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Production Systems

Economic efficiency of fattening on different genotypes of slow-growing and fast-growing broiler chickens

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Abstract. In the present study six lines from the National Gene Pool (Bulgaria) were used, four of which line NG (New Hampshire G), line E (Barred Plymouth Rock), line Ss (Sussex) and line F (NG x Red Rhode Island) as maternal forms in the crossing schedule and two sire lines, meat type line L (White Plymouth Rock) and line M (Cornish), for production of slow-growing broilers. The effect of genotype on meat quality traits was studied with 5 groups of 150 unsexed day-old chicks from each genotype, and after the manifestation of sexual dimorphism – male and female chickens at 70 and 84 days of age. In valuation on revenues and costs of the fattening of the compared groups current prices at the time of the experiment were used. Cost of feed is determined according to the actual feed. In determining the economic efficiency of fattening, three variants of sale prices per kg of meat - 3.60 BGN/kg, 4.65 BGN/kg and 5.30 BGN/kg have been analysed. The rate of profitability is a synthetic indicator for economic efficiency, calculated by the formula: NP = (Profitability / Production costs) * 100, %. Feed expenses for experimental group I were lowered by 22.8%, while in groups II, III, and IV- by 13.46%, 9.42% and 9.05%, respectively, compared to group V, which registered the highest consumption of feed in the amount of 5.52 BGN. The share of feed expenses in group I was 53.45% of total expenses, and in groups II, III, and IV group they were 59.88%, 56.30%, 57.50%, and 56.87%, respectively. The highest profits per the accepted sale prices were observed in group V- 10.71 BGN, 13.68 BGN and 15.52 BGN, respectively, followed by group IV with 8.56 BGN, 10.92 BGN, and 12.38 BGN, respectively. At a level of sale prices of 3.60 BGN/kg a positive value of profitability was registered for the fattening of chickens from group V - 16.03%. In all other groups, the profitability norm was negative. At a level of sale prices of 4.65 BGN/kg, the highest profitability was observed in the chickens of group V - 48.21%, followed by group IV - 25.37%, while the lowest cost efficiency was in group III - 4.24%. In the variant with a sale price of 5.30 BGN/kg, the profitability norm was the highest in group V - 68.14%, followed by group IV - 42.13% and group II - 40.96%, while the lowest level was in group III - 18.21%.

Keywords: broiler chickens, slow-growing, productivity, feed conversion, economic efficiency, profitability

Introduction

Throughout the years there have been different opinions regarding the content of the term "broiler". With the great achievements in the field of genetics during the 1990s, a trend emerged for the production of heavier broilers, 1.8-2.3 kg, as well as an increase in the size of deboned meat packages (Vanchev, 1989). Broiler production was related to relatively high losses from mortality due to cardiovascular problems in birds. On one hand, this causes economic losses, and on the other, it reduces the birds’ welfare. It is known that broiler combinations with lower growth rates and higher feed conversion are used in practice, due to which they are less susceptible to cardiovascular diseases (Van Harm and Van Middelkoop, 2001). Animal breeders can keep such birds, yet it is obvious that the produce’s value would increase. A Dutch study on the future of poultry production recommended to select a type of broiler that will grow slower than the contemporary commercial lines, yet faster than the organic and "Label Rouge" type broilers (Van Harm and Van Middelkoop, 2001).

Customers are more and more often interested in naturally produced or eco-friendly products, produced by systems ensuring good welfare and health for the birds (Sundrum, 2001; Owens et al., 2006). For broiler chickens bred in extensive systems, consumers’ demand and consumption are per whole body and customers are willing to pay a higher price (Zanusso and Dionello, 2003). In fact, there is a consensus that organic chicken meat is safer and more nutritional than that of conventional broilers, and therefore an increasing number of consumers are prone to pay a higher price for certified chicken meat (Magdeliane and Bloch, 2004; Crandall et al., 2009).

The European market of slow-growing broilers makes up 30%. In some countries, such as France and Portugal, owners invest into this product in order to obtain quality certificates. Studies are conducted on the productivity of these birds, the economic efficiency of their production, as well as the productive processes themselves. These special poultry products have had a longer history in Europe. One of the most successful productive systems is French – Label Rouge, which requires access to free open space and has taken over 30% of the French poultry products market, despite the twice lower cost of conventional poultry farming produce (Westgren, 1999; Fanatiko and Born, 2001).

Numerous slow-growing genotypes are available in Europe and their efficiency is lower than the fast-growing ones. The slow-growing types are better adapted to such breeding systems and the meat quality is more suitable for the gourmet market (Castellini et al., 2002; Gordon and Charls, 2002). Scientific studies are needed to determine the fitness of fast- and slow-growing genotypes towards organic systems for breeding and customer acceptability. The more in-depth studying of the interaction among the factors of genotype,
feeding, density, environment and grazing would help improve the breeding of free-range birds.

