Part 3. Biosafety

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MONITORING OF FEED FOR CHICKENS BY THE CONTENT OF VITAMINS AND MICROELEMENTS

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Summary. The paper presents the results of monitoring of compound feeds for different types of chickens for the period 2017–2021 by the indicators of the content of vitamins (A, E, B_2) and trace elements (Zn, Cu, Se). Vitamin A content did not show significant deviations from the norm in compound feeds for productive chickens and for reproductive meat poultry, and in compound feeds for reproductive egg hens, samples with low vitamin A content (5.7%) were found. By the content of vitamin E in compound feeds for commercial chickens, the percentage of samples with reduced content was 75.2%, in compound feeds for reproductive egg hens — 63.9%, and in compound feeds for reproductive meat hens — 12.7%. By the content of vitamin B_2 in compound feeds for reproductive egg chickens, samples with reduced content of vitamin B_2 were not observed, while in compound feeds for reproductive meat chickens, reduction of vitamin B_2 was found in 4.0% of samples, and in compound feeds for commercial laying hens in 5.1%. The average zinc content in compound feeds for productive laying hens and reproductive egg and meat hens was within normal limits, but reduced zinc levels were observed in 11.0, 2.5, and 17.3% of samples, and above the MAL — in 11.1, 16.9, and 47.1% of the samples, respectively. The average content of copper in compound feeds for commercial laying hens and reproductive egg and meat hens was within the norm, but the reduced level of the element was registered in 1.4, 0.0, and 18.0% of samples, and above the MAL — in 1.4, 8.3, and 16.9% of samples, respectively. The average content of selenium in compound feeds for commercial laying hens and reproductive egg and meat hens was within the norm, but the reduced level of the element was registered in 52.8, 29.3, and 26.8% of samples, the exceeding of the maximum allowable level was not detected

Keywords: vitamins A, E, B_2, zinc, cooper, selenium

Introduction. Modern chicken crosses have a potential productivity of more than 330 eggs per year. Over the past 20 years, the live weight of 42-day-old broilers has increased 2.3 times (2.4 kg), and the fattening period to a weight of 2 kg has decreased by 26 days (from 63 to 37 days). At the same time, the efficiency of compound feed use increased, the costs per 1 kg of weight gain decreased from 2.5 to 1.65 kg of feed.

In the near future, broilers are expected to reach a live weight of 2 kg by 36 days of age with the conversion of compound feed 1.4 kg (Makarynska and Vorona, 2019).

Given the above, the increase of the load on the body in terms of sensitivity to various stresses would be logical, so to realize the inherent genetic potential the bird's need for vitamins and trace elements will increase, especially those involved in antioxidant protection and affect reproductive function: vitamins B_2, A, and E (Abd El-Hack et al., 2019; Lauridsen, 2019; Idamokoro et al., 2020), trace elements selenium, zinc, copper (Huma et al., 2019; Sobolev et al., 2019; Ghasemi et al., 2020).

Monitoring of nutrients in feed is one of the elements of a timely correction of the measures for the optimal provision of vitamin and mineral nutrition of chickens in modern conditions (Kutsan and Orobchenko, 2011, 2015; Alagawany et al., 2021).

Therefore, the **work was aimed** to monitor feed for chickens with indicators of vitamins and trace elements.

Materials and methods. As part of achieving the goal of this work, we monitored feed for chickens of different areas of productivity in terms of vitamins (A, E, B_2) and trace elements (zinc, copper, selenium) for the period 2017–2021.

Compound feed samples were examined in the Laboratory of Toxicological Monitoring of the National Scientific Center 'Institute of Experimental and Clinical Veterinary Medicine' (Kharkiv) and in the Scientific Chemical and Toxicological Department of the State Scientific and Research Institute of Laboratory Diagnostics and Veterinary and Sanitary Expertise (Kyiv).

The study of the content of vitamins in compound feeds was carried out according to Kutsan and Orobchenko (2009) and using liquid chromatography following DSTU 4687:2006 (DSSU, 2007); trace elements — using the methods of atomic absorption spectrometry following DSTU EN 14082:2019 (SE 'UkrNDNC', 2019) and X-ray fluorescence analysis (Kutsan, Orobchenko and Kocherhin, 2014).

In total for the period 2017–2021 there were examined:

— for the content of vitamin A — 678 samples of compound feeds (281 samples for commercial laying hens, 228 samples for reproductive population of laying hens, and 169 samples for reproductive meat chickens);

— for the content of vitamin E — 305 samples of compound feeds (129 samples for commercial laying hens, 97 samples for reproductive population of laying hens, and 79 samples for reproductive meat chickens);

— for the content of vitamin B_2 — 531 samples of compound feeds (237 samples for commercial laying hens, 168 samples for reproductive population of laying hens, and 126 samples for reproductive meat chickens);

— for the content of zinc — 725 samples of compound feeds (298 samples for commercial laying hens, 236 samples for reproductive population of laying hens, and 191 samples for reproductive meat chickens);

— for the content of copper — 713 samples of compound feeds (288 samples for commercial laying hens, 242 samples for reproductive population of laying hens, and 183 samples for reproductive meat chickens);

— for the content of selenium — 588 samples of compound feeds (233 samples for commercial laying hens, 191 samples for reproductive population of laying hens, and 164 samples for reproductive meat chickens).

The obtained results have been calculated by the methods of variation statistics using the software package StatPlus v. 5.9.8.5. Data are presented as mean values with standard deviation at a confidence level of 95%, the reliability of research results was evaluated by Fisher's test.

Results and discussion. Monitoring of feed for chickens (commercial and reproductive population of egg and meat chickens) in 2017–2021 by the content of vitamins (A, E, B_2) and trace elements (zinc, copper, selenium), which affect the reproductive function of poultry, has been carried out.

For the content of vitamin A 678 samples of compound feeds have been tested over the years (281 samples for commercial laying hens, 228 samples for reproductive population of laying hens, and 169 samples for reproductive meat chickens): the average content was respectively 11,510.59 ± 62.88 IU/kg (10,009.98–14,238.5 IU/kg), 14,749.57 ± 175.75 IU/kg (7,912.14–17,622.87 IU/kg) and 18,240.04 ± 36.94 IU/kg (17,366.59–19,631.89 IU/kg) (Fig. 1).

The content of vitamin A in all terms of research was reliably higher ($p < 0.05$) in compound feeds for reproductive population of meat chickens relative to the rate of feed for commercial poultry: in 2017 — by 47.6%, in 2018 — by 59.2%, in 2019 — by 53.2%, in 2020 — by 69.0%, in 2020 — by 68.4%, and exceeding the overall figure for 5 years was 58.5%.

A similar pattern was observed in compound feeds for reproductive population of egg hens relative to the indicators of compound feeds for commercial poultry: in 2017, the excess ($p < 0.05$) of vitamin A content was 38.7%, in 2018 — 46.7%, in 2019 — 32.8%, in 2020 and 2021 — 5.7 and 1.0%, respectively (but the value was not reliable), and the excess of the overall figure for 5 years was 28.1% (Fig. 1).

It should be noted that the average content of vitamin A in compound feeds for commercial laying hens was within normal limits (10,000.0–12,000.0 IU/kg) (Melnyk et al., 2013), while in compound feeds for reproductive population of chickens of both directions of productivity, the content of vitamin A was higher than the upper limit of normal (Melnyk et al., 2013) by an average of 43.3%. In addition, there is a tendency to reduce the content of vitamin A in feed for reproductive population of egg chickens starting from 2020 (Fig. 1).

Dynamics of the norm and lack of vitamin A, the in feed for chickens of different types of productivity is shown in percentage in Fig. 2. Thus, in compound feeds for commercial chickens and reproductive meat poultry during the whole period of research no samples with reduced content of vitamin A were observed.

Samples with reduced vitamin A content were detected in compound feeds for reproductive hens: in 2020 — 14.0% (norm — 86.0%), and in 2021 — 21.2% (norm — 78.8%), that was reflected in the average for 5 years: 5.7% of samples were below normal (Fig. 2).

305 samples of compound feeds were investigated for the content of vitamin E over the years (for commercial laying hens — 129 samples, for reproductive population of laying hens — 97 samples, and for reproductive meat chickens — 79 samples): the average content was 119.16 ± 2.77 mg/kg (62.72–181.03 mg/kg), 165.10 ± 4.68 mg/kg (75.32–247.76 mg/kg), and 219.93 ± 2,02 mg/kg (180.6–267.02 mg/kg) (Fig. 3).

The content of vitamin E in all terms of research was reliably higher ($p < 0.05$) in compound feeds for reproductive meat chickens relative to the rate in feed for commercial poultry: in 2017 — by 85.4%, in 2018 — by 86.7%, in 2019 — by 78.7%, in 2020 — by 95.4%, in 2021 — by 76.9%, and exceeding the overall figure for 5 years was 84.6%.

A similar pattern was observed in compound feeds for reproductive population of egg hens relative to the indicator of compound feeds for commercial poultry: in 2017 the excess ($p < 0.05$) of vitamin E content was 68.4%, in 2018 — 39.6%, in 2019 — 35.8%, in 2020 — by 22.3%, in 2021 — by 24.7%, and the excess of the overall figure for 5 years was 38.6% (Fig. 3).

