Description of productive qualities of Russian selection turkeys

Vladimir Pogodaev^{1,*}, *Alexey Sheplyakov*², *Lidia Shinkarenko*², *Kirill Baidikov*² and *Marina Bezgubova*²

¹North Caucasian Federal Scientific Agrarian Center, 49, Nikonova str., 356241, Mikhailovsk, Russia

²Selection Genetics Center «North Caucasus Zonal Poultry Experimental Station» - branch of the Federal State Budget Scientific Institution Federal Science Center «Russian Research and Technological Institute of Poultry» Russian Academy of Sciences, 12, Prodolnaya str., 303578, Stavropol region, Georgievsky district, Obilnoye, Russia

Abstract. The article presents results of comparative assessment of productivity and tribal qualities of six breeds of turkeys at the gene pool economy selection and genetic center «North Caucasus Zonal Poultry Experimental Station» and populations of blue and red turkeys. Among the studied breeds best egg production for primary and middle layers amк 20 weeks of productive period is noted in silver North Caucasian breed: 50,33 and 64,10 eggs respectively, at intensity 45,19%. For the turkeys of the new gene pool this indicator was more in blue turkeys – 49,32 and 59,28 eggs for primary and middle layers respectively. The highest egg mass was marked in white North Caucasian turkeys – 82,7 g, with Haugh Units (HU) highest value and form index – Uzbek pale yellow breed – 83,6; 69,3% respectively. Thus, we can conclude that selection with domestic breeds of turkeys in centre of collective usage Bioresource breeds collection Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station» is conducted up to the mark; breeds are preserved and rationally used depending on the tasks. Silver turkeys of the North Caucasian breed and blue turkeys of the new gene pool possessed the best productive qualities.

1 Introduction

Turkey farming is an important source of increased high-quality poultry meat production. Years of experience show that turkeys farming in industrial production is an effective industry branch [1–5]. Among the meat species of poultry, turkey has special place. By its biological and economic characteristics - this is one of the most promising types of poultry [6–9]. The biological diversity of poultry by form of breeds, populations, lines is a necessary factor in improving existing and creating new breeding forms [10–13].

The turkey gene pool at Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station» allows to create new cross-breeds by selecting birds with different genotypes for industrial production, but at the same time keep the breeds, populations and

---

*Corresponding author: pogodaev_1954@mail.ru

lines clean [14–15]. This is especially actually for the Development of Russian Agriculture and regulation of agricultural markets, raw materials and food for 2013–2020 State Program decision, where the tasks are set to increase livestock production and accelerated import substitution.

Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station» – Federal Science Center «Russian Research and Technological Institute of Poultry» Russian Academy of Sciences branch has tribal status of selection and genetic center for conservation and breeding of six breeds of turkeys. All breeds are listed in the state register of breeding achievements approved for use, included to the centre of collective usage turkey Bioresource breeds collection.

The aim of research was a comparative assessment of turkey domestic breeds productivity and breeding qualities of gene pool stocks of blue and red turkeys populations at Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station».

2 Material and research methods

Each breed was equipped with 90–100 heads of females and 30 males. The main characteristics that were taken into account when preserving the gene pool: liveweight, plumage color, bird exterior, egg-laying capacity, birth rate, livability.

The productivity of turkeys in the gene pool economy is allowed 20% lower than industrial forms corresponding to productivity directions. Tribal work was mainly based on selection and assortment of turkeys. Selection and assortment is based on the assessment of individuals, families and stirpes or the population as a whole.

The main method of reproduction in the gene pool is artificial insemination. All males were evaluated by response to massage before the start of the breeding season. After evaluation, there was selected a number of males and 20% of the reserve.

When growing and keeping young stock of all breeds and breeding groups of the gene pool, there were used the technological parameters for turkeys – Reference document for agro-industrial complex 1.10.05.04.-13.

From daily to 6 weeks age, poultry were reared in R-15 cell batteries, and then grown on bedding in buildings of production teams 2, 5, 6. Up to 16 weeks age, turkey poultry grown without dividing by gender. At the age of 16 weeks, when scoring, gender separation and further separate cultivation were carried out. From 18 weeks age, female turkey poult were converted to reduced 7-hour light day, male turkey poult were reared at 14–15 hours of light day with illumination equal to 15 lux.

Feeding poultry in all age periods was carried out in accordance with feeding recommendations and by TC 10.91.10-00215613932-2017, developed by Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station».

