Productivity and morphological indicators of egg quality of meat hens of maternal lines of the Cornish and Plymouth Rock breeds of the new Smena-9 cross

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Abstract. The article is devoted to the assessment of productivity and morphological indicators of egg quality of maternal lines of Cornish and Plymouth Rock breeds of the new Russian Smena-9 cross. It was found that during the breeding of meat hens of the maternal lines of Cornish and Plymouth Rock breeds (from 2019 to 2021), the egg production increased by 1.6-2.2% (Cornish) and by 2.2-4.3% (Plymouth Rock) during the 30 and 52 weeks of life. There was a 0.1-1.9% decrease in eggs with such defects as double-yolk, irregular shape, breakage + check, weight less than 52 g. The best morphological parameters had eggs obtained from the maternal lines of Cornish and Plymouth Rock hens at 30 weeks of age. The hatchability of eggs obtained from the maternal line of the Cornish breed hens at that age was 83.9%, and for the Plymouth Rock breed it was 86.1%. Productivity and morphological indicators of the quality of eggs of the maternal lines of Cornish and Plymouth Rock breeds of Smena-9 cross are high, the chickens are competitive.

1 Introduction

During the period of poultry farming intensification, the meat and egg productivities have increased significantly. These achievements are mainly explained by the directional breeding and the optimization of livestock feeding. At the present stage of development of poultry farming, both quantitative and qualitative indicators of egg productivity of meat hens are considered in the breeding process [1,2], the list of which is determined by the market. At the same time, it is necessary to "design" the crosses, and the lines included in the crosses should be bred for this design. This work should be performed based on the theoretical provisions of genetics and breeding, as well as the economic feasibility of their use [3], by introducing new methods and techniques of assessment and selection of poultry [4,5].

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The quality of hatching eggs is one of the most important factors affecting the level of realization of the genetic potential of productivity.

The major indicator of assessment and selection of lines, crosses and individuals is the number of products obtained on average from one hen during the productive period [6]. The number of hatching eggs and the yield of chicks is determined for breeder hens [7].

To realize the genetic potential of the productive qualities of poultry, an objective assessment of the family, flock, and individuals is essential.

The egg weight and the ratio of egg white, yolk and eggshell are important for both incubation and the production of commercial products and deep processing [8]. Chicken breeding is the most effective way to increase the weight and quality of eggs. The hatchability of eggs and the quality of hatchlings cannot be improved without controlling the quality of eggs obtained from the parent flock.

Poultry selection by egg production and egg weight has a negative impact on the quality of eggs, especially eggshell and egg white [9]. Assessment and selection by quality indicators reduces the number of eggs laid by hens. It was found [10] that selection by eggshell strength results in a decrease in the egg production of poultry, and selection by the increase in live body weight changes the quality of eggs [11].

While considering the experimental lines of egg hens and analyzing the productivity of five generations, the authors [12] associated the increase in the frequency of appearance of double-yolk eggs and, to a lesser extent, eggshell defects with the weight of eggs and live body weight of laying hens. They found that the egg white height positively correlates with its weight, and eggshell thickness correlates with the egg weight.

The authors [13] recommend to perform selection by shape index, eggshell thickness, relative weight of yolk and egg white, egg white height, and Haugh units simultaneously, because they found a relationship between these parameters and egg weight.

Thus, when assessing and selecting poultry, the live body weight, egg production, egg weight, and quality indicators should be included in the breeding program.

This study aims to assess the new maternal lines of the Cornish and Plymouth Rock breeds of the Smena-9 cross by productivity and morphological indicators of egg quality.

2 Material and methods

The work was carried out in 2019 - 2021 at the Selection and Genetic Center "Smena" on the maternal lines of the Cornish and Plymouth Rock breeds of the new Smena-9 cross.