It should be noted that the average content of vitamin E in compound feeds for commercial laying hens and reproductive population of egg hens was less than normal (150.0 and 200.0 mg/kg, respectively) (Kutsan and Orobchenko, 2009) by 20,6% and 17.5%, while in compound feeds for reproductive population of meat chickens the content of vitamin E was higher than the upper norm (Kutsan and Orobchenko, 2009) by 10.0%. In addition, there is a tendency to reduce the content of vitamin E in feed for reproductive population of egg hens, especially pronounced in 2020 (Fig. 3).

In percentage, the dynamics of the norm and lack of vitamin E in compound feed for chickens of different directions of productivity is shown in Fig. 4.

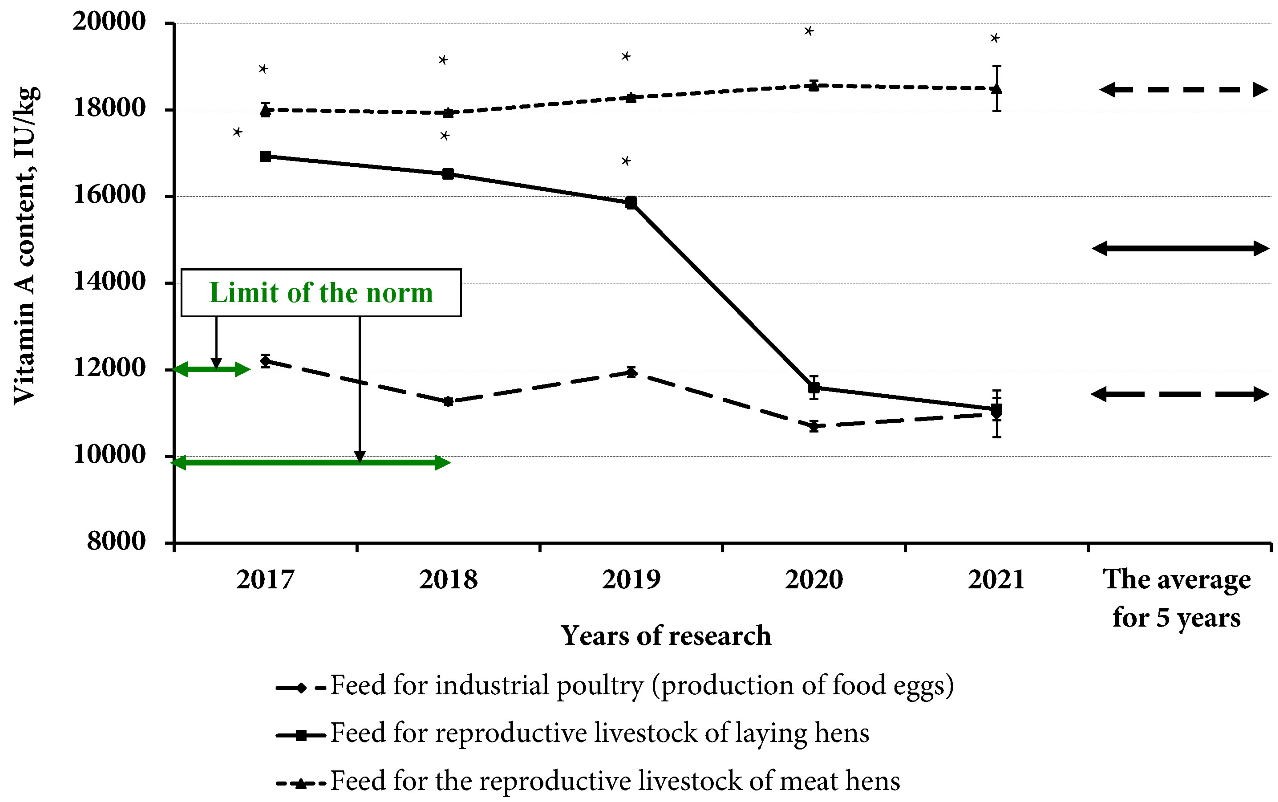

Figure 1. The content of vitamin A in compound feed for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 678, * — $p < 0.05$ relative to the figure of feed for commercial chickens)

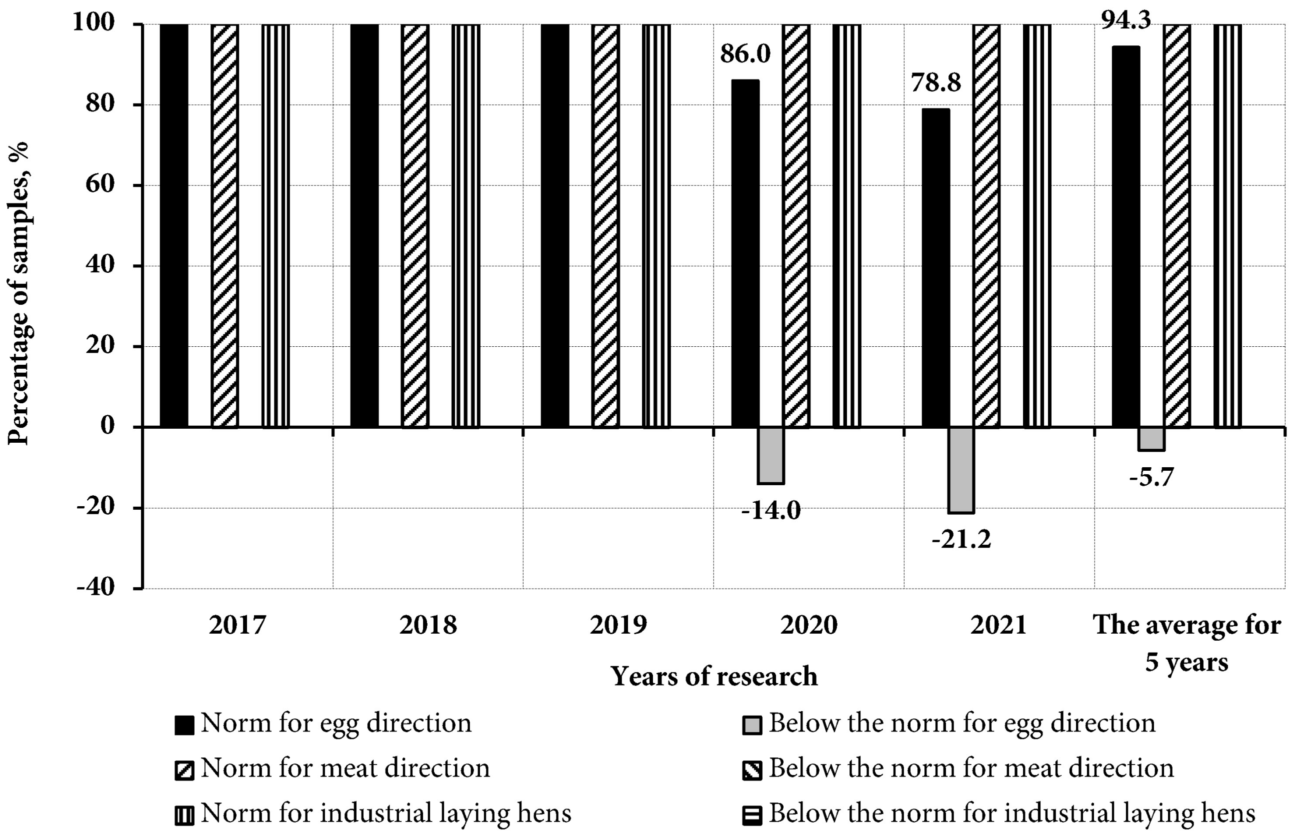

Figure 2. The ratio of vitamin A norm and deficiency in feed for chickens of different areas of productivity in the dynamics of 2017–2021 (M ± m, n = 678)