To study morphological and biochemical parameters, we evaluated 20 hatching eggs from six breeds of turkeys according to developed by Selection and Genetic Center «North Caucasus Zonal Poultry Experimental Station» technical conceptions.

3 Research results and discussion

The productivity of main gene pool turkeys for 20 weeks of egg production when feeding with reduced nutritional intake for the period (average: 5.3 kcal in exchange energy, raw protein by 4.5%, raw fiber 3.4%, calcium by 0.2%, digestible phosphorus by 0.1%), that is associated with the preparation of animal feed from available ingredients within the financial resources allocated by the enterprise are presented in the tables 1. 2.

Table 1. Productivity indicators of turkey breeds bioresource collection for 2018.

Breed	Gender	Live weight at 30 weeks. kg	Livestock of females. heads		Gross egg collection. pcs.
			initial	middle	
Bronze North Caucasian	♀	4.99±0.021	450	437	22298
	♂	9.46±0.068			
White North Caucasian	♀	5.67±0.034	470	457	23180
	♂	10.56±0.072			
Silvery North Caucasian	♀	5.00±0.024	480	466	24158
	♂	9.84±0.041			
Moscow white	♀	5.78±0.031	470	461	23481
	♂	11.13±0.081			
Uzbek fawn	♀	5.05±0.026	450	437	18761
	♂	9.83±0.090			
Tikhoretskaya black	♀	4.98±0.031	250	241	12583
	♂	10.18±0.024			

Table 2. Productivity indicators of main gene pool laying turkeys for 2018.

Breed	Egg production per layer. pcs.		Oviposition rate. %	Safety taking into account falling. %
	initial	middle		
Bronze North Caucasian	49.55	60.40	43.15	97.01
White North Caucasian	49.32	59.28	42.34	97.19
Silvery North Caucasian	50.33	64.10	45.19	97.03
Moscow white	49.96	60.64	43.31	98.15
Uzbek fawn	48.71	58.36	41.69	97.11
Tikhoretskaya black	50.33	57.20	40.86	96.30

It was established that silver turkeys of the North Caucasian breed, respectively, 50.33 and 64.10 eggs possessed the best egg production for the initial and middle layers in 20 weeks. This is 1.62% –5.74% more than of Uzbek pale yellow breed, by 1,01%–4,82% than of White North Caucasian, by 0,78%–3,70% than of Bronze North Caucasian. Oviposition rate on the average laying turkey hen of the Tikhoretskaya black breed was less than that of silvery North Caucasus by 6.90%.

The safety of turkeys for the egg production period, taking into account falling, ranged within 98-96%. Highest safety rate taking into account falling was tagged for Moscow white turkeys and accounted for 98%, Tikhoretsky black breed turkeys possessed the lowest safety index – 96%.

By the oviposition intensity, we can judge the egg production dynamics over a certain time period and characterize the population as a whole [14]. Among six breeds, the highest percentage of intensity for 20 weeks of egg laying was observed in silver North Caucasian breed and amounted to about 45.19%. The differences between the silvery North Caucasus and Tikhoretsky black breeds amounted to 4.33%; Uzbek fawn – 3,50%; White North Caucasian – 2,85% and Bronze North Caucasian – 2,04%.

Data on the new gene pool turkeys’ productivity for 20 weeks of egg production are presented in tables 3.4.

Preservation of turkeys for the period of egg laying taking into account falling ranged within 98-93%, highest safety rate taking into account falling was tagged for Blue turkeys and amounted 98,39%, Red geen pool breed turkeys possessed the lowest safety index –

93,75%. Differences in safety, taking into account culling between breeds, amounted to 4,64%. High percentage of intensity for 20 weeks of oviposition was observed for Blue turkeys and amounted to about 42,34%, that is higher than 8,56% of Red turkeys population.

Table 3. New Gene Pool Turkey Performance Indicators for 2018.

Populations	Gender	Live weight at 30 weeks. kg	Livestock of females. heads		Safety taking into account falling. %
			initial	middle	
Blue turkeys	♀	5.11±0.051	120	119	98.39
	♂	8.36±0.242			
Red turkeys	♀	4.73±0.045	120	113	93.75
	♂	6.60±0.083			

Table 4. Productivity Indicators of Laying Turkeys of the New Gene Pool for 2018.

