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Egg productivity of XL chicken population

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Abstract

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The production of table eggs is relatively conservative, based on hybrid forms laying eggs with white or brown shells. In a number of countries, consumers interest in eggs with shells different than the standard shell color, such as chocolate, cream, or blue-green. In order to produce auto-sexing Easter egger layers, a chicken population labeled XL was created. The purpose of this study was to investigate the egg production capacity of the XL population. A 52-week productive period was covered, from reaching 50% laying intensity until 72 weeks of age. The total of 45 hens were tested, divided into three subgroups of 15 each, reared on deep litter. The conducted research on the productive characteristics of the XL population could be summarized as follows: age at 50% production was reached on 147±2.12 days of age; the average number of eggs per Hen Housed for 52 weeks was 296.89±3.33, while the number of settable eggs per Hen Housed was 279.49±0.44; the average intensity of laying for the testing period was 81.56±0.89% with reached peak production of 92.38±1.36%; the average egg weight was 61.06±0.6 g; the produced average eggs mass per Hen Housed was 18.13±0.03 kg; feed consumption for the period was 44.02±0.43 kg per hen. Calculated Feed Conversion Ratio for producing of one kg egg mass and for one egg was 2.43±0.04 kg and 148.27±1.77 g, respectively. The differences between the subgroups on the traits studied were not statistically significant (P>0.05). The eggshell color was green to gray-green. The average live weight at reaching 50% egg productivity was 1.646±0.012 kg and at the end of the period - 2.082±0.021 kg, respectively. Taking into account the results obtained, it can be concluded that the participation of the XL population in breeding schemes for the production of Easter egger hybrids would not adversely affect the egg productivity of the layers.

Keywords: egg laying capacity; FCR; egg weight; egg mass; body weight

Introduction

Modern egg-laying poultry farming is characterized by a large dose of conservatism, with white and brown egg-laying hybrids dominating, which produce respectively eggs with white or brown shell color (Lukanov et al., 2015), as the former dominate the world production (Morton, 2013). The main laying hen hybrids are produced by several global companies, which are part of consortiums uniting them (Besbes et al., 2007; Gura, 2007). One of the main opportunities for the survival of smaller producers of genetic material in the field of egg-laying poultry is to offer new and interesting from a consumer point of view products. In this regard, there are various marketing strategies in some parts of the world aimed at offering attractive to consumers products, such as eggs with non-traditional shell color - cream, dark brown or blue-green (Kabakchiev, 2014). The Japanese market, for example, prefers eggs with a dark brown eggshell, while in other markets light-tinted brown egg is more acceptable (Johnston et al., 2011). Recently, there has been an increase in interest in eggs with chocolate or blue-green color of the shell, produced mostly free range or organic (Lukanov et al., 2012).

Regardless of the manufacturer of the particular egg-laying hybrid, one of the main characteristics of all modern laying hens is the possibility of early sex determination through one of the forms of auto-sexing: color sexing or feather sexing. The heterogamy of female domestic fowl is used in poultry breeding practice for production of auto-sexing hybrids (Kaliasheva et al., 2017).

Population XL was created in order to be used in schemes for obtaining Easter egger hybrids of hens, ie. laying eggs with biliverdin pigmentation (Lukanov et al., 2018). The birds have a reddish-brown plumage, which can be successfully used for the production of auto-sexing crosses (Stevens, 1991).

Another possible opportunity for early sexing is the fact that they have a normal growth rate of feathers (Sohn et al., 2012). The color of the legs and beak is yellowish-brown, and the eyes are orange. The comb has a pea shape, which is also related to small size of the wattles (van Grouw, 2018). The earlobes are red.

Egg-laying characteristics of the hens, representatives of this population should be very good, considering the scheme for its production and the significant share of participation in highly productive forms of Rhode Island Red breed (Lukanov et al., 2018). To date, no results have been published regarding the egg-laying potential of population XL in the scientific literature, which determined the purpose of the present study: to investigate the egg production capacity of the XL population on the yearly basis.

Material and Methods

Experimental design

45 pullets from population XL were used for the needs of the experimental design, equal in age and live weight. The birds were equally divided into three subgroups. The period from reaching 50% of egg production to 72 weeks of age was covered, a total of 52 weeks of productive period.