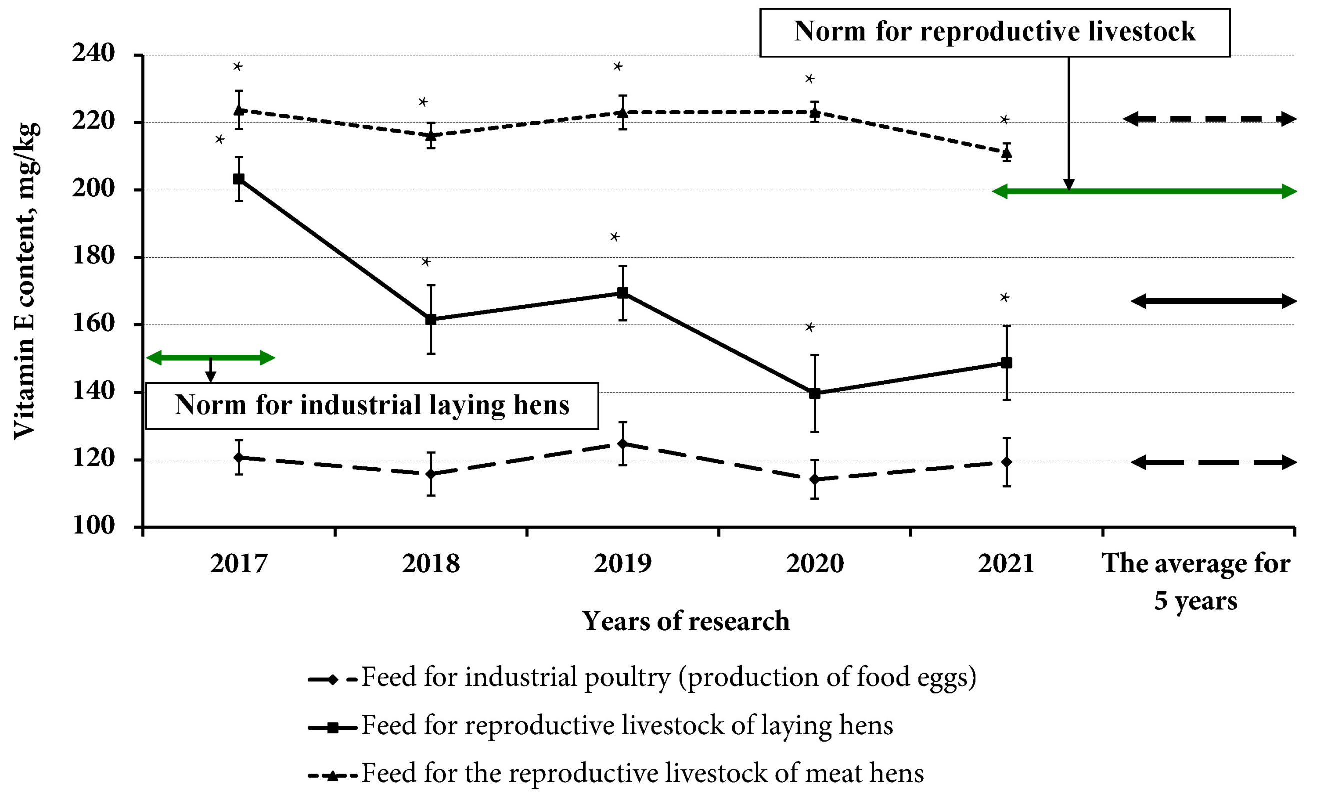

Figure 3. The content of vitamin E in feed for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 305, * — $p < 0.05$ relative to the rate in feed for commercial chickens)

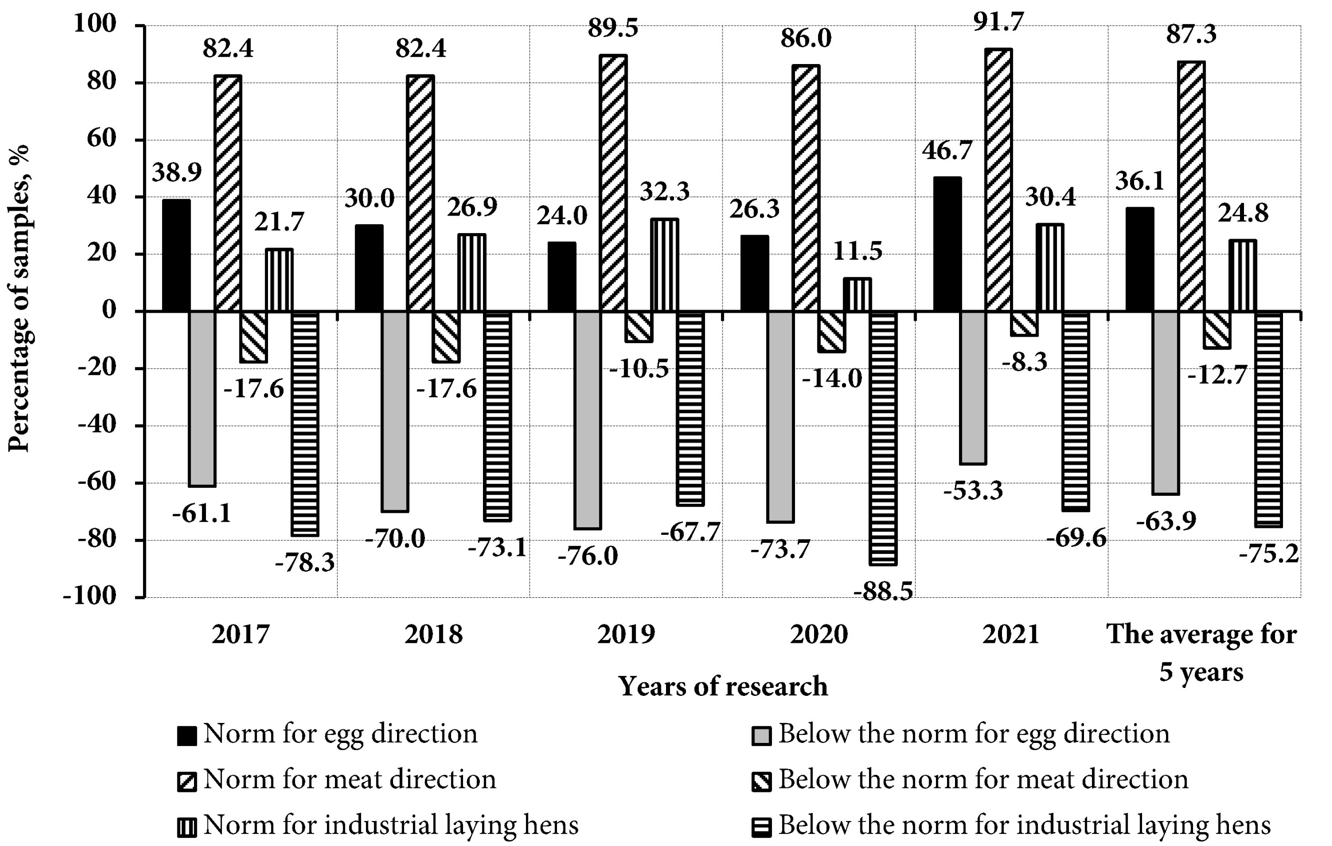

Figure 4. The ratio of vitamin E norm and deficiency in compound feed for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 305)

Thus, in compound feeds for commercial chickens at all terms of research we found a significant percentage of samples with low vitamin E content: in 2017 — 78.3% (norm — 21.7%), in 2018 — 73.1% (norm — 26.9%), in 2019 — 67.7% (norm — 32.3%), in 2020 — 88.5% (norm — 11.5%), and in 2021 — 69.6% (norm — 30.4%), which was reflected in the average indicator for 5 years: 75.2% of samples were below the norm.

A similar pattern was observed in compound feeds for the reproductive population of egg hens: the percentage of samples with low vitamin E content in 2017 was 61.1% (norm — 38.9%), in 2018 — 70.0% (norm — 30.0%), in 2019 — 76.0% (norm — 24.0%), in 2020 — 73.7% (norm — 26.3%), and in 2021 — 53.5% (norm — 46.7%), which was reflected in the average for 5 years: 63.9% of samples were below normal .Samples with a reduced content of vitamin E were also found in compound feeds for the reproductive population of meat chickens, but their percentage was not significant: in 2017 — 17.6% (norm — 82.4%), in 2018 — 17.6% (norm — 82.4%), in 2019 — 10.5% (norm — 89.5%), in 2020 — 14.0% (norm — 86.0%), and in 2021 — 8.3% (norm — 91.7%), which was reflected in the average for 5 years: 12.7% of samples were below the norm (Fig. 4).

531 feed samples were tested for vitamin B_2 content over the years (for commercial laying hens — 237 samples, for reproductive egg hens — 168 samples and for reproductive meat hens — 126 samples): the average content was 5.84 ± 0.04 mg/kg (4.79–7.78 mg/kg), 7.06 ± 0.08 mg/kg (5.14–9.78 mg/kg), and 7.92 ± 0.13 mg/kg (4.60–10.61 mg/kg) (Fig. 5). The content of vitamin B_2 in all terms of research was reliably higher ($p < 0.05$) in compound feeds for reproductive meat chickens relative to the rate of feed for commercial poultry: in 2017 — by 32.3%, in 2018 — by 28.9%, in 2019 — by 22.5%, in 2020 — by 55.0%, in 2021 — by 49.9%, and exceeding the overall figure for 5 years was 35.6%. A similar pattern was observed in compound feeds for reproductive population of egg hens relative to the rate of feed for commercial poultry: in 2017, the excess ($p < 0.05$) was 30.2%, in 2018 — 13.6%, in 2019 — 21.3%, in 2020 — 15.1%, in 2021 — by 26.4%, and exceeding the overall figure for 5 years was 20.9%. It should be noted that the average content of vitamin B_2 in compound feeds for commercial laying hens was within normal limits (5.0–6.0 mg/kg) (Melnyk et al., 2013), while in compound feeds for reproductive population of both meat and egg chickens, the vitamin content was higher than the upper limit of normal (Melnyk et al., 2013) by an average of 28.3% (Fig. 5).

In percentage terms, the dynamics of the norm and lack of vitamin B_2 in the compound feed for chickens of different directions of productivity is shown in Fig. 6.

Thus, in the compound feed for reproductive egg hens throughout the study period, no samples were observed with low levels of vitamin B_2. In compound feeds for reproductive population of meat chickens samples with the reduced rate of the content of vitamin B_2 were found: in 2017 — 10.7% (norm — 89.3%), in 2018 — 6.5% (norm — 93.5%), and in 2019–2021 there were no samples with low vitamin B_2 content, which was reflected in the average for 5 years: 4.0% of samples were below normal.

Samples with reduced content of vitamin B_2 were also found in compound feeds for commercial laying hens: in 2017 — 4.7% (norm — 95.3%), in 2018 — 3.5% (norm — 96.5%), in 2020 — 4.2% (norm — 95.8%), and in 2021 — 16.2% (norm — 83.8%), in 2019 there were no samples with low vitamin B_2 content, that was reflected in the average for 5 years: 5.1% of samples were below normal (Fig. 6).