Populations	Gross egg collection. pcs.	Egg production per layer. pcs.		Oviposition rate. %
		initial	middle	
Blue turkeys	5918	49.32	59.28	42.34
Red turkeys	4860	40.50	47.28	33.78

From the presented data, it is clear that blue turkeys had 49.32 and 59.28 eggs, respectively, for initial and average laying hens for 20 weeks of egg laying. These indicators were higher by 9.01-14.69% in relation to Red turkeys, respectively.

Data on the morphological composition of turkey eggs for 20 weeks of productive period are presented in table 5.

Table 5. Morphological indicators of turkey eggs at the centre of collective usage Bioresource breeds collection (n = 60).

Indicator	TC standard*	Turkey breeds		
		Bronze North Caucasian	White North Caucasian	Silvery North Caucasian
The mass of eggs. g	65-95	79.3±0.75	82.7±0.74	78.5 ±0.68
Elastic deformation. micrometers. µm	22	18.6±0.51	18.2 ±0.39	20.2 ± 0.52
The density of the egg. g / cm³	no less 1.075	1.080±0.005	1.079±0.0007	1.080 ±0.0008
Form index. %	70-76	68.4 ±0.30	68.4 ± 0.32	66.7 ±0.32
HU	no less 80	78.3 ± 1.68	78.4±1.57	75.3 ± 1.50
Shell thickness. mm	0.32-0.34	0.38 ±0.006	0.38 ±0.005	0.38 ±0.004
The ratio of protein mass to yolk mass	1.8-2.0	1.8 ±0.45	1.8 ±0.41	1.8 ±0.44
Indicator	TC standard*	Moscow white	Uzbek fawn	Black Tikhoretskaya
The mass of eggs. g	65-95	80.5 ±0.78	77.4 ± 0.74	79.3 ± 0.67
Elastic deformation. micrometers. µm	22	19.3 ±0.41	21.0 ±0.59	20.5 ±0.61
The density of the egg. g / cm³	no less 1.075	1.071±0.0008	1.080 ±0.0008	1.078± 0.0007
Form index. %	70-76	68.8 ±0.30	69.3 ±0.38	67.9 ± 0.30
HU	no less 80	80.6 ±1.59	83.6±1.35	79.6±1.37
Shell thickness. mm	0.32-0.34	0.37±0.006	0.37±0.006	0.38±0.007
The ratio of protein mass to yolk mass	1.8-2.0	1.9±0.78	1.8±0.47	1.9±0.48

Note: *TC 9844-001 - 57150110-2015.

The largest egg mass was in white turkeys of the North Caucasian breed – 82,7 g, which is more than in Uzbek fawn breed by 5,3 g, or at 6,8%; silvery North Caucasian breed by 4,2 g, or a 5,4%; black Tikhoretskaya and bronze North Caucasian breeds by 3,4 g, or at 4,3%; Moscow white breed by 2,2 g, or at 2,7%.

To determine the quality of shell, strength was evaluated by measuring elastic deformation. White turkeys of the North Caucasus breed had the lowest egg strength – 18,2 μm and Bronze North Caucasian – 18,6 μm . This is lower than in Moscow white breed 1,1 (2,2%) and 0,7 μm (3,8%); Silvery North Caucasian by 2 μm (11%) и 1,6 μm (8,6%); Tikhoretskaya black breed by 2,3 μm (12,6%) and 1,9 μm (10,2%); Uzbek fawn by 2,8 μm (15,4%) and 2,4 μm (12,9%). The elastic deformation degree of eggshell of turkeys varies within 18-21 μm , which is lower than the value of the technical conditions of the enterprise.

Egg density is mainly due to the size of air chamber and thickness of shell. This indicator varies depending on shelf life of the eggs. The density of fresh turkey eggs ranges from 1.078-1.080 g / cm^3 and corresponds to standard values, except for the Moscow white breed, which is slightly inferior in egg density by 0.5%. The shape of the eggs is an important indicator of quality, as it significantly affects embryo position in development process. Accurate indicator of the shape is shape index, which is largely related to the number of fights and notches of eggs, normally should be 70-76%. In current studies, the egg shape index ranged within 66.7-69.3%. Uzbek fawn turkeys has the highest form index – 69,3 %, which is higher than Moscow white breed by 0,5%; Bronze North Caucasian and White North Caucasian breeds by 0,9%; Tikhoretskaya black by 1,4%; Silver North Caucasian by 2,6%.