Rearing and nutrition

The hens were reared on a deep litter at a density of 2 birds per m^2. Each subgroup was provided with one nest for every 5 hens. A perch modul was available to the birds in accordance with the zootechnological requirements. A light program was used, providing 16 hours of light and 8 hours of darkness during the period from 26 weeks of age to 72 weeks of age, with a previous gradual increase from 12 to 16 hours of light for the period of 19-25 weeks of age. The hens were kept in poultry house without controlled temperature regime. The poultry house does not have artificial humidity control systems. Ventilation was natural.

Food was provided *ad libitum*. Three phases of compound feed in the form of coarse mash with nutrient characteristics showed in Table 1 were fed.

Table 1. Chemical composition of the compound feed for experimental birds

Chemical composition	Feed phase		
	Prelay phase* (until 5% of lay)	Layer phase I* (> 5% of lay – 50 weeks of age)	Layer phase II* (>50 weeks of age)
Metabolizable energy, kcal/kg	2850	2800	2800
Crude protein, %	17.00	17.00	16.00
Crude fat, %	4.50	4.50	4.00
Crude fibre, %	5.40	5.50	6.00
total Lysine, %	0.85	0.85	0.80
total Methionine, %	0.40	0.42	0.40
Calcium, %	2.50	3.90	4.20
available Phosphorus, %	0.45	0.45	0.40
Linoleic acid, %	1.40	1.50	1.20

*Vitamins and trace minerals composition per kg compound feed: Vitamin A – 8000 IU; Vitamin D_3 – 3500 IU; Vitamin E – 50 IU; Vitamin K – 3 IU; Thiamin – 2 mg; Riboflavin – 5 mg; Pyridoxine – 3 mg; Pantothenic acid – 10 mg; Folic acid – 1 mg; Biotin – 100 µg; Niacin – 40 mg; Choline – 400 mg; Vitamin B_{12} – 10 µg; Manganese – 60 mg; Iron – 30 mg; Copper – 5 mg; Zinc – 50 mg; Iodine – 1 mg; Selenium – 0.3 mg

Studied parameters

The following parameters were investigated through the test period:

- Age at 50% production, days;
- Intensity of laying, % - the intensity of laying was recorded daily. The average weekly laying intensity and the average for the period by subgroups were calculated on this basis;
- Peak production, % - the highest average weekly laying intensity;
- Number of eggs per Hen Housed – the number of eggs laid from one hen for the whole test period, which can be sold as table eggs;
- Number of settable eggs per Hen Housed – the number of eggs laid from one hen for the whole experimental period which can be realized as hatching eggs;
- Egg weight, g – the average weekly egg weight was recorded by weighing all standard eggs laid for three consecutive days by the hens of each subgroup. The weighing was made with calibrated electronic balance, precision of 0.01 g;
- Eggs mass per Hen Housed, kg – total egg mass produced by an average Hen Housed for the entire test period;
- Total feed consumption, kg – average amount of layer feed consumed during the test period;
- Feed Conversion Ratio – efficiency of the feed transformation to obtain 1 kg of egg mass and 1 egg, summarized by weeks and total for the period;
- Live body weight, kg – mean weight of hens from each subgroup, measured at 21 weeks of age and 72 weeks of age. The weighing was performed with calibrated electronic balance with precision of 0.1 g, by individual weighing.

Statistical analysis

All data were processed with statistical software Statistica 13.0 (Statistica for Windows; Stat–Soft, 2015). Mean (m) and standard error of mean (SEM) values were calculated for each subgroup. The differences considered statistically significant at $P < 0.05$, using Student's t-test, if the data were normally distributed.