725 samples of compound feeds were studied for the content of zinc in the dynamics of years (for commercial laying hens — 298 samples, for reproductive population of egg hens — 236 samples and for reproductive meat chickens — 191 samples): the average content was 89.54 ± 1.29 mg/kg (50.49–131.60 mg/kg), 98.06 ± 1.38 mg/kg (52.44–135.88 mg/kg), and 118.32 ± 1.31 mg/kg (80.09–147.62 mg/kg) (Fig. 7).

The content of zinc in all terms of research was reliably higher ($p < 0.05$) in compound feeds for reproductive population of meat chickens relative to the rate of feed for commercial poultry: in 2017 — by 28.6%, in 2018 — by 55.9%, in 2019 — by 38.4%, in 2020 — by 23.0%, in 2021 — by 24.9%, and the excess of the overall figure for 5 years was 32.1%. A slightly different picture was observed in compound feed for reproductive egg hens relative to the rate of feed for commercial poultry: in 2017, 2020, and 2021 — no significant changes in zinc content were registered; in 2018, the excess ($p < 0.05$) of zinc content was 34.0%, in 2019 — 19.6%, and the excess of the overall figure for 5 years was 9.5% (Fig. 7).

It should be noted that the average zinc content in compound feeds for commercial laying hens and reproductive chickens of both directions of productivity was within the norm (approximate indicator, according to the instructions on the operation of poultry crosses) (not less than 60.0 and not less than 100.0 mg/kg, respectively) (Fig. 7).

However, in addition to zinc deficiency in compound feeds, the maximum allowed level (MAL) was exceeded (120.0 mg/kg) (MAPFU, 2012) during the study period: in commercial chickens — 11.1% of samples, in reproductive egg chickens — 16.9% of samples, and in reproductive meat chickens — 47.1% of samples.

In percentage, the dynamics of the norm and zinc deficiency in compound feed for chickens of different directions of productivity is shown in Fig. 8.

Thus, the lowest percentage of samples with reduced zinc content was observed in compound feeds for reproductive population of egg hens during the entire study period: in 2017 — 4.3% (norm — 95.7%), in 2018 — 100.0% samples corresponded to the norm, in 2019 — 4.3% (norm — 95.7%), in 2020 — 3.4% (norm — 96.6%), and in 2021 — 100.0% of samples corresponded to the norm, that was reflected in the average for 5 years: 2.5% of samples were below the norm.

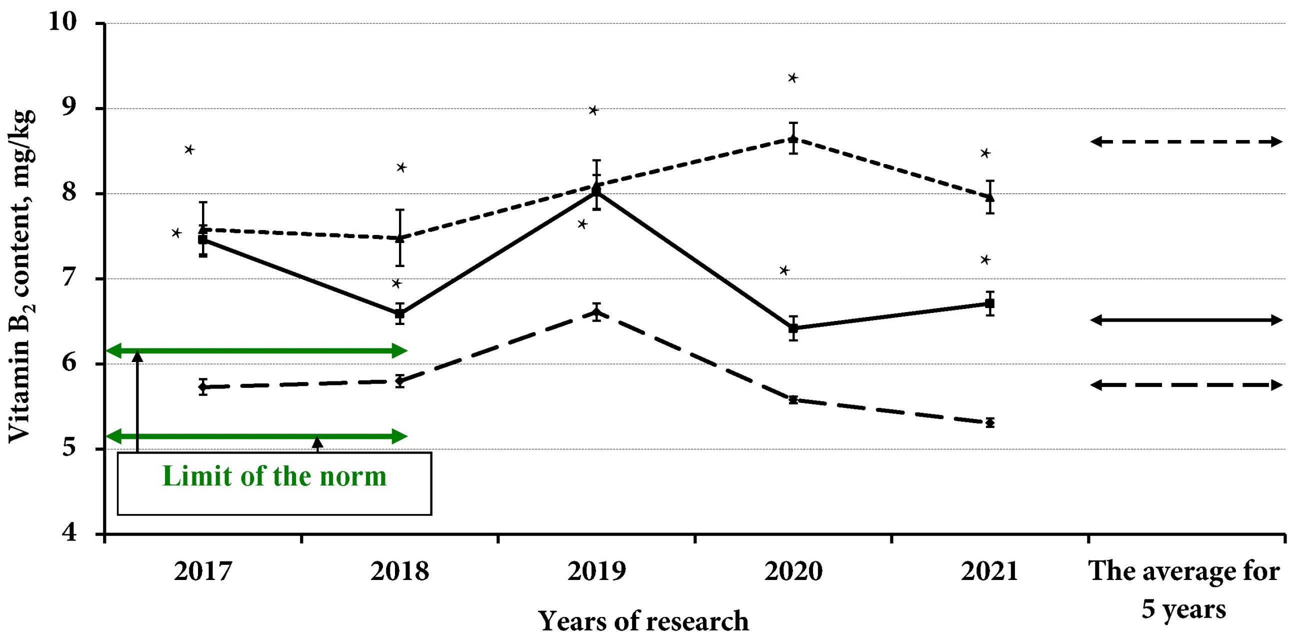

Figure 5. The content of vitamin B_2 in compound feed for chickens of different productivity directions in the dynamics of 2017–2021 (M ± m, n = 531, * — $p < 0.05$ relative to the indicator of feed for commercial chickens)

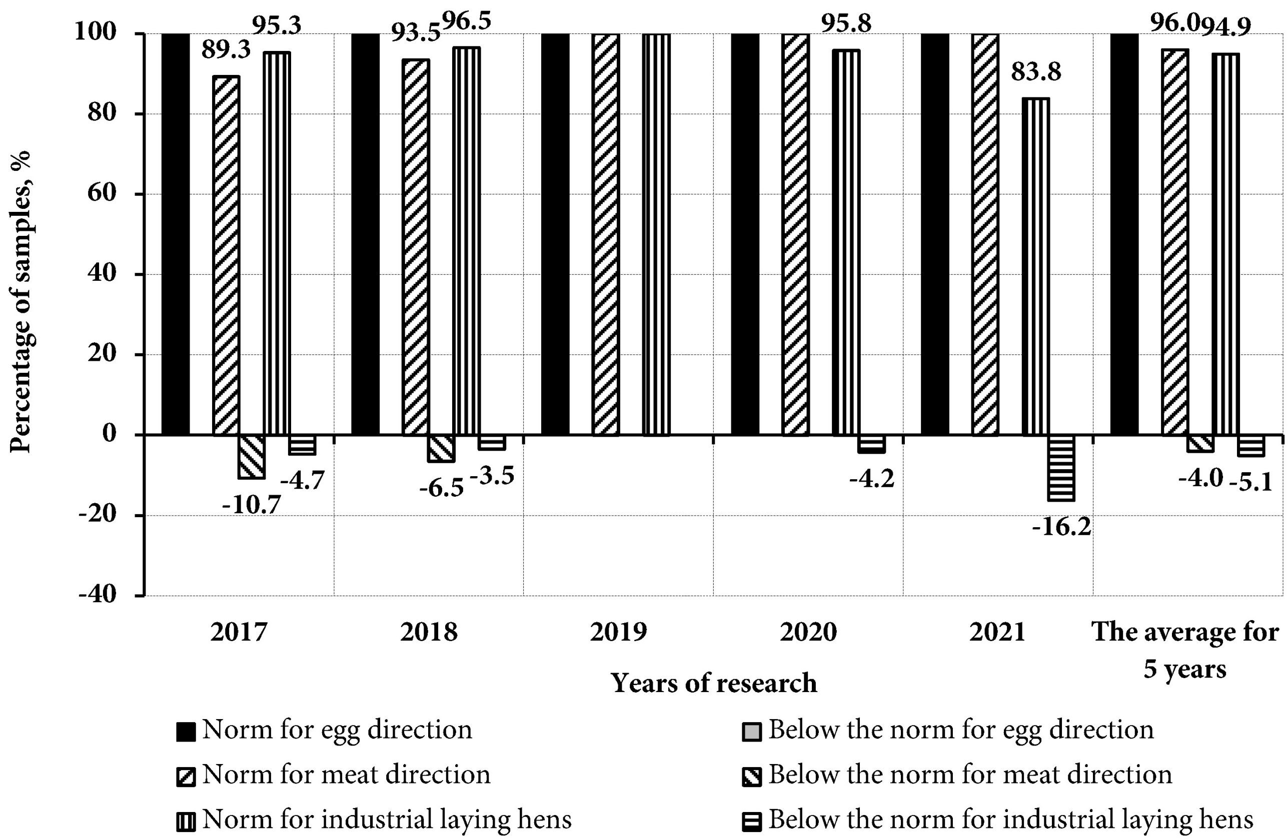

Figure 6. The ratio of vitamin B_2 norm and deficiency in feed for chickens of different areas of productivity in the dynamics of 2017–2021 (M ± m, n = 531)