Highest connection with its index of protein quality indicators is the HU, since both of these indicators are determined based on measuring dense protein height. For 20 weeks of productive period, Uzbek fawn (83.6) and Moscow white (80.6) breeds meet the optimal standard. Lower indices have Silver turkeys of the North Caucasian breed by 6,2%, White North Caucasian and Bronze North Caucasian by 2 and 2,2%; Tikhoretskaya black by 0,5% respectively.

Shell thickness mainly determines its strength and, therefore, resistance to mechanical destruction. There was no significant difference in these indicators between the eggs of current turkey breeds, the difference was only 0.01 mm, or 0.2% less. However, these indicators exceed the standard values by 0.04 mm or 11.8%.

The ratio of protein to yolk is defined as the ratio of protein mass to yolk mass. The density of the yolk and protein is judged on the content of solid components inside and egg "aging". Among the indices of current turkeys breeds eggs, a slight difference was found that corresponds to optimal standards – 1,8-1,9.

The biochemical analysis data of hatching eggs of turkeys' bioresource collection is presented in the table 6.

High hatchability of eggs depends on the content of vitamins in it, which play a huge role in developing embryo metabolism. The most important are water-soluble B vitamins, vitamin A and its provitamins – carotenoids. According to current data, the level of carotenoids in eggs' yolk obtained from turkeys of the studied breeds was within 8,58-8,70 mkg/g, what is the norm (5,5-11,0 mkg/g).

Vitamin A (retinol) localized in yolk, its content in turkey eggs should be at the level of 6,5-8,0 mkg/g. From the presented data it is seen, that the vitamin A content in eggs' yolk of turkey bioresource collection is higher than the permissible norm: Tikhoretskaya black breed by 0,5 mkg/g or at 6,3%; Bronze North Caucasian by 0,46 mkg/g or at 5,8%; Silver North Caucasian by 0,42 mkg/g or at 5,3%; Uzbek fawn by 0,4 mkg/g or at 5%; White North Caucasian by 0,34 mkg/g or at 4,3%; Moscow white breed by 0,31 mkg/g or at 3,9% respectively.

The highest content of vitamin B₂ in eggs yolk was observed in Tikhoretsky black breed. This indicator amounted to 6,93 mkg/g, which is more than in Bronze North Caucasian by 0,01 mkg/g or at 0,1%; Silver North Caucasian by 0,11 mkg/g or at 1,6%; Uzbek fawn by 0,14 mkg/g or at 2,1%; White,North Caucasian by 0,22 mkg/g or at 3,3%; Moscow white breed by 0,23 mkg/g or at 3,4%.

Table 6. Biochemical indicators of turkey eggs at centre of collective usage Bioresource breeds collection (n = 60).

Indicator	TC standard*	Turkey breeds		
		Bronze North Caucasian	White North Caucasian	Silvery North Caucasian
Content in yolk. mkg/g: carotenoids	5.5-11.0	8.68 ±0.162	8.58 ±0.151	8.63 ±0.160
vitamin A	6.5-8.0	8.46 ±0.134	8.34 ± 0.117	8.42 ±0.113
vitamin B ₂	5.5-10.0	6.92 ±0.112	6.71 ±0.117	6.82 ±0.087
Content of vitamin B ₂ in protein. mkg/g	2.5-3.0	4.43 ±0.156	4.35 ±0.090	4.38 ±0.103
pH protein	8.2-9.0	8.45 ± 0.020	8.43 ± 0.020	8.44 ± 0.020
pH yolk	5.9-7.0	6.18 ±0.039	6.14 ±0.049	6.15 ±0.039
Indicator	TC standard*	Moscow white	Uzbek fawn	Tikhoretskaya black
Content in yolk. mkg/g: carotenoids	5.5-11.0	8.60 ±0.163	8.62 ±0.152	8.70 ±0.148
vitamin A	6.5-8.0	8.31 ±0.115	8.40 ±0.125	8.50 ±0.105
vitamin B ₂	5.5-10.0	6.70 ±0.112	6.79 ±0.088	6.93 ± 0.097
Content of vitamin B ₂ in protein. mkg/g	2.5-3.0	4.27 ±0.120	4.37 ±0.126	4.56 ±0.182
pH protein	8.2-9.0	8.44 ±0.021	8.43 ±0.018	8.45 ±0.017
pH yolk	5.9-7.0	6.13 ±0.051	6.15 ±0.039	6.20 ± 0.037

Note: * TC 9844-001 - 57150110-2015.