Annually, 30 breeding nests were formed in each line (13 females and 1 male). The breeding group of the maternal line of the Cornish breed was selected from breeders - improvers and neutral individuals considering the main economically important indicators (live body weight of chickens, egg production, hatchability of eggs, hatching eggs yield, egg weight). In the maternal line of the Plymouth Rock breed, the individuals were selected according to egg production, hatching eggs yield, egg weight, hatchability of eggs, live body weight of chickens. In each line, 6792-7269 heads of day-old chicks were taken for rearing.

Productivity in breeding nests was counted individually. Live body weight, egg production, egg weight, hatchability of eggs, hatching egg yield and morphological quality were determined by conventional methods. Individual caps and a standard set of winglets were used to control the origin of offspring during incubation.

The birds were kept on the floor. Sawdust from coniferous trees was used as bedding. Feeding and housing conditions met the accepted recommendations.

The data obtained were statistically processed using Statistika 10.0 (Stat Soft, Inc., USA) and Microsoft Excel.

3 Results

The live body weight of chickens of the Cornish breed maternal line at 30 days of age was 4.2% (2019), 4.5% (2020), and 4.7% (2021) higher than that of the Plymouth Rock breed maternal line.

The 1.6% increase in live body weight in 30-week-old Cornish chickens was observed in 2021compared to 2019; in 52-week-old chickens, this increase amounted to 0.7%. The 2.2% increase in egg production in 30-week-old chickens and 1.6% increase in 52-week-old chickens was observed for the same years. The egg weight increased by 1.2% in 30-week-old chickens, and by 1.5% in 52-week-old chickens; the hatchability of eggs increased by 1.4% in 30-week-old chickens, and by 1.5% in 52-week-old chickens.

These indicators in the maternal line of Plymouth Rock hens increased during the breeding process by 0.8-4.3% compared to 2019.

The livability of hens of the maternal lines of Cornish and Plymouth Rock breeds was within 94.7-96.2% (Table 1).

Table 1. Characteristics of maternal lines of Cornish and Plymouth Rock poultry by main traits

Test year	Maternal line			
	Cornish		Plymouth Rock	
	30 weeks	52 weeks	30 weeks	52 weeks
	Live body weight of chickens, g			
2019	3690±29.6	4100±40.5	3540±28.4	3970±39.7
2020	3730±24.5	4120±41.2	3570±27.3	3990±42.3
2021	3750±29.6	4130±39.9	3580±25.8	4000±40.1
	Egg production per average laying hen, pcs.			
2019	22.7±0.25	116.3±0.700	28.2±0.266	134.8±0.717
2020	23.0±0.34	117.8±0.887	28.5±0.311	135.9±0.830
2021	23.2±0.34	118.2±0.72	29.0±0.28	136.7±0.82
	Weight of chicken eggs, g			
2019	57.8±0.18	68.31±0.24	56.70±0.10	66.50±0.23
2020	57.90±0.18	68.90±0.23	56.73±0.14	66.70±0.21
2021	58.50±0.17	69.30±0.24	57.40±0.18	67.11±0.22
	Hatchability of eggs, %			
2019	82.5	82.1	83.8	82.9
2020	82.7	82.5	84.7	83.8
2021	83.9	83.6	86.1	84.5
	Livability, %			
2019	95.0	94.7	95.5	95.1
2020	95.2	94.9	95.8	95.7
2021	95.7	95.1	96.2	95.9

The main focus of purposeful breeding of meat hens to increase the yield of chickens is paid to the indicator of the number of hatching eggs obtained from one laying hen.

The selection of hens - mothers according to the yield of hatching eggs, resulted in a 0.30-0.45% decrease in the amount of double-yolk eggs, a 0.2-0.3% decrease in the amount of eggs of irregular shape, a 0.10-0.035% decrease in the amount of breakage + check, and a 0.2-0.5% decrease in the amount of eggs weighting less than 52 g.

In addition, a 0.1-0.35% decrease in contaminated eggs in 2021 compared to 2019 was registered.