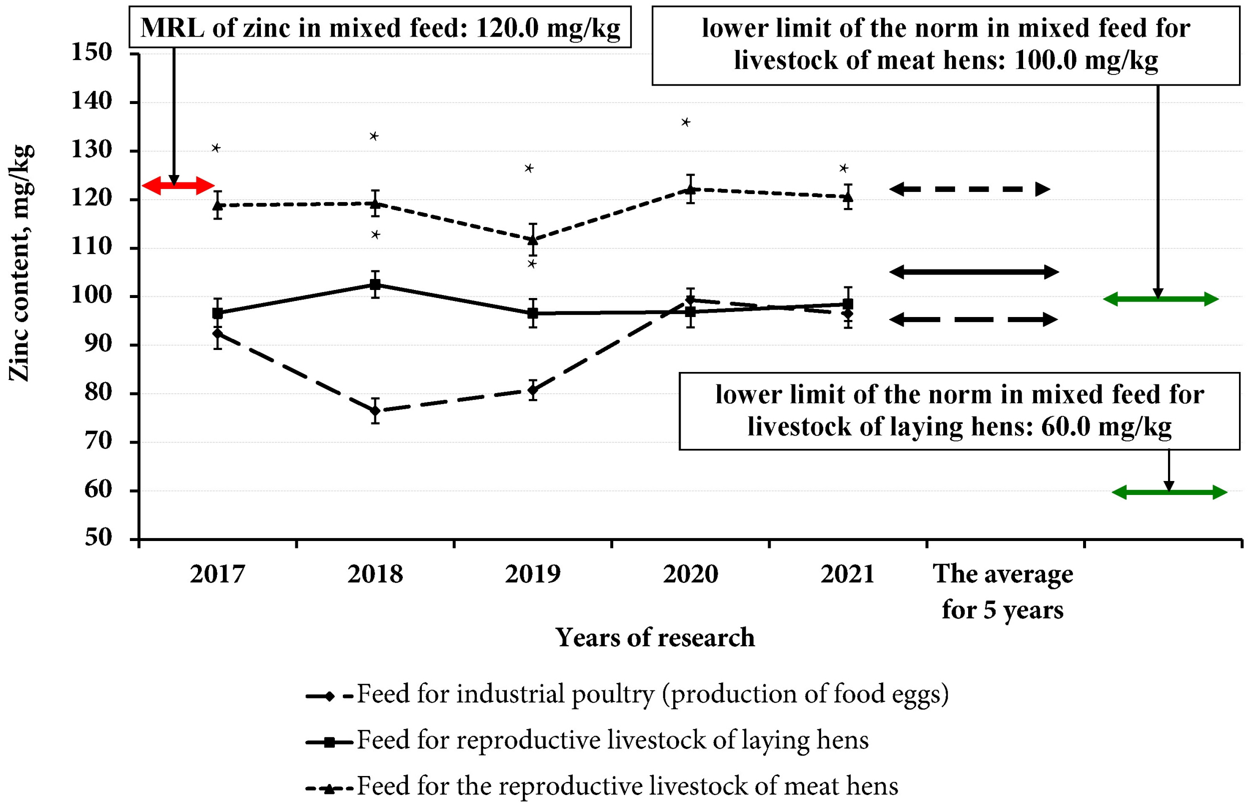

Figure 7. Zinc content in compound feeds for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 725, * — p <0.05 — relative to the rate of compound feeds for commercial chickens)

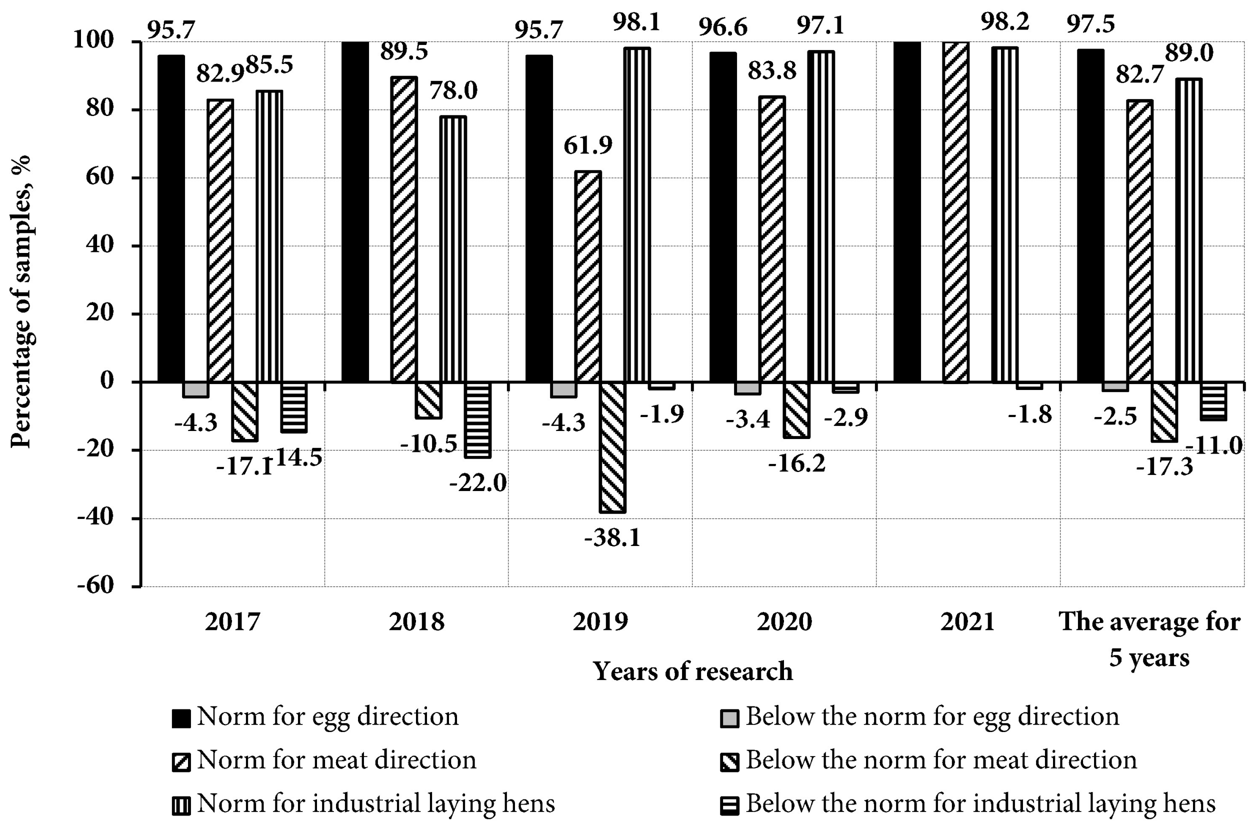

Figure 8. The ratio of norm and zinc deficiency in compound feed for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 725)

In compound feeds for the reproductive population of meat chickens the largest number of samples with low zinc content was detected: in 2017 — 17.1% (norm — 82.9%), in 2018 — 10.5% (norm — 89.5%), in 2019 — 38.1% (norm — 61.9%), in 2020 — 16.2% (norm — 83.8%), and in 2021 — 100.0% of samples corresponded to the norm, which was reflected in the average for 5 years: 17.3% of samples were below the norm.

Samples with reduced zinc content were also found in compound feeds for laying hens: in 2017 — 14.5% (norm — 85.5%), in 2018 — 22.0% (norm — 78.0%), in 2019 — 1.9% (norm — 98.1%), in 2020 — 2.9% (norm — 97.1%), and in 2021 — 100.0% of samples corresponded to the norm, that was reflected in the average for 5 years: 11.0% of samples were below the norm (Fig. 8).

713 samples of compound feeds were investigated for the content of copper in the dynamics of years (for commercial laying hens — 288 samples, for reproductive egg hens — 242 samples, for reproductive meat hens — 183 samples): the average content was respectively 10.49 ± 0.25 mg/kg (4.37–26.68 mg/kg), 17.39 ± 0.31 mg/kg (8.03–28.29 mg/kg), and 20.28 ± 0.31 mg/kg (11.53–29.87 mg/kg) (Fig. 9).

The content of copper in all terms of the research was reliably higher ($p < 0.05$) in compound feeds for reproductive meat chickens relative to the rate of feed for commercial poultry: in 2017 — by 98.7%, in 2018 — 2 times, in 2019 — by 39.9%, in 2020 — 2.4 times, in 2021 — 2.4 times, and the excess of the overall figure for 5 years was 93.3%.

A similar pattern was observed in compound feeds for reproductive population of egg hens relative to the rate of compound feeds for commercial poultry ($p < 0.05$): in 2017, the excess of copper content was 65.8%, in 2018 — 87.3%, in 2019 — 36.1%, in 2020 — 62.5%, in 2021 — 91.7%, and exceeding the overall figure for 5 years was 65.8%. (Fig. 9).

It should be noted that the average content of copper in compound feeds for commercial laying hens and reproductive chickens of both directions of productivity was within the norm (approximate indicator, according to the instructions on the operation of poultry crosses) (not less than 5.0 and not less than 16.0 mg/kg, respectively) (Fig. 9).

However, in addition to the lack of copper in compound feeds, it was found that its MAL was exceeded (25.0 mg/kg) (MAPFU, 2012) during the study period: in commercial chickens — 1.4% of samples, in reproductive egg chickens — 8.3% of samples, and in reproductive population of meat chickens — 16.9% of samples.

In percentage, the dynamics of the norm and lack of copper in compound feed for chickens of different directions of productivity is shown in Fig. 10.

Thus, the highest percentage of samples with reduced copper content was observed in compound feeds for reproductive meat chickens in the entire period of research: in 2017 — 35.9% (norm — 64.1%), in 2018 — 25.0% (norm — 75.0%), in 2019 — 19.5% (norm — 80.5%), while in 2020 and 2021 — 100.0% of samples were within the norm, that is reflected in the average for 5 years: 18.0% of samples were lower than norm.