Indicators for the vitamin B₂ content in hatching eggs protein of turkeys exceeded the standard indicators by 1,56 mkg/g. High amount of vitamin B₂ in eggs protein of Tikhoretskaya black breed turkeys were possessed – 4,56 mkg/g, which is higher than White North Caucasian breed by 0,21 mkg/g or at 4,8%; Uzbek fawn by 0,19 mkg/g or at 4,3%; Silver North Caucasian by 0,18 mkg/g or at 4,1%; Bronze North Caucasian by 0,13 mkg/g or at 2,9% at the normative indicator 2,5-3,0 mkg/g. The concentration of hydrogen ions (pH) of turkey eggs protein and yolk met the quality indicators requirements of hatching eggs 8,43-8,4 and 6,13-6,20 at the normative indicator 8,2-9,0 for protein and 5,9-7,0 for yolk respectively.

Thus, the hatching eggs of all breeds of turkeys are fully consistent with the requirements.

Analysis of appraisal of domestic gene pool turkeys breeds farming showed that there is a reduction in the number of all breeds (Table 7).

Table 7. Valuation indicators of turkey gene pool economy at centre of collective usage Bioresource breeds collection «North Caucasus Zonal Poultry Experimental Station».

Evaluation year	Breed	Livestock. heads		Live weight at 16 weeks. kg		Egg production per middle layer. pcs.	Young growth safety till 16 weeks. %	Output ind.. %	Class by a set of features
		males	females	males	females				
2016	Bronze North Caucasian	590	520	5.5	3.7	75.2	88.1	62.2	elite record
2017		697	747	5.7	3.9	74.2	88.7	54.6	elite record
2018		905	950	4.7	3.7	70.5	89.5	51.7	elite
2016	White North Caucasian	430	390	6.0	3.8	75.5	88.3	63.6	elite record
2017		745	783	6.3	3.9	72.1	89.0	55.1	elite record
2018		670	710	4.9	3.7	64.7	89.7	54.8	elite
2016	Silver North Caucasian	354	315	5.7	3.7	75.4	88.6	62.5	elite record
2017		787	807	6.6	4.2	76.7	90.1	57.1	elite record
2018		446	607	5.7	4.0	70.8	90.7	55.7	elite
2016	Moscow White	327	300	6.0	3.9	72.0	87.9	61.2	elite record
2017		750	770	6.2	4.0	70.7	88.1	56.8	elite record
2018		717	740	5.5	3.8	68.7	87.8	56.1	elite
2016	Uzbek fawn	372	335	5.4	3.5	70.6	86.4	60.4	elite
2017		689	726	5.3	3.7	71.0	87.2	54.7	elite record
2018		787	790	5.0	3.7	60.7	88.7	53.9	elite
2016	Tikhoretskaya black	336	290	5.0	3.5	70.2	86.6	60.2	elite
2017		432	437	5.2	3.6	70.5	87.5	49.8	elite record
2018		210	347	4.7	3.5	57.5	87.9	50.7	elite

In 2018, compared with 2016, the number of males and females of Bronze North Caucasian breed increased by 745 heads, White North Caucasian – by 560 heads, Silver North Caucasian – by 382 heads, Moscow white – by 830 heads, Uzbek fawn – by 870 heads, and the number of Tikhoretskaya black breed turkeys was reduced by 69 heads.

Average data on turkeys' scoring for 2016–2018 indicates that silver livestock of North Caucasus breed (males – 6.00 kg, females – 3.97 kg) have a higher live weight at 16 weeks of age. At second place in live weight are Moscow white turkeys (males – 5.73 kg, females – 3.9 kg), in third – white North Caucasian (males – 5.73 kg, females – 3.80 kg), in fourth – Moscow white breed (males – 5.30 kg, females – 3.77 kg), on the fifth – Uzbek fawn breed (males – 5.10 kg, females – 3.63 kg). The smallest live weight was found in Tikhoretskaya black breed (males – 4.97 kg, females – 3.53 kg).

Egg production (on average for 2016-2018) was for Silver North Caucasian – 74,30 pcs., which is more compared to Bronze North Caucasian – by 1,0 pcs., White North Caucasian – by 3,53 pcs., Moscow white – by 3,83 pcs., Uzbek fawn – by 6,87 pcs., Tikhoretskaya black breed – by 8,23 pcs.