Customers prefer birds with more white meat, thighs, legs (Sauza, 2004). Fast-growing broilers bred in semi-intensive systems give a higher yield of white meat and legs than slow-growing ones (Fanatîko et al., 2005). There are also differences between the two sexes – the males have better developed thighs while the females - breast muscles (Takahashi, 2006). Westgren (1999), Fanatîko and Born (2001) used fast-growing broilers for breeding under the Label system, as well as the European programmes for organic production (EEC, 1991). There is a possibility for fast-growing broilers of this type to reach high live weight.

In Europe, a growing number of customers are liable to pay higher prices for ecologically produced animal products (Bennet, 1996). The production of organic animal produce is regulated by EC Regulation No. 1804/1999, which includes specifications for the conditions of keeping, feeding, breeding, reproduction and veterinary care. With regard to the choice of breed, the regulation indicates that their adaptability to the local conditions, vitality and diseases resistance have to be taken into consideration.

In the USA, broilers of the fast-growing genotype are used in systems with free outdoor access and extensive production systems. Considering the fast-growing broiler specific predisposition to illnesses, the usage of slow-growing broiler chickens is recommended for a period of no less than 81 days. In practice, in the USA fast-growing chickens are primarily used for organic production, whereas European producers tend to use slow-growing genotypes leading to lower body weights at the end of fattening because the fast-growing chickens reach slaughter age after 81 days of age, as prescribed by EC Regulation No. 889/2008 (Bogosavljević-Bošković et al., 2012).

The market for organic products has grown by 20% over the last few years in the USA (ERS, USDA, 2002) and domestic birds are a part of this trend. The production of organic animal products is accompanied by natural and organic systems whose goal is to avoid the usage of additives from animal products and antibiotics, i.e. to use 100% natural biological ingredients - without synthetic pesticides and herbicides. Free access for the birds to open space is required.

Attempts to use French breeder forms for production of slow-growing chickens have been made in Bulgaria as well. A commercial breeding farm of the Agricultural Institute, Stara Zagora. Six original lines from the National Gene Pool were used to produce experimental broiler chickens: line Ss, line E, line NHG, line F from the all-purpose type were used as maternal forms. The sire line - line M (Cornish) was selected in line with the main purpose: production and investigation of production performance of slow-growing broiler chickens with excellent growth performance, good meat production and quality. It is used for production of conventional broilers together with line L (White Plymouth Rock). Both are from the meat production type.

The five broiler genotypes (4 slow-growing and 1 fast-growing) were obtained using the following breeding schedule:

I. ♂ M x ♀ Ss
II. ♂ M x ♀ E
III. ♂ M x ♀ NHG
IV. ♂ M x ♀ F
V. ♂ M x ♀ L

In order to study the influence of genotype on meat traits, five groups of 150 unsexed one-day-old chickens from each genotype were formed, marked and vaccinated against Marek's disease and after expression of the sexual dimorphism divided per sex. They were kept under an indoor floor system, on a deep permanent litter of woodchips. The chickens from each group were kept under the same conditions, in the same room, in accordance with the technological requirements for feeding and rearing applied at the poultry farm of the Agricultural Institute. They were provided constant access to compound feed prepared at the Institute's feed shop, coordinated with the birds’ age and category. Their feeding was conducted per schedule, providing the necessary nutrients for each fattening period – starter (1-14 day), grower (14-28 day), and finisher (28-84 day).

The nutritional value of compound feeds are listed in Table 1 (AOCA, 1996).

Live weight was monitored via individual weighing at the ages of 1, 14, 28, 42, 56, 70, 84 days. Mortality of chickens was registered daily. Feed intake was determined by periods. Towards the end of the experiment a slaughter analysis was conducted with three

