7         |
| Relative organ weight (%) of pre-slaughter live weight | | | | | |
| Liver: males                                | 2.35±0.05   | 2.34±0.14    | 2.35±0.10    | 2.34±0.19    | 2.33±0.20    |
| females                                     | 2.44±0.13   | 2.53±0.07    | 2.51±0.14    | 2.52±0.11    | 2.52±0.03    |
| on average                                  | 2.40        | 2.44         | 2.43         | 2.43         | 2.43         |
| Heart: males                                | 0.33±0.02   | 0.34±0.01    | 0.34±0.02    | 0.37±0.03    | 0.35±0.01    |
| females                                     | 0.31±0.02   | 0.33±0.00    | 0.33±0.02    | 0.35±0.00    | 0.34±0.01    |
| on average                                  | 0.32        | 0.34         | 0.34         | 0.36         | 0.35         |
| Gizzard: males                              | 0.84±0.16   | 0.88±0.09    | 0.87±0.08    | 0.96±0.04    | 0.93±0.09    |
| females                                     | 0.92±0.07   | 0.95±0.08    | 0.93±0.07    | 0.98±0.14    | 0.93±0.04    |
| on average                                  | 0.88        | 0.92         | 0.90         | 0.97         | 0.93         |
| Lights: males                               | 0.48±0.05   | 0.51±0.00    | 0.50±0.02    | 0.51±0.03    | 0.51±0.03    |
| females                                     | 0.52±0.01   | 0.56±0.02    | 0.55±0.03    | 0.56±0.04    | 0.54±0.01    |
| on average                                  | 0.50        | 0.54         | 0.53         | 0.54         | 0.53         |
| Kidney: males                               | 0.68±0.06   | 0.71±0.04    | 0.70±0.01    | 0.71±0.01    | 0.71±0.01    |
| females                                     | 0.63±0.03   | 0.66±0.07    | 0.66±0.01    | 0.65±0.04    | 0.64±0.02    |
| on average                                  | 0.66        | 0.69         | 0.68         | 0.68         | 0.68         |
Feeding broiler chickens with a diet of 5% sunflower seeds and the enzyme preparation Ronozim (250 g/t) for 35 days of cultivation had the greatest positive effect on meat productivity and relative weight of internal organs. At the same time, an increase in the percentage of sunflower injection leads to a decrease in the indicators studied.

References
[1] Furlan R L, Machado JG D, Giachetto P F, Malheiros E B, Furlan L R and Macari M 2002 Desempenho e composição da carcaça de frangos de corte submetidos a diferentes períodos de arraçamento. Revista Brasileira de Zootecnia 31(6)
[2] Tůmová E and Chodová D 2018 Performance and changes in body composition of broiler chickens depending on feeding regime and sex. Czech J. Anim. Sci. 63 518–525
[3] Mirghelenj S A and Golian A 2009 Effects of feed form on development of digestive tract, performance and carcass traits of broiler chickens. Journal of animal and veterinary advances 10(8) 1911-1915
[4] Khan K, Zaneb H, Rehman Z U, Maris H and Rehman H U 2019 Effect of phytase supplementation on growth performance in chickens. Pakistan Journal of Zoology 2(51) 731-735
[5] Masoudi A, Chaji M, Bojarpour M and Mirzadeh Kh 2011 Effects of different levels of date pits on performance, carcass characteristics and blood parameters of broiler chickens. Journal of Applied Animal Research 4(39) 399-405
[6] Biesek J, Kuzniacka J, Banaszak M, Kaczmarek S, Adamski M, Rutkowski A, Zmudzinska A, Perz K and Hejdysz M 2020 Growth performance and carcass quality in broiler chickens fed on legume seeds and rapeseed meal. Animals 10(5) 846
[7] Yu J, Yang H M, Wan X L, Chen Y J, Yang Z, Liu W F, Liang Y Q and Wang Z Y 2020 Effects of cottonseed meal on slaughter performance, meat quality, and meat chemical composition in Jiangnan White goslings. Poultry Science 1(99) 207-213
[8] Zhu Y W, Yang W C, Liu W, Yin X H, Luo X B, Zhang S A, Wang W C and Yang L 2019 Effects of dietary rapeseed meal inclusion levels on growth performance, organ weight, and serum biochemical parameters in Cherry Valley ducks. Poultry science 12(98) 6888-6896
[9] Zajac M, Kiczorowska B, Samolinska W and Klebaniuk R 2020 Inclusion of camelina, flax, and seeds in the diets for chickens: apparent digestibility of nutrients, growth performance, health status, and carcass and meat quality traits. Animals 10(2) 321
[10] Miya A, Sithole A N., Mthethwa N, Khanyile M and Chimonyo M 2020 Response in carcass yield, organ weights, and gut morphology of broiler chickens to incremental levels of Vachellia tortilis leaf meal. Canadian journal of animal science 2(100) 282-291
[11] Suchy P, Strakova E, Herzig I, Steinhausler L, Vopalensky J and Kroupa L 2010 Effect of replacing soybean meal with lupin seed-based meal in chicken diet on performance, carcass value and meat quality. ACTA VETERINARIA BRNO 2(79) 195-202
[12] Ciurescu G, Vasilachi A, Habeau M and Dragomir C 2017 Effects of dietary lentil seeds inclusion on performance, carcass characteristics and cecal pH of broiler chickens. Indian Journal of Animal Sciences 9(87) 1130-1134
[13] Gruzina Y, Firsova I and Strielkowski W 2021 Dynamics of human development in economic development cycles. Economies 9(2) 67
[14] Nikiforov A, Kuchumov A, Terentev S, Karamulina I, Romanova I and Glushakov S 2020 Neural network method as means of processing experimental data on grain crop yields. E3S Web of Conferences 161 01031
[15] Sidorov A, Abdullozoda R, Sadullozoda S, Saifiddinzoda O and Abdullozoda I 2021 Method for determining the state of an grounding device. IOP Conference Series: Earth and Environmental Science 808 012005