By safety of significant differences among current breeds was not observed. The safety of young growth up to 16 weeks of age on average for 3 years was within 87,33–89,80%.

The highest safety was among the turkeys of Silver North Caucasian breed (89.80%), and the lowest – among Uzbek fawn and Tikhoretskaya black breed (87.43 and 87.33%).

Number of individuals (3 years on average) was the highest among Silver North Caucasian breed turkeys (58,43%), which is more than of Moscow white breed by 0,4 abs.%, White North Caucasian – by 0,6 abs.%, Moscow white breed – by 2,1 abs.%, Bronze North Caucasian breed – by 2,26 abs.% and Tikhoretskaya black – by 4,86 abs.%.

Based on current data analysis, it was found that all domestic breeds of turkeys belong to the class of elite and elite record in terms of a set of characteristics. However, it should be noted that the productivity of turkeys of all breeds significantly decreased in 2018 due to a lack of financial resources for the purchase of ingredients for balancing feeding diets.

4 Conclusion

Thus, we can conclude that breeding and selection with domestic breeds of turkeys in centre of collective usage Bioresource breeds collection «North Caucasus Zonal Poultry Experimental Station» conducted at the proper level, breeds are preserved and rationally used depending on the tasks.

Silver turkeys of the North Caucasian breed and Blue turkeys of the new gene pool possessed the best productive qualities.

According to morphological indicators of hatching eggs, turkeys of the Uzbek pale yellow breed prevail, by biochemical indicators – turkeys of the Tikhoretskaya black breed. Hatching eggs of all breeds of turkeys fully comply with the requirements.

All domestic breeds of turkeys belong to the class of elite and elite record according to a set of characteristics.

References

1. M. Zampiga, S. Tavaniello, F. Soglia, *Poultry science* **98(5)**, 2305-2315 (2019)
2. E.E. Ostrikova, N.A. Ostapenko, A.S. Chernyshkov, *Bulgarian journal of agricultural science* 25(4), 768-781 (2019)
3. S. Gallot, J. Champagne, *Bulletin de l'academie veterinaire de France* **163(3)**, 199-205 (2010)
4. M. Sarica, N. Ocak, S. Turhan, C. Kop, U.S. Yamak, *Poult. Sci.* **90**, 1313-1323 (2011)
5. B.A. Patterson, S.K. Matarnah, K.M. Stuft, E.M. England, T.L. Scheffler, R.H. Preisser, H. Shi, E.C. Stewart, S. Eilert, D.E. Gerrard, *Poult. Sci.* **96**, 1492-1503 (2017)
6. M.A. Erasmus, H.C. Lee, I. Kang, J.C. Swanson, *Poultry Science* **94(91)**, 2018-2026 (2015)
7. D.N.R.G. Kapell, P.M. Hocking, P.K. Glover, V.D. Kremer, S. Avendaño, *Poultry Science* **96(61)**, 1553-1562 (2017)
8. C.D. Quinton, B.J. Wood, S.P. Miller, *Poultry Science* **90(111)**, 2479-2486 (2011)
9. Y. Piestun, I. Zimmerman, S. Yahav, *Poultry Science* **94(21)**, 273-280 (2015)
10. D.L. Clark, G.M. Strasburg, K.M. Reed, S.G. Velleman, *Poultry Science* **96(41)**, 1015-1027 (2017)
11. Dalton, H.A., B.J. Wood, S. Torrey, *World's Poult. Sci. J.* **69**, 865-875 (2013)
12. M.A. Erasmus, J.S. Swanson, *Appl. Anim. Behav. Sci.* **157**, 100–108 (2014)

13. M.S. Lilburn, A. Antonelli, Get rights and content Poultry Science **91(4)**, 823-828 (2012) doi.org/10.3382/ps.2011-01883
14. V.A. Pogodaev, S.V. Frolko, A.P. Marynich, E.G. Mishvelov, A.Y. Glushko, Research Journal of Pharmaceutical, Biological and Chemical Sciences **7(4)**, 1349-1352 (2016)
15. V. Pogodaev, V. Shcherbatov, V. Slepulin, T. Pakhomova, I. Shcherbatov, Indo american journal of pharmaceutical sciences **06(03)**, 6867-6872 (2019) ISSN: 2349-7750