Results and Discussion

In Fig. 1 dynamics in the laying intensity during the test period, summarized for the three subgroups are presented since there are no serious differences between them in terms of this feature. The curve shows a typical form of laying intensity in modern laying hens (Jacob et al., 2017). The shape of the curve is defined by the following stages: sexual maturity, stage of increasing production; peak production, decline of egg production; and persistency of production (Safari-Aliqiarloo et al., 2018). During the first four weeks after the start of egg-laying, there was a rapid increase in laying capacity associated with the maturation of the birds. 50% laying intensity was reached at 144, 150 and 147 days, in subgroups 1, 2 and 3 respectively. The average age of reaching 50% laying intensity for the three subgroups was 147±2.12 days. The results obtained by us are in accordance with those typical of modern egg-laying lines and hybrids of hens, reaching group maturity at about 140-150 days of age (Kabakchiev, 2014). With the help of a light program the age of laying in hens can be manipulated (Lewis, 2010; Ma et al., 2013). For comparability of the results obtained in the present study, a universal light program for laying hens was chosen. Investigating the egg-laying characteristics of two parental forms for obtaining Araucana and Schijndelaar breed-based Easter eggers, Lukanov et al. (2016) reported a higher age of reaching 50% laying intensity, 165 (for Araucana) and 205 days (for Schijndelaar), respectively. This can be explained by the decorative nature of those breeds in which no productivity based selection was conducted.

Peak values of laying intensity were reached between 31 and 39 weeks of age in accordance with the normal age for reaching peak productivity in modern laying hens (Bhatia, 2016). The highest average weekly laying capacity, after summarizing the results of the three subgroups, was registered in 36 week – 92.38%. These weekly peak levels are in line with those achieved by modern laying hens (Campbell et al., 2003; Kabakchiev, 2014). After 40 weeks of age, there was a steady slight decrease in egg-laying, and after 64 weeks of age the intensity of laying declines below 80%, reaching about 75% at the end of the test period. The average laying intensity for the three subgroups for a 52-week production period was 81.56±0.89% (81.71±0.84%, 81.60±0.97% and 81.38±0.88% in subgroup I, II and III respectively; $P>0.05$). The presented results about the average laying intensity are significantly higher than those reported in Araucana and Schijndelaar breeds (Lukanov, 2016; Lukanov et al., 2016), approaching modern achievements in the species.

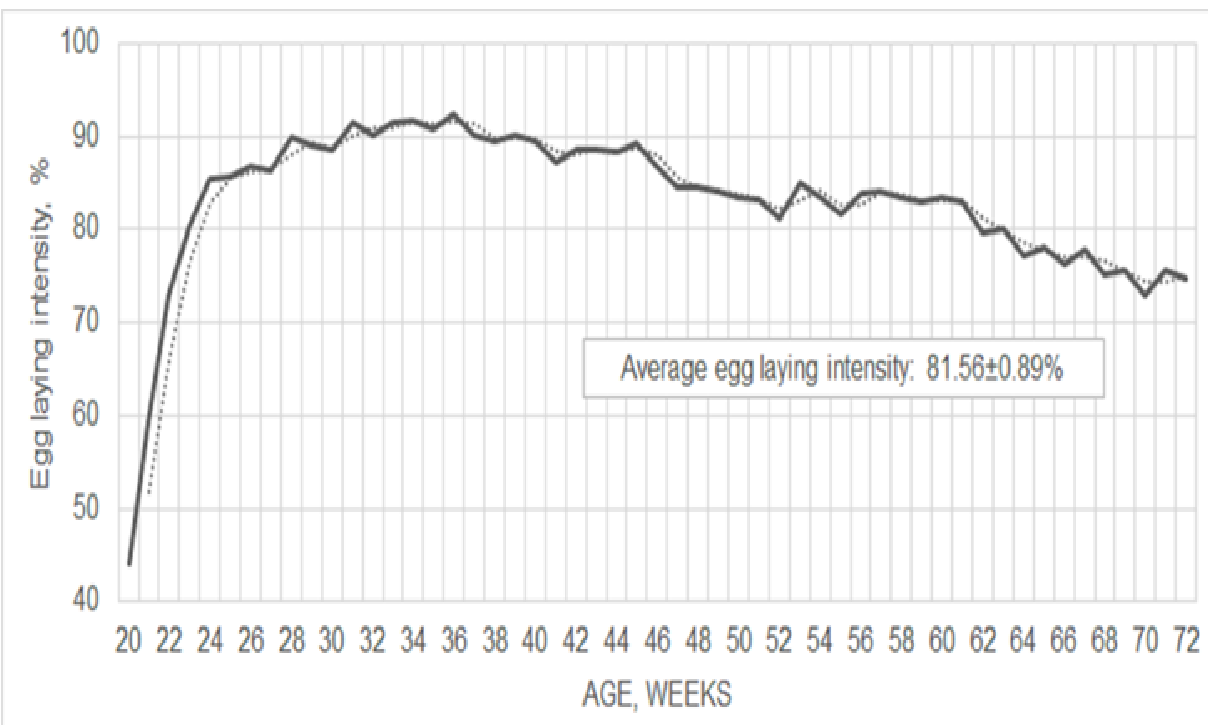

Fig. 1. Generalized laying intensity for the three hens subgroups of the XL population, %