No samples with reduced copper content were detected in the feed for reproductive population of egg hens. A small percentage of samples with reduced copper content was found in compound feeds for commercial laying hens: in 2017, 2018, and 2021 — 100.0% of samples were within the norm, in 2019 — 1.7% (norm — 98.3%) and in 2020 — 1.8% (norm — 98.2%), which was reflected in the average for 5 years: 1.4% of samples were below the norm (Fig. 10).

588 samples of compound feeds were studied for the content of selenium over the years (for commercial laying hens — 233 samples, for reproductive population of egg hens — 191 samples, and for reproductive meat hens — 164 samples): the average content was respectively 0.21 ± 0.005 mg/kg (0.11–0.49 mg/kg), 0.24 ± 0.004 mg/kg (0.12–0.36 mg/kg), and 0.34 ± 0.01 mg/kg (0.17–0.48 mg/kg) (Fig. 11).

The content of selenium in all terms of research was reliably higher ($p < 0.05$) in feed for reproductive population of meat chickens relative to the rate of feed for commercial poultry: in 2017 — by 94.4%, in 2018 — by 77.8%, in 2019 — by 42.3%, in 2020 — by 40.9%, in 2021 — by 70.0%, and exceeding the overall figure for 5 years was 61.9%.

A slightly different picture was observed in compound feeds for reproductive population of egg-laying hens in relation to the indicator of compound feeds for commercial poultry ($p < 0.05$): in 2017, the excess of selenium content was 50.0%, in 2018 — 33.3%, in 2020 — 13.6%, while in 2019 — the figure was reliably lower than the commercial by 23.1%, and in 2021 the excess was not reliable. Exceeding the overall figure for 5 years was 14.3%. (Fig. 11).

It should be noted that the average content of selenium in feed for commercial laying hens and hens of reproductive population in both areas of productivity was within the norm (approximate indicator, according to the instructions on the operation of poultry crosses) (not less than 0.2 and not less than 0.3 mg/kg, respectively) (Fig. 11) while exceeding MAL (0.5 mg/kg) (MAPFU, 2012) during the study period was not detected.

In percentage, the dynamics of the norm and the lack of selenium in feed for chickens of different directions of productivity is shown in Fig. 12.

Thus, the following percentage of samples with reduced selenium content was observed in compound feeds for reproductive population of meat chickens during the entire study period: in 2017 — 23.7% (norm — 76.3%), in 2018 — 45.0% (norm — 55.0%), in 2019 — 10.8% (norm — 89.2%), in 2020 — 9.7% (norm — 90.3%), and in 2021 — 27.8% (norm 72.2%), which was reflected in the average for 5 years: 26.8% of samples were below the norm.

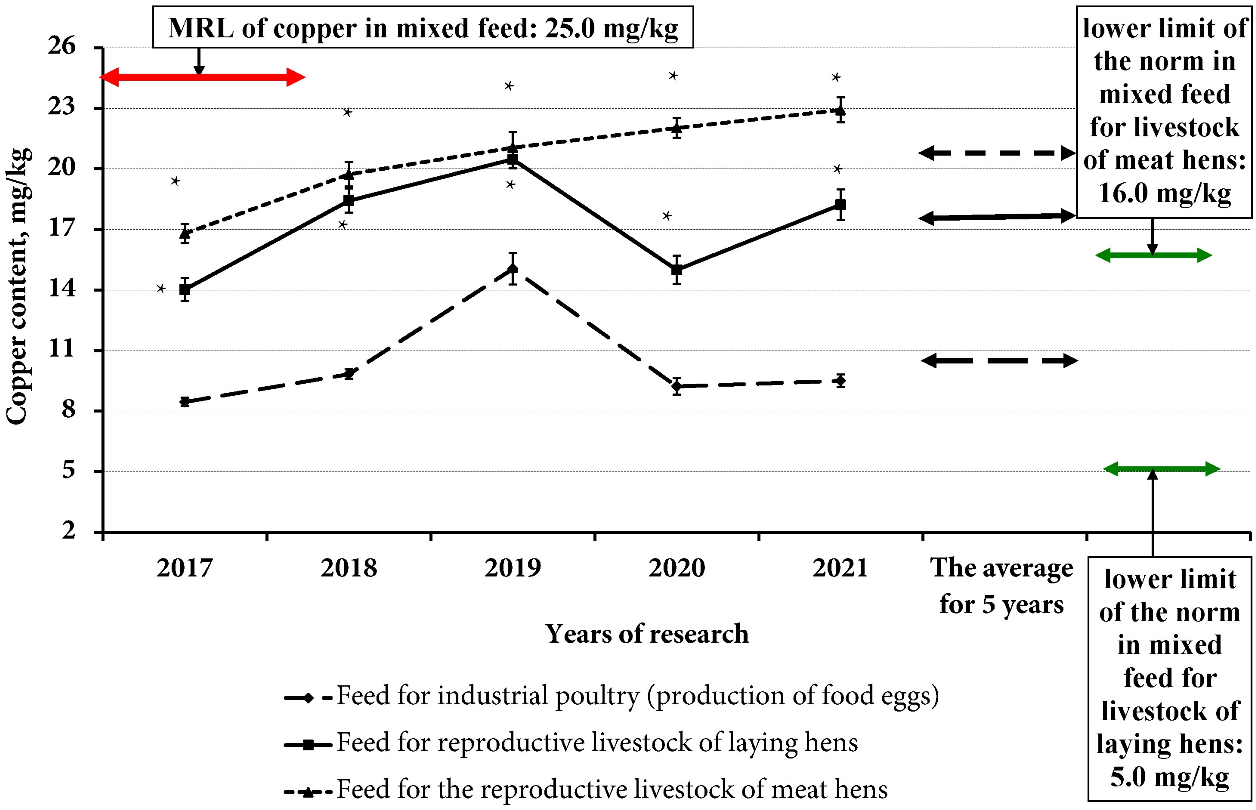

Figure 9. Copper content in compound feeds for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 713, * — $p < 0.05$ relative to the rate of compound feeds for commercial chickens)

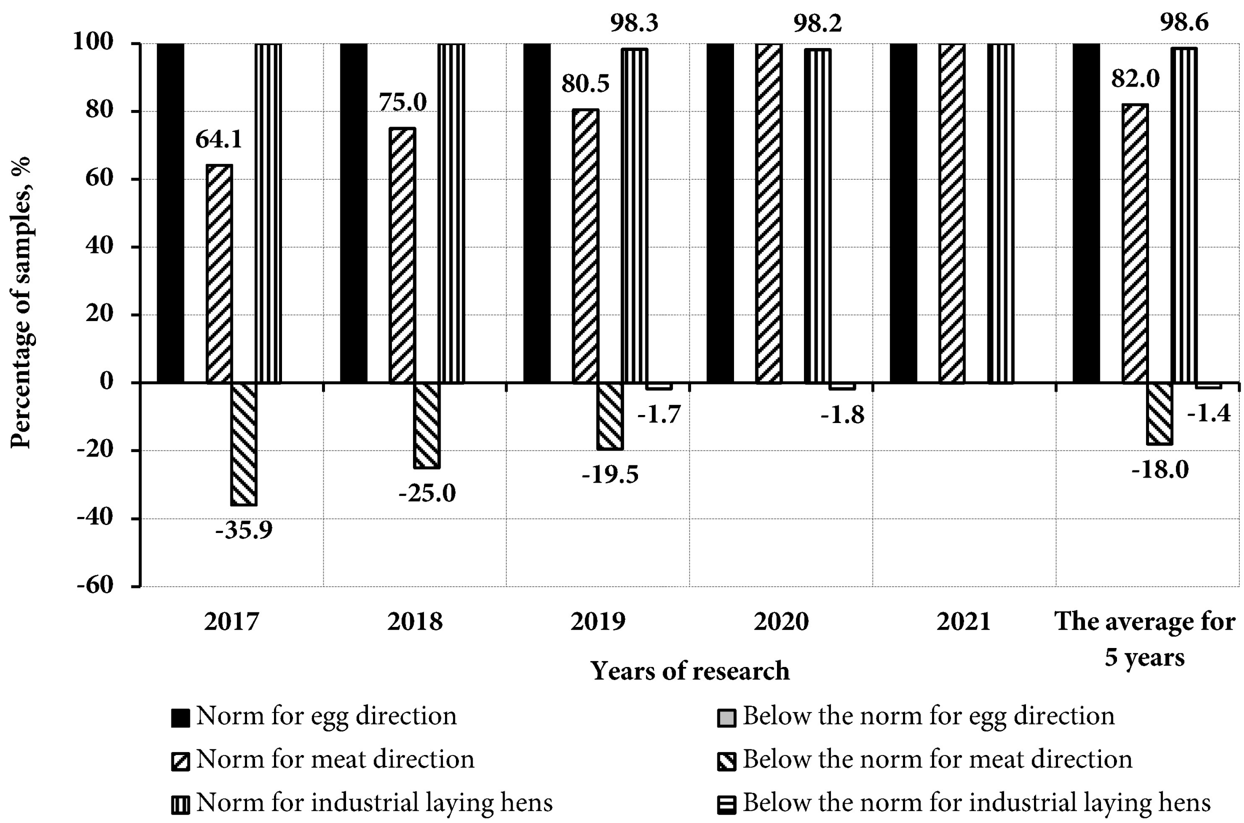

Figure 10. The ratio of the norm and lack of copper in the feed of chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 713)