Hatching egg yields from meat hens of the maternal lines of the Cornish and Plymouth Rock breeds were 1.0 and 1.4% higher in 2021 than in 2019 in 30-week-old chickens; 1.3 and 1.9% higher in 52-week-old chickens (Table 2).

Table 2. Hatching egg yield of meat hens of maternal lines of the Cornish and Plymouth Rock breeds, %

Test year	Maternal line			
	Cornish		Plymouth Rock	
	30 weeks	52 weeks	30 weeks	52 weeks
	Hatching egg yield			
2019	91.1	93.8	91.2	94.0
2020	91.7	94.4	91.9	94.9
2021	92.1	95.1	92.6	95.9
	Contaminated eggs			
2019	2.5	2.0	2.4	1.85
2020	2.4	1.9	2.3	1.8
2021	2.4	1.8	2.25	1.5
	Irregular shape			
2019	1.5	1.1	1.4	1.05
2020	1.3	1.0	1.2	0.9
2021	1.2	0.9	1.1	0.8
	Breakage + check			
2019	1.7	1.6	1.7	1.55
2020	1.7	1.4	1.7	1.4
2021	1.6	1.3	1.55	1.2
	Double-yolk			
2019	1.5	0.7	1.4	0.75
2020	1.3	0.6	1.2	0.5
2021	1.2	0.4	1.1	0.3
	Egg weight < 52 g			
2019	1.7	0.8	1.9	0.8
2020	1.6	0.7	1.7	0.5
2021	1.5	0.5	1.4	0.3

Irregularly shaped eggs are most often observed in sister hens and daughter hens obtained from mothers who lay irregularly shaped eggs. When the offspring were bred from mothers carrying round or long eggs, daughters had similar anomalies, which indicates the inheritance of the traits. Throughout the egg-laying period, the laying of such eggs is a predominant feature of the same hens.

In our studies, the shape index of eggs of the maternal lines of the Cornish and Plymouth Rock breeds at 30 weeks of age was in the range 76.8-75.8% and 78.3-77.0% at 52 weeks of age. With aging, this index decreased by 1.1% for the eggs of the Cornish breed line, and by 1.3% for the Plymouth Rock breed. The egg shape index of the Plymouth Rock hens is higher than that of the Cornish breed by 1.4% (30-week-old chickens) and by 1.2% (52-week-old chickens).

An important indicator of hatching eggs is the quality of the eggshell.

Eggs of meat hens of the Cornish and Plymouth Rock breeds at 30 weeks of age had higher eggshell thickness and percentage content in relation to eggs obtained from hens at 52 weeks of age (0.6% and 0.9%). A direct linear relationship was observed between this index and the egg density. Egg density also increased with increased eggshell thickness from 1.075 to 1.085 g/cm3 (Table 3). Assessment of egg density from the maternal lines of Cornish and Plymouth Rock hens showed that egg density decreased slightly with aging . For example, the egg density from 30-week-old hens of the maternal line of the Cornish breed decreased by 52 weeks by 0.6%, and for the Plymouth Rock breed the egg density decreased by 0.7%. Eggs from the maternal line of the Plymouth Rock breed showed a tendency to a slight increase in egg density compared to the Cornish breed at both 30 and

52 weeks of age. The difference was 0.4 and 0.2% at 30 and 52 weeks of age, respectively (Table 3).

One of the indicators characterizing the quality of egg white is Haugh units. Analyzing the data obtained, we conclude that this indicator decreases with aging by 1.8% in eggs of the Cornish breed hens, and by 1.7% in eggs of the Plymouth Rock breed hens. The Haugh units of eggs from the Plymouth Rock hens are higher by 4.52% (30-week-old chickens) and 1.2% (52-week-old chickens) than those of eggs from the Cornish hens.