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Starter 1-14 day</th>
<th>Grower 14-28 day</th>
<th>Finisher 28-84 day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>21.16</td>
<td>19.37</td>
<td>18.77</td>
</tr>
<tr>
<td>Crude fat, %</td>
<td>8.18</td>
<td>5.92</td>
<td>5.90</td>
</tr>
<tr>
<td>Metabol. energy, kcal/kg</td>
<td>1927.77</td>
<td>2148.15</td>
<td>2194.26</td>
</tr>
<tr>
<td>Crude fibre, %</td>
<td>4.45</td>
<td>4.11</td>
<td>4.12</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.97</td>
<td>0.90</td>
<td>0.78</td>
</tr>
<tr>
<td>Digestible phosphorus, %</td>
<td>0.806</td>
<td>0.45</td>
<td>0.69</td>
</tr>
<tr>
<td>Methionine, %</td>
<td>0.46</td>
<td>0.44</td>
<td>0.38</td>
</tr>
<tr>
<td>Lysine, %</td>
<td>1.19</td>
<td>1.11</td>
<td>0.98</td>
</tr>
</tbody>
</table>
female and three male broilers from each genotype with a live weight corresponding to the group average. After 12 hours of fasting the birds were stunned and slaughtered, in accordance with the requirements of Regulation No. 22/14.12.2005 on the reduction to a minimum of animals’ suffering during slaughter. The live weight after a 12-hour fasting was determined, as well as the mass of the grill, the separate body parts (breasts, thighs, wings), of the edible offal (heart, liver, gizzard), as well as the mass of the abdominal fat. On the grounds of this, the slaughter yield and the separate body cuts were calculated.

While evaluating the profits and expenses from the fattening of the compared groups, the methodical approach of Stoimenov et al. (1997), Kaitazov et al. (2000) and Hristakieva, (2006) was used, along with the current prices at the time of conducting the experiment. The feed expenses were determined per the actual feeding. The other expenses (labour, electricity, treatment, depreciation, etc.) were calculated on the grounds of reality, including the costs, norms and pricelists of the Agriculture Institute - Stara Zagora, and they were distributed per single chicken in accordance with the length of the fattening period. Three variants of sale prices for a kilogram of poultry meat were analysed while determining the economic efficiency of fattening: 3.60, 4.65 and 5.30 BGN/kg; the 3.60 BGN/kg being the country average price for wholesale refrigerated meat. Chickens of the DUC brand are sold 15% more expensive due to genetic factors and their slaughter quality – the so-called slow-growing chickens. Therefore, their economic parameters were hypothetically calculated at a price of 5.30 BGN/kg.

The profitability norm is a synthetic parameter of economic efficiency. It was calculated per the following formula:

\[ Hp = \frac{\text{Profit}}{\text{Production expenses}} \times 100, \% \]

The results were submitted to statistical analysis (ANOVA/MANOVA and LSD post hoc test) to determine the effect of the genotype and the sex using Statistica 8 software (StatSoft, 2009).

Results and discussion

The value level of broiler production is affected by numerous factors, such as the birds' genetic qualities for high growth intensity and conversion of combined feed; the quality and cost of the combined feed; the viability and cost of the hybrid chickens, the expenses for maintaining animal hygienic and technological parameters, lighting, heating, ventilation, timely sale of the ready birds, the extent of work force utilisation (Stoimenov, 1976).

When analysing the feed expenses as part of the production expenses (Table 2) it was determined that it was the highest in group V, followed by group III and group IV, 5.52 BGN, 5.02 BGN, and 5.00 BGN, respectively. The groups with the lowest feed expenses were I and II, 4.26 BGN and 4.78 BGN, respectively. Similar results in this regard were established by Aleksieva (2004) and Ivanova (2015) in broiler chickens. The observed differences were explained by the variations in the amounts of feed in the separate groups during the different stages of fattening. The feed expenses in test group I were lower by 22.8%, and in groups II, IV, and III - by 13.48%, 9.42%, and 9.05%, respectively, compared to group V, which registered the highest feed consumption in the amount of 5.52 BGN.

Table 3 presents the production expenses from the fattening of the birds included in the experiment. Apart from the feed expenses, all other expenses were constant for all groups, since they were regarded were established by Aleksieva (2004) and Ivanova (2015) in broiler chickens. The observed differences were explained by the variations in the amounts of feed in the separate groups during the different stages of fattening. The feed expenses in test group I were lower by 22.8%, and in groups II, IV, and III - by 13.48%, 9.42%, and 9.05%, respectively, compared to group V, which registered the highest feed consumption in the amount of 5.52 BGN.