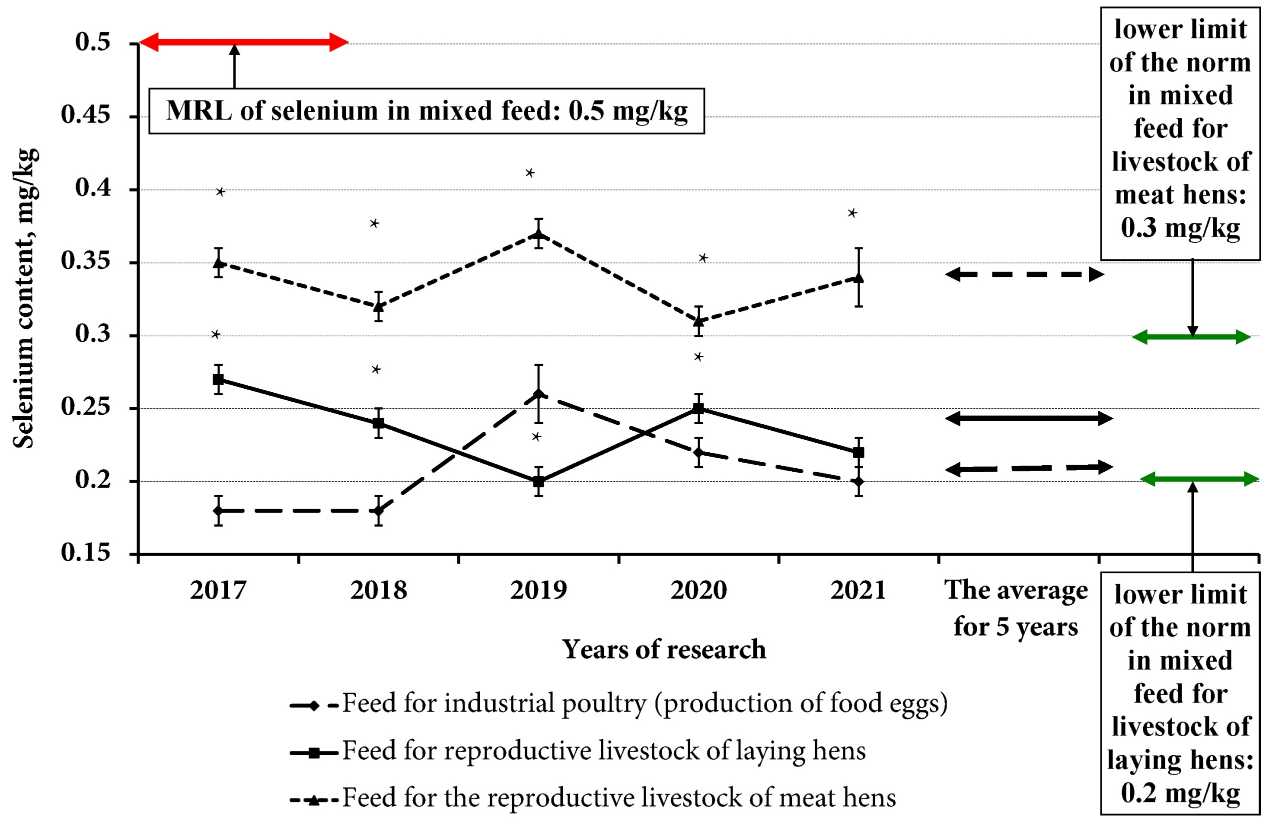

Figure 11. Selenium content in compound feeds for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 588, * — $p < 0.05$ relative to the rate of compound feeds for commercial chickens)

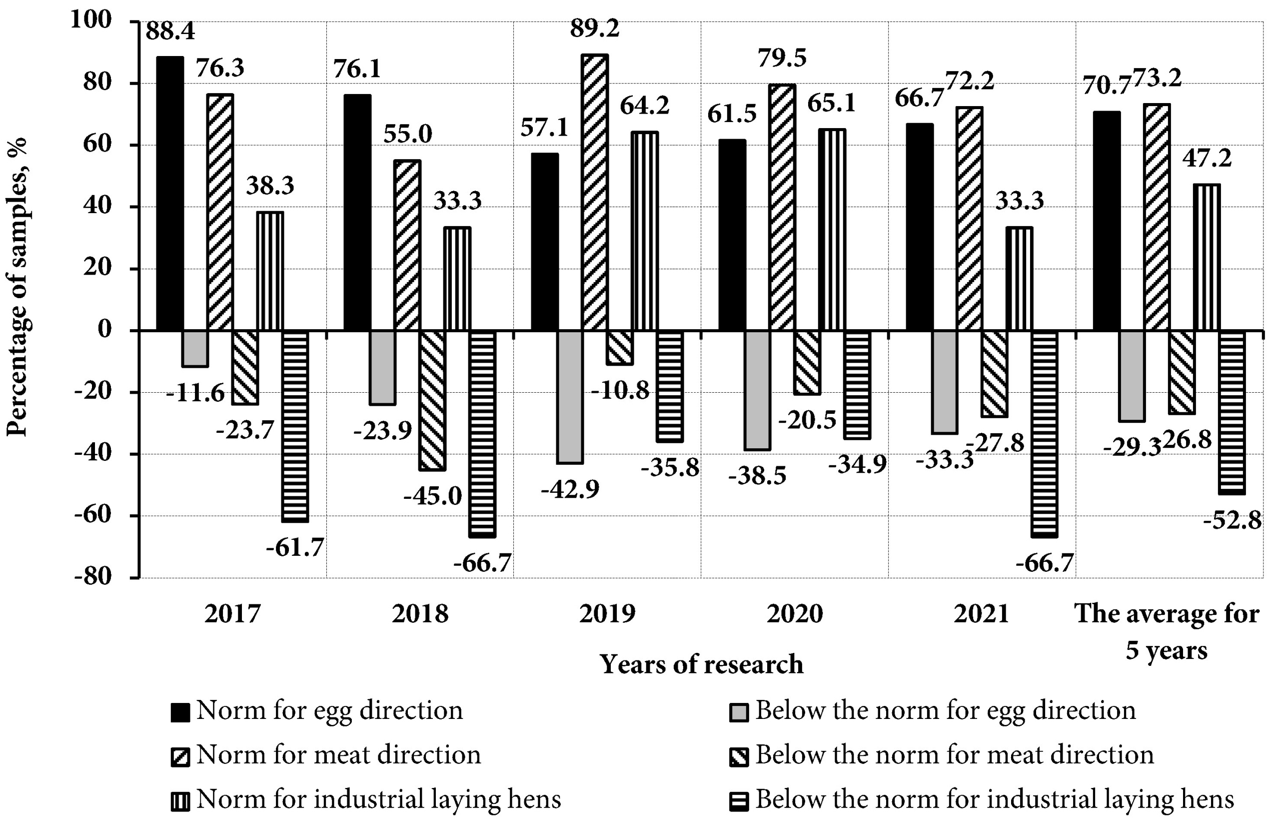

Figure 12. The ratio of the norm and the lack of selenium in the compound feed for chickens of different directions of productivity in the dynamics of 2017–2021 (M ± m, n = 588)

Samples with reduced selenium content were also detected in compound feeds for reproductive population of egg hens: in 2017 — 11.6% (norm — 88.4%), in 2018 — 23.9% (norm — 76.1%), in 2019 — 42.9% (norm — 57.1%), in 2020 — 38.5% (norm — 61.5%), and in 2021 — 33.3% (norm — 66.7%), that was reflected in the average for 5 years: 29.3% of samples were below the norm.

The following percentage of samples with reduced selenium content was found in compound feeds for commercial laying hens: in 2017 — 61.7% (norm — 38.3%), in 2018 — 66.7% (norm — 33.3%), in 2019 — 35.8% (norm — 64.2%), in 2020 — 34.9% (norm — 65.1%), and in 2021 — 66.7% (norm — 33.3%), that was reflected in the average for 5 years: 52.8% of samples were below the norm (Fig. 12).

Therefore, based on the monitoring of feed for chickens, the following can be stated: for the feed for reproductive population of meat chickens there are disproportions in the content of vitamin E and selenium in fee; in feed for reproductive population of egg chickens — disproportions in the content of vitamin E, zinc and selenium; and in compound feeds for commercial chickens — a pronounced deficiency of vitamin E, zinc and selenium.

Vitamin A content did not show significant deviations from the norm in compound feeds for commercial chickens and reproductive population of meat chickens, while in compound feeds for reproductive population of egg hens 5.7% of samples with reduced vitamin A content were found. According to Karkach and Mashkin (2020) lack of vitamin A in feed leads to the hatching of non-viable or weak young chickens, embryos deficient in this vitamin showed signs of abnormal circulatory system, had poor plumage, swollen joints, beak abnormalities and dwarfism.

According to the content of vitamin E in compound feeds for commercial chickens, the percentage of samples with reduced content was 75.2%, in compound feeds for reproductive population of egg hens — 63.9%, and in compound feeds for reproductive livestock of meat hens — 12.7%.

Vitamin E deficiency in birds is manifested in increased embryonic mortality due to a decrease in the content of α-tocopherol in eggs. There is a direct relationship between the content of vitamin E in the diets of breeding birds and the hatchability and viability of broiler chickens.