The increase in egg weight is explained by the increase in the absolute weight of the components of the egg. In particular, with aging of the birds, the absolute weight of egg white increased by 5.71-5.24 g, the absolute weight of yolk increased by 4.24-4.36 g, the absolute weight of eggshell increased by 0.77-0.30 g.

It should be noted that although the absolute weight of egg white increased, its relative content in egg decreased from 60.85% (Cornish) and 60.86% (Plymouth Rock) at 30 weeks of age to 59.68% (Cornish) and 59.70% (Plymouth Rock) at 52 weeks of age and the relative weight of the yolk increased by 1.38% (Cornish) and 2.6% (Plymouth Rock) during this period. These data indicate that as the weight of eggs increases, the relative yolk content increases and the relative egg white content decreases, which is reflected in the decreased ratio of egg white to yolk.

The relative weight of eggshells decreased with aging and was 8.53-8.32% in Cornish and 9.20-8.30% in Plymouth Rock.

Table 3. Morpho-biochemical parameters of egg quality of meat hens of maternal lines of the Cornish and Plymouth Rock breeds

Characteristics	Maternal line			
	Cornish breed		Plymouth Rock	
	30 weeks	52 weeks	30 weeks	52 weeks
Egg weight, g	58.78±0.62	69.5±0.75	57.40±	67.3±0.73
Egg density, g/cm^3	1.080±0.002	1.075±0.001	1.085±0.001	1.077±0.002
Yolk weight:				
g	18.00±0.27	22.24±0.31	17.18±0.42	21.54±0.53
% of egg weight	30.62±0.54	32.00±0.49	29.94±0.53	32.0±0.61
Egg white weight:				
g	35.77±0.94	41.48±1.01	34.93±0.96	40.17±1.20
% of egg weight	60.85±0.57	59.68±0.49	60.86±0.53	59.70±0.61
Eggshell weight:				
g	5.01±0.17	5.78±0.21	5.29±0.15	5.59±0.19
% of egg weight	8.53±0.18	8.32±0.15	9.20±0.11	8.30±0.17
Yolk to egg white weight ratio	1.99/0.50	1.87/0.54	2.03/0.49	1.86/0.54
Shell thickness, μm	334.1±6.45	332±7.79	336.3±8.71	333.0±9.10
Haugh units	75.82±1.51	74.51±1.28	79.25±1.85	75.38±2.99
Egg shape index, %	76.9±0.79	75.8±0.76	78.3±0.62	77.0±0.85
Content in yolk, μg/g:				
vitamin A	7.34	7.05	7.27	7.01
vitamin E	357.38	342.00	351.84	341.00
B_2 vitamin	7.58	6.73	7.18	6.58
Content in egg white, μg/g:				
vitamin B_2	4.61	4.30	4.60	4.18

In our studies, the level of vitamin B2 in egg white was within the normal limits. For example, in eggs obtained from meat hens of the maternal line of the Cornish breed it was 4.61 μg/g (30-week-old chickens), and 4.30 μg/g (52-week-old chickens). For the meat

hens of the maternal line of the Plymouth Rock breed, this value was in the range from 4.60 (30-week-old chickens) to 4.18 μg/g (52-week-old chickens) (Table 3). The content of this vitamin in the yolk of eggs of meat hens of the maternal line of the Cornish breed was 7.58 μg/g (30-week-old chickens) and 6.73 μg/g (52-week-old chickens); for the maternal line of the Plymouth Rock hens it was 7.18 μg/g (30-week-old chickens) and 6.58 μg/g (52-week-old chickens), which corresponds to the standard data.

Vitamin A (retinol) is also localized in the egg yolk. The data presented show that its content in the yolk of eggs obtained from the maternal line of the Cornish breed hens was 7.34 μg/g (30-week-old chickens) and 7.05 μg/g (52-week-old chickens). For the Plymouth Rock breed this value was 7.27 μg/g (30-week-old chickens) and 7.01 μg/g (52-week-old chickens), which corresponds to the norm (Table 3).