A number of factors can affect laying capacity such as body weight, environmental factors, diseases, nutrition (Safari-Aliqiarloo et al., 2018). Modern laying hens lay 290 to 330 eggs in a 52-week production period, depending on the hybrid and the rearing method (Prabakaran, 2003; Kabakchiev, 2014). Laying capacity of a Hen Housed in the three subgroups varied from 296.21±3.21 eggs in subgroup III to 297.44±3.23 eggs in subgroup I with statistically unsignificant differences between them (P>0.05). The average laying capacity for the three subgroups was 296.89±3.33 eggs for a 52-week production period, which is comparable to that of the parent forms for brown egg-laying hybrids producing (Lalev et al., 2011). The obtained high results on the two related features, laying capacity and laying intensity in hens of population XL can be explained by the significant participation in their creation of a highly productive Rhode Island Red strains (Lukanov et al., 2018). For comparison, laying capacity of the other breed involved in the population creation scheme, the Dutch Schijndelaar shows an yearly laying capacity from 132.5 eggs (Lukanov et al., 2016) to 140.5 eggs (Lukanov, 2016). The hatching eggs quality is imperative for good incubation results. Eggs provide both embryo protection and nutrition (Ulmer-Franco et al., 2010). After removal of the eggs unsuitable for incubation, the mean number of hatching eggs obtained from a hen was determined, ranging from 278.81 in the third subgroup to 280.04 in the first, with an average value for the three subgroups of 279.49±0.44 eggs (Fig. 2). As no mortality or culling of birds was reported during the test period among the three subgroups, the results for the Hen Housed overlapped with those for the Hen Day productivity.

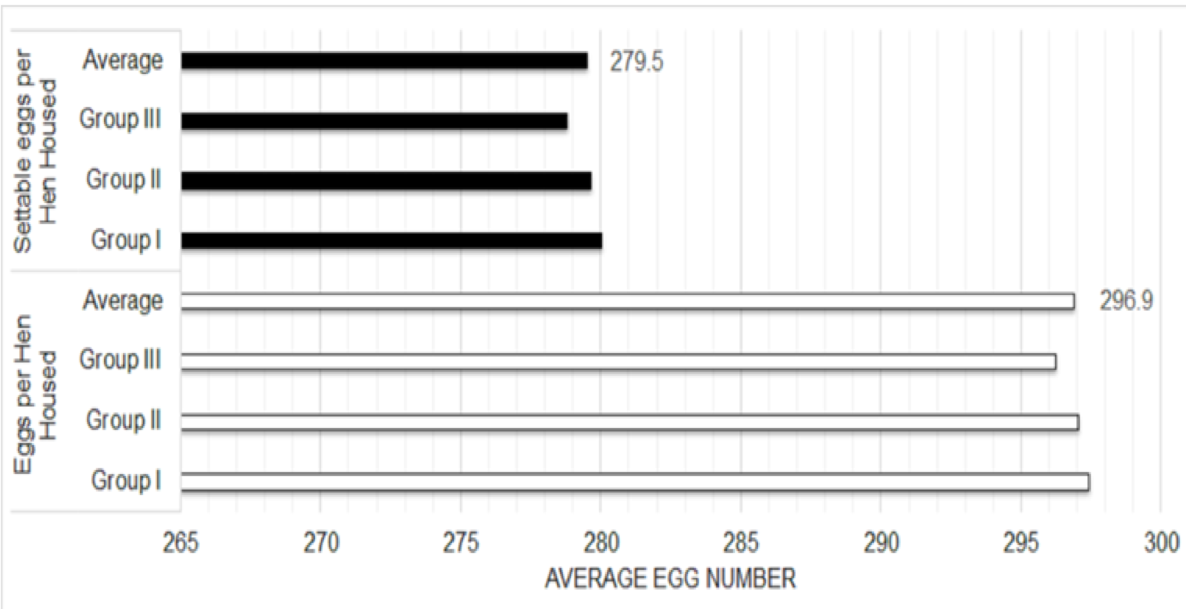

Fig. 2. Table and hatching egg number per Hen Housed by subgroup and total for XL population