<table>
<thead>
<tr>
<th>Feed expense</th>
<th>I Group</th>
<th>II Group</th>
<th>III Group</th>
<th>IV Group</th>
<th>V Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starter</td>
<td>184.19</td>
<td>176.38</td>
<td>142.798</td>
<td>215.65</td>
<td>265.10</td>
</tr>
<tr>
<td>BGN</td>
<td>0.17</td>
<td>0.16</td>
<td>0.13</td>
<td>0.20</td>
<td>0.24</td>
</tr>
<tr>
<td>Grower</td>
<td>816.9</td>
<td>957.46</td>
<td>774.66</td>
<td>1017.21</td>
<td>879.6</td>
</tr>
<tr>
<td>BGN</td>
<td>0.65</td>
<td>0.77</td>
<td>0.62</td>
<td>0.82</td>
<td>0.70</td>
</tr>
<tr>
<td>Finisher</td>
<td>4920.67</td>
<td>5492.87</td>
<td>6103.86</td>
<td>5663.6</td>
<td>6541.14</td>
</tr>
<tr>
<td>BGN</td>
<td>3.44</td>
<td>3.85</td>
<td>4.27</td>
<td>3.97</td>
<td>4.58</td>
</tr>
<tr>
<td>Total</td>
<td>5921</td>
<td>6627</td>
<td>7021.31</td>
<td>6896.6</td>
<td>7685.84</td>
</tr>
<tr>
<td>BGN</td>
<td>4.26</td>
<td>4.78</td>
<td>5.02</td>
<td>5.00</td>
<td>5.52</td>
</tr>
<tr>
<td>Compared to group V, %</td>
<td>22.8</td>
<td>13.48</td>
<td>9.05</td>
<td>9.42</td>
<td>100</td>
</tr>
</tbody>
</table>

*1 USD=1.63095 BGN
*1 EUR=1.95583 BGN

Table 3. Production expenses per chicken during the test period, BGN.

<table>
<thead>
<tr>
<th>Parameters, BGN</th>
<th>I Group</th>
<th>II Group</th>
<th>III Group</th>
<th>IV Group</th>
<th>V Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeds</td>
<td>4.26</td>
<td>4.78</td>
<td>5.02</td>
<td>5.00</td>
<td>5.52</td>
</tr>
<tr>
<td>Labour costs with social insurances included</td>
<td>2.70</td>
<td>2.70</td>
<td>2.70</td>
<td>2.70</td>
<td>2.70</td>
</tr>
<tr>
<td>Depreciation</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
<td>0.37</td>
</tr>
<tr>
<td>Medication and treatment</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
<td>0.16</td>
</tr>
<tr>
<td>Electricity and water</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
<td>0.28</td>
</tr>
<tr>
<td>Other expenses</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Total expenses</td>
<td>7.97</td>
<td>8.49</td>
<td>8.73</td>
<td>8.71</td>
<td>9.23</td>
</tr>
</tbody>
</table>
calculated per animal per the experimental period. For this reason, the feed expense with its financial expression has the greatest effect on all production expenses. Production expenses in the fattening of conventional broilers were 6.58 BGN, 6.94 BGN, and 6.98 BGN per broiler (Ivanova, 2015). According to data by Kaitazov et al. (2000) this expense represents about 65-80% of the total expenses in fattening broilers. Our data indicated that the share of feed expenses for group I was 53.45% of the total expenses, in groups II, III, IV and V it was 59.88%, 56.30%, 57.50%, 56.87%, respectively. The lower share of feed expenses in the fattening of slow-growing broilers was due to the longer period of feeding the chickens from all groups, and thus due to the higher share of the other expenses within the structure of production expenses. The work remuneration fund was relatively the lowest in group V, compared to the total expenses 29.25% and the highest in group I - 33.87% (Figure 1).

Figure 1. Production expenses, BGN

According to other authors (Stoimenov et al., 1997; Kaitazoov, 2000), labour costs, depreciation, value of the one-day-old chickens make up about 35%. In poultry farming, the remuneration system of fatteners is formed by the value of boilers sold in live weight, the value of one-day-old chickens, plus the feed value (Aleksieva, 2004). Čobanoglu et al. (2014) reported that the higher slaughter age within the system for organic production (81 days versus 42 days) and the additional feeds needed for these older chickens were the reasons for the higher expenses. It has been established in numerous studies (Padel et al., 1997; Rossiter, 2001; USDA/AMS, 2003; Vermeij, 2004; Fanatico, 2008; Rodenburg et al., 2008) that the share of feed in the total expenses was higher in organic than in the conventional systems.

The Dutch Agricultural Economic Institute (LEI) gets a picture of economic effect from fattening of slow-growing broilers. The evaluation is that the cost per kg of live weight for the broiler farmer would increase by 8.5 - 10% mainly due to higher housing costs, higher feed costs and higher labour cost (Van Harn and Van Middelkoop, 2001). There are some facts that reduce cost per kg: a cheaper day-old cost, lower mortality and cheaper feed. Table 4 presents the profits from fattening slow-growing broilers at three levels of grill sale prices - 3.60 BGN/kg, 4.65 BGN/kg and 5.30 BGN/kg, respectively, and of the edible offal and the neck - 2.60 BGN/kg. It was found that for the three levels of sale prices, the lowest profits were observed in group III - 7.13 BGN, 9.