Exclusion of vitamin E supplements from the diet of laying hens, ducks and quails leads to the rapid disappearance of its reserves in the yolk and significantly reduces the hatchability of chickens. In the process of incubation of eggs obtained from birds with vitamin E deficiency in the diet, the growth and development of embryos slows down and they die in the first 2-4 days of incubation. Chickens obtained from hens with vitamin E deficiency can not independently break the shell during hatching, they have pathology of the cardiovascular system (Kutsan and Orobchenko, 2009).

By the content of vitamin B_2 in compound feeds for hens of reproductive population of egg chickens throughout the study period samples with low content of vitamin B_2 were not observed, while in feed for reproductive population of meat chickens the decreased in vitamin B_2 content was detected in 4.0% of samples, and in compound feeds for commercial laying hens in 5.1%. According to Zon (2013), a decrease in the amount of riboflavin in feed, or its poor absorption, provokes toxicosis, causes the excretion of the amino acids of tryptophan, histidine and phenylalanine in unchanged form. Vitamin B_2 deficiency has the most negative effect on the nervous system, which inhibits the intensity of tissue respiration in the body of birds. Lack of vitamin B_2 in the diet of laying hens negatively affects the quality of hatching eggs, causes increased embryonic death, degrades the quality of hatched young.

Zinc average content in compound feeds for commercial laying hens and reproductive population of egg and meat chickens was within the norm, but a reduced level of zinc was observed in 11.0, 2.5, and 17.3% of samples, and above the MAL — in 11.1, 16.9, and 47.1% of the samples, respectively. Zinc deficiency in poultry is characterized by loss of appetite, growth retardation, impaired feather growth, pigmentation and replacement. In addition, egg fertility reduces, dermatoses, chondrodystrophy occur, all long bones of pelvic extremities are shortened. In embryos, there is curvature of the spine, head injuries, edema, abnormalities in the development of eyes, internal organs (Medvid et al., 2017). Excess zinc causes growth retardation and inhibits the reproductive functions of birds. In addition, zinc is an antagonist of copper, so high doses of zinc lead to a decrease in absorption and assimilation of copper, accompanied by functional and morphological abnormalities of the central nervous system, digestive organs, liver, kidneys (Kutsan and Orobchenko, 2011).

According to the content of copper, its average indicator in compound feeds for commercial laying hens and reproductive population of egg and meat hens was within the norm, but the reduced level of the element was registered in 1.4, 0.0 and 18.0% of samples, and above the MAL — in 1.4, 8.3 and 16.9% of samples, respectively. Copper deficiency leads to the development of anemia in chickens, a decrease in egg weight, deformation of the shell or even its absence (Berwanger et al., 2018). Growth depression, muscular dystrophy, and lesions of the cuticle of the muscular stomach, and liver dystrophy have been observed with long-term intake of high doses of copper in poultry (Kutsan and Orobchenko, 2011).

The average content of selenium in compound feeds for commercial laying hens and reproductive population of meat and egg chickens was within the norm, but the reduced level of the element was registered in 52.8, 29.3, and 26.8% of samples, and no exceeding of the maximum allowable level were detected. The most common diseases of the poultry caused by selenium deficiency are myopathy, exudative diathesis and encephalomalacia in chickens, arthritis, enteritis, renal autolysis, hemolysis of erythrocytes, decreased visual acuity, etc. Excess selenium in chickens is manifested by a decrease in egg production, growth inhibition, weight loss, deteriorating hatching of chickens, embryonic abnormalities, fragile feathers. In addition, muscle and skin edema and macrocytic anemia develop (Orobchenko, 2011).

Conclusions. 1. 678 samples of compound feeds (for commercial laying hens — 281 samples, for reproductive flocks of egg hens — 228 samples, and for reproductive flocks of meat chickens — 169 samples) have been studied for the content of vitamin A by years: the average content was 11,510.59 ± 62.88 IU/kg (10,009.98–14,238.5 IU/kg), 14,749.57 ± 175.75 IU/kg (7,912.14–17,622.87 IU/kg), and 18,240.04 ± 36.94 IU/kg (17,366.59–19,631.89 IU/kg). The content of vitamin A in all terms of research was reliably higher ($p < 0,05$) in compound feeds for reproductive flocks of meat chickens relative to the indicators of feed for commercial poultry by 58.5%, and in compound feeds for reproductive flocks of egg hens — by 28.1%. In feed for commercial chickens and for reproductive flocks of meat chickens during the whole period of research no samples with reduced content of vitamin A were observed, while in compound feeds for reproductive flocks of egg hens samples with low content of vitamin A were detected in 5.7% of samples.

2. 305 samples of compound feeds were tested for the content of vitamin E by years (for commercial laying hens — 129 samples, for reproductive flocks of egg hens — 97 samples, and for reproductive flocks of meat chickens — 79 samples): the average content was 119.16 ± 2.77 mg/kg (62.72–181.03 mg/kg), 165.10 ± 4.68 mg/kg (75.32–247.76 mg/kg), and 219.93 ± 2.02 mg/kg (180.6–267.02 mg/kg). The content of vitamin E in all periods of research was reliably higher ($p < 0,05$) in compound feeds for reproductive flocks of meat chickens relative to the indicators of feed for commercial poultry by 84.6%, and in compound feeds for reproductive flocks of egg hens — by 38.6%. In compound feeds for commercial chickens, the percentage of samples with low vitamin E content was 75.2%, in compound feeds for reproductive flocks of egg hens — 63.9%, and in compound feeds for reproductive flocks of meat hens — 12.7%.

3. 531 samples were tested for vitamin B_2 content by years (for commercial laying hens — 237 samples, for reproductive flocks of egg hens — 168 samples, and for reproductive flocks of meat chickens — 126 samples): the average content was 5.84 ± 0.04 mg/kg (4.79–7.78 mg/kg), 7.06 ± 0.08 mg/kg (5.14–9.78 mg/kg), and 7.92 ± 0,13 mg/kg (4.60–10.61 mg/kg). The content of vitamin B_2 at all periods of the study was reliably higher ($p < 0.05$) in compound feeds for reproductive flocks of meat chickens relative to feed for commercial poultry by 35.6%, and in compound feeds for reproductive flocks of egg hens — by 20.9%. In compound feeds for reproductive flocks of egg hens during the whole period of research no samples with reduced content of vitamin B_2 were observed, while in compound feeds for reproductive flocks of meat hens reduction of vitamin B_2 content was detected in 4.0% of samples, and in compound feeds for commercial laying hens in 5.1%.

4. 725 samples of compound feeds were studied for the content of zinc by years (for commercial laying hens — 298 samples, for reproductive flocks of egg hens — 236 samples, and for reproductive flocks of meat chickens — 191 samples): the average content was 89.54 ± 1.29 mg/kg (50.49–131.60 mg/kg), 98.06 ± 1.38 mg/kg (52.44–135.88 mg/kg), and 118.32 ± 1.31 mg/kg (80.09–147.62 mg/kg). The content of zinc in all periods of research was reliably higher ($p < 0.05$) in compound feeds for reproductive flocks of meat chickens relative to the indicators of feed for commercial poultry by an average of 32.1%, in compound feeds for reproductive flocks of egg hens — by 9.5%. The average zinc content in compound feeds for commercial laying hens and reproductive flocks of both meat and egg chickens was within the norm, but a reduced level of zinc was observed in 11.0, 2.5, and 17.3% of samples, and above the MAL — in 11.1, 16.9, and 47.1% of the samples, respectively.

5. 713 samples of compound feeds were investigated for the content of copper by years (for commercial laying hens — 288 samples, for reproductive flocks of egg hens — 242 samples, and for reproductive flocks of meat chickens — 183 samples): the average content was respectively 10.49 ± 0.25 mg/kg (4.37–26.68 mg/kg), 17.39 ± 0.31 mg/kg (8.03–28.29 mg/kg), and 20.28 ± 0.31 mg/kg (11.53–29.87 mg/kg). Copper content at all research periods was reliably higher ($p < 0.05$) in compound feeds for reproductive flocks of meat chickens relative to the indicators of feed for commercial poultry on average by 93.3%, and in compound feeds for reproductive flocks of egg hens — by 65,8%. The average content of copper in compound feeds for commercial laying hens and for reproductive flocks of both egg and meat chickens was within the norm, but the reduced level of the element was registered in 1.4, 0.0, and 18.0% of samples, and above the MAL — in 1.4, 8.3, and 16.9% of samples, respectively.

6. 588 samples of compound feeds were studied for the content of selenium by years (for commercial laying hens — 233 samples, for reproductive flocks of egg hens — 191 samples, and for reproductive flocks of meat chickens — 164 samples): the average content was 0.21 ± 0.005 mg/kg (0.11–0.49 mg/kg), 0.24 ± 0.004 mg/kg (0.12–0.36 mg/kg), and 0.34 ± 0.01 mg/kg (0.17–0.48 mg/kg), respectively. The content of selenium at all research periods was reliably higher ($p < 0.05$) in compound feeds for reproductive flocks of meat chickens relative to the indicators of feed for commercial poultry by 61.9%, and in compound feeds for reproductive flocks of egg hens — by 14.3%. The average content of selenium in compound feeds for commercial laying hens and reproductive flocks of both egg and meat chickens was within the norm, but the reduced level of the element was registered in 52.8, 26.8, and 29.3% of samples, and no exceedances of the maximum allowable level were detected.

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