Egg mass is influenced by a number of genetic and environmental factors that can be controlled with appropriate farm management practices (Thiele, 2012). The mass of hen's eggs increases with increasing of the productive age (Shalev & Pasternak, 1993), which is in line with the results from the current study (Fig. 3). In parallel with the beginning of laying there was a sharp jump in the egg mass, and the tendency for its faster increase in all three experimental subgroups was maintained for several weeks after the peak laying. Then, after 50 weeks of age, the egg mass showed a significantly slower growth rate. The difference between the mean values at the age of 50 weeks and at 72 weeks of age was only 1.24%. Unlike these data, during the period of 21-50 weeks of age, the increase in mean egg weight was 25.47%. In modern egg-laying poultry farming such a form of egg weight curve - increase early egg weights, hold mid-cycle egg weights constant, and decrease late egg weights is desirable (Hyline International, 2018).

The mean egg weight for the period was 61.06±0.6 g with statistically insignificant differences between the three subgroups (P>0.05), ranging from 61.12±0.59 g for subgroup I, to 61.01±0.62 g for subgroup III. The results obtained with regard to this productive trait are lower in comparison with the modern highly productive strains of Rhode Island Red breed (Kabakchiev, 2014) and are comparable to other studies on egg mass in this breed (Malago & Baitilwake, 2009; Durmuş et al., 2010; Lukanov, 2016). Compared to the other breed involved in the creation of population XL - Schijndelaar, the egg mass in it is significantly lower – 45.76±0.07 g (Lukanov, 2016). The main part of the eggs obtained during the period 1-24 productive weeks was from weight category M (53-63 g), and from 25-52 productive week - L (63-73 g). The obtained eggs have a grayish-green color of the eggshell, with individual differences from lighter to darker shades.

In contrast, eggs obtained from most other breeds with biliverdin pigmentation of the shell have a lighter blue to blue-green color (Lukanov, 2014). The darker color of the eggshell from population XL is due to the combination of biliverdin and protoporphyrin (Kennedy & Vevers, 1976; Schwartz et al., 1980), coming from Schijndelaar and Rhode Island Red respectively (Lukanov et al., 2016).