The vitamin E content in the egg yolk showed a tendency to decrease slightly with aging in both the maternal line of the Cornish breed from 357.38 to 342.00 μg/g, and in the maternal line of the Plymouth Rock breed from 351.84 to 341.00 μg/g.

4 Discussion

In this work, during targeted breeding of meat hens of maternal lines of the Cornish and Plymouth Rock breeds, it was found that their egg production in 2021 was higher by 2.2%, 1.6% (Cornish) and by 4.3%, 2.2% (Plymouth Rock) at 30 and 52 weeks of age, respectively, as compared to 2019.

The results obtained are consistent with those obtained by other scientists [14]. The age of the parents has a dominant effect on egg hatchability compared to genotype [15]. In meat hens, egg hatchability decreases with aging. In the study performed in the Netherlands [15], egg hatchability in meat hens was 66%, 86%, and 50% at the age of 25, 31-36, and 65 weeks, respectively. In our studies (Table 1), the effect of parental age on hatchability remains.

The phenomenon of increasing egg weight with aging of laying hens was found in almost all species of poultry. In meat hens of Cobb500 cross the egg weight was 53.8 and 71.3 g at the age of 29 and 59 weeks, i.e. it increased by 32.8% [16]. We also obtained an increase in egg weight at 52 weeks of age compared with 30 weeks by 18.2-19.0% (Cornish) and by 16.9-17.6% (Plymouth Rock), depending on the year of testing (Table 1).

There was a 0.1-1.9% decrease in eggs with such defects as double-yolk, irregular shape, breakage + check, weight of eggs less than 52 g in 2021 compared to 2019. This can be explained by the selection of maternal hens by the yield of hatching eggs. This indicator was 1.0% and 1.4% higher in the maternal lines of Cornish and Plymouth Rock breeds in 2021 compared to 2019 for 30-week-old chickens; 1.3% and 1.9% higher for 52-week-old chickens. The results of this study are consistent with results of other authors [14,17].

With an increase in the absolute weight of eggs, the same happens with egg white, yolk and eggshell, but these changes are asynchronous. The increase in yolk weight is more significant than in egg white weight, which is expressed in the ratio yolk to egg white. As females get older, they lay eggs with a higher ratio of yolk to egg white. For example, for eggs from Arbor Acres cross hens from week 26 to week 36, this ratio was 0.4-0.5 [18]. In our experiment, this ratio in eggs from maternal lines was 0.50-0.54 (Cornish) and 0.49-0.54 (Plymouth Rock).

With the aging of laying hens, the quality of the eggshells changes [17,19,20]. The weight of eggs and eggshells increases, but the relative weight of the eggshells and its thickness decrease. The eggshell thickness decreased from 0.37 to 0.36 mm for the period from 30- to 60-week-old age for Cobb500 hens [19]. We also obtained a decrease in egg eggshell thickness with aging (Table 3).

5 Conclusion

The performed studies showed that during the breeding of meat hens of the maternal lines of Cornish and Plymouth Rock breeds (from 2019 to 2021), the egg production increased by 1.6-2.2% (Cornish) and by 2.2-4.3% (Plymouth Rock) during the 30 and 52 weeks of life. There was a 0.1-0.5% decrease in amount of eggs with such defects as double-yolk, irregular shape, breakage + check, weight of eggs less than 52 g. This was achieved by the selection of mother hens according to the yield of hatching eggs. This trait was increased by 1.0-1.9%.

The best morphological parameters had eggs obtained from the maternal lines of Cornish and Plymouth hens at 30 weeks of age. Hatchability of eggs obtained from the maternal line of the Cornish hens at this age was 83.9% and 86.1% from Plymouth Rock hens.

Productivity and morphological indicators of egg quality of maternal lines of the Cornish and Plymouth Rock breeds of the Smena-9 cross are high, the poultry is competitive.

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