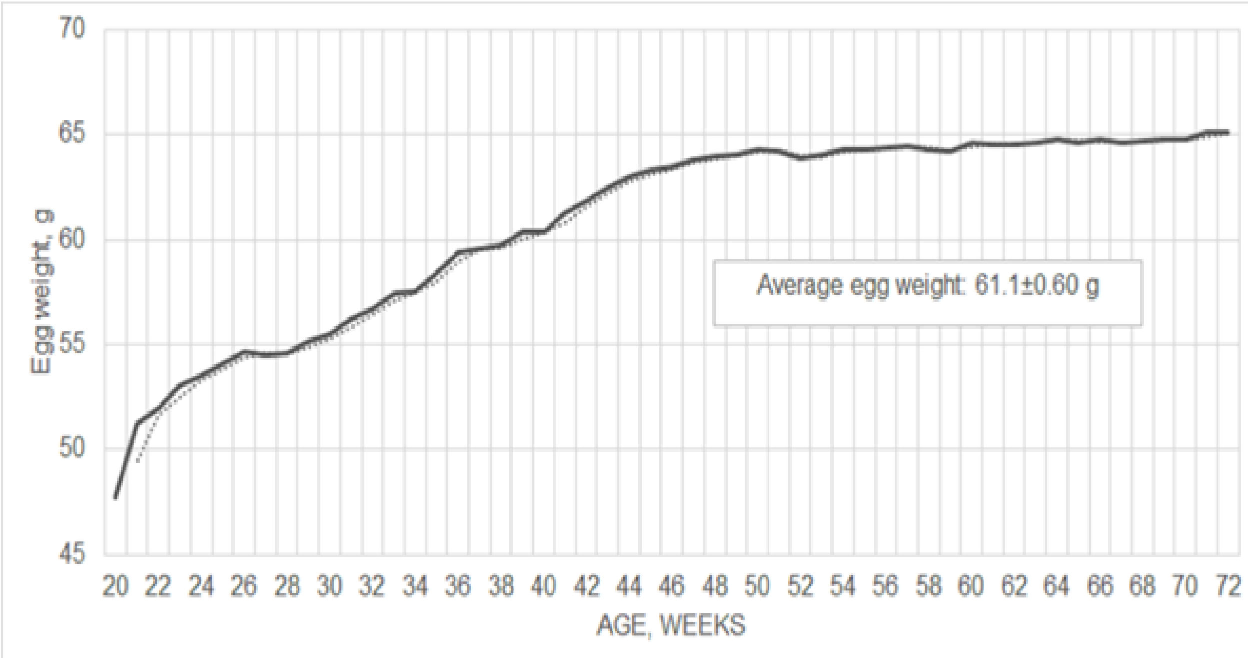

Fig. 3. Generalized egg weight for the three hens subgroups of the XL population, g

A major part of the cost of production, in our case - table or hatching eggs, is provided by the cost of poultry feed (Gabarrou et al., 1998; Arango, 2009). In this regard, a long-term selection of laying capacity and efficiency of feed utilization in egg-laying hens has been conducted (Flock, 1998). With the increase in feed prices worldwide, this selection continues to be one of the most important in modern industrial poultry farming (Yuan et al., 2015). One of the main features for measuring production efficiency in egg-laying farming is feed conversion. It can be expressed in different ways, with the transformation of feed into one kilogram of egg mass being perhaps the most popular. Important parameter, both in the rearing of laying hens and parental forms, is the effectiveness of the transformation of feed to obtain a single table or hatching egg. For the table eggs production, the proposed methodology for determining the efficiency of transformation of energy and protein in feed to egg content can also be applied (Penkov & Grigorova, 2020). The feed conversion ratio for the production of a kilogram of egg mass and for one egg is presented in Figure 4. During the first weeks, less efficient feed conversion was measured due to the low laying intensity and egg mass. The highest values on both indexes concerning the feed conversion were observed during the first four weeks of the test period, corresponding to the most active increase in laying intensity: 3.08 for obtaining a kilogram of egg mass and 0.161 for obtaining one egg, on average for the three subgroups. Towards the end of the productive period, especially after 44th productive week, there was again an increase in the values of the trait due to a decrease in egg laying, which cannot be compensated by the increasing mass of eggs. This less efficient utilization of feed, based on the production of a kilogram of egg mass, is less pronounced, compared to the period of 1-4 productive weeks and comparable in terms of the feed required obtaining one egg. The most efficient utilization of feed to obtain a kilogram of egg mass was reported for all three subgroups during the period 12th-39th productive week, respectively an average of 2.27±0.01. A significantly shorter period covers the most efficient feed conversion to obtain one table egg: 8th to 31st productive week or average 0.135±0.003. The average feed conversion for the period in the three subgroups was 2.43±0.04 and 0.148±1.77, to obtain one kilogram of egg mass and one egg respectively. The differences in the two traits between the three subgroups were also statistically insignificant ($P>0.05$). The obtained results showed significantly better utilization of feed, compared with purebred carriers of biliverdin pigmentation of the eggshell (Lukanov, 2016; Lukanov et al., 2016), getting closer to modern high-productive egg-laying hens (Kabakchiev, 2014).

After summarizing and mathematical processing of the obtained results, it was found that on average from one test hen 18.13±0.03 kg of eggs were obtained for a 52-week production period. The total compound feed from experimental hen for the period from 21st to 72nd week of age was 44.02±0.43 kg, or 25.18 kg Layer phase I and 18.84 kg Layer phase II respectively.

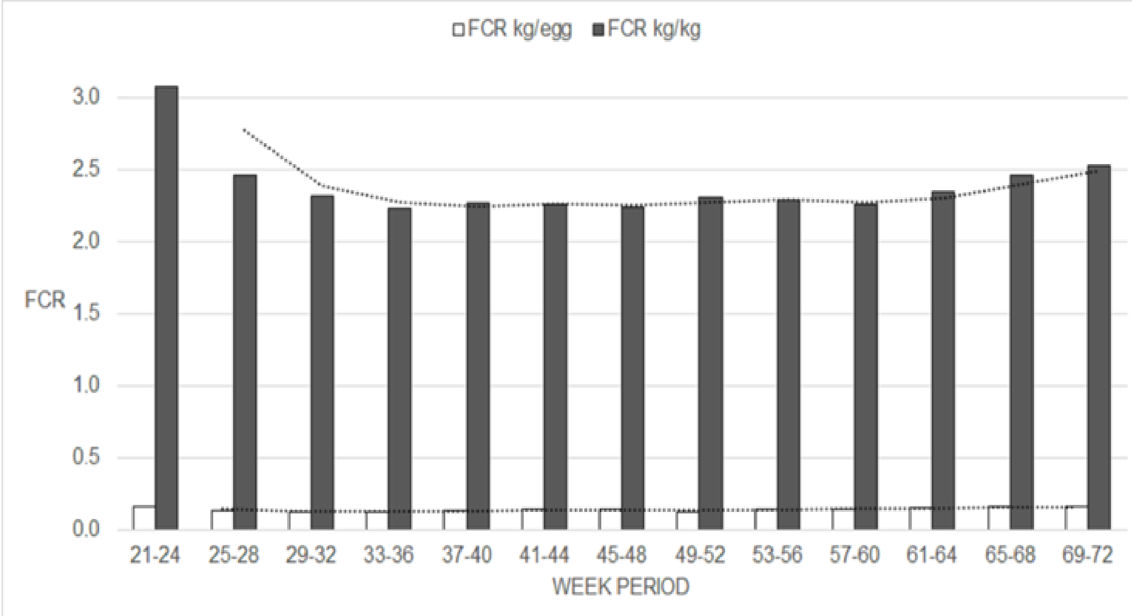

Fig. 4. Generalized Feed Conversion Ratio per kg egg mass produced and for one egg produced for the three subgroups of the XL population

The average body weight of hens from the three subgroups at the beginning and end of the experimental period is presented in Table 2. Significant differences in body weight between the individual subgroups were not reported, both in terms of initial weight and final weight. This is a sign of good population consolidation, combined with the application of identical breeding and feeding conditions for the three subgroups. Statistically significant intragroup differences were found between different age weighings (P<0.001). Summarizing the results of the weights of all hens, an average weight at 21 weeks of age of 1.646±0.012 kg and 2.082±0.021 kg at 72 weeks of age was measured. The increase in body weight during the productive period is 26.48%. The obtained results about live weight in population XL are significantly lower than that of classical Rhode Island Red breed (EE, 2006), and are consistent with the mass of modern high-productive light populations in the breed used in intensive poultry farming. (Lalev et al., 2012; Göger et al., 2014; Kabakchiev, 2014). The other breed that participated in the creation of population XL – Schijndelaar, is distinguished with lower live weight at reaching 50% laying capacity, 1552.8±51.78 g (Lukanov, 2016) and 1524.70± 9.08 g (Lukanov et al., 2016) respectively.

Table 2. Average body weight of the experimental hens at 21 and 72 weeks of age, kg

	Subgroup I		Subgroup II		Subgroup III	
Age, weeks	21	72	21	72	21	72
n	15	15	15	15	15	15
Mean	1.629[a]	2.050[a]	1.660[b]	2.093[b]	1.650[c]	2.103[c]
SEM	0.02	0.03	0.02	0.04	0.02	0.04
CV, %	4.63	5.13	4.22	7.16	5.33	7.27

[a-a], [b-b], and [c-c]: statistically significant differences at P<0.001

Conclusions

Summarizing the results obtained, it can be concluded that the XL population is distinguished by the following productive characteristics:

- Age at 50% production: 147±2.12 days of age;
- Average Intensity of Hen Housed laying: 81.56±0.89%;
- Peak production: 92.38±1.36%;
- Average number of eggs per Hen Housed: 296.89±3.33;
- Average number of settable eggs per Hen Housed: 279.49±0.44;
- Average egg weight: 61.06±0.6 g;
- Egg shell color: grayish green;
- Average eggs mass per Hen Housed: 18.13±0.03 kg;
- Feed Conversion Ratio per kg egg mass: 2.43±0.04;
- Feed Conversion Ratio per egg: 0.148±0.002;
- Live body weight at 21/72 weeks of age: 1.646±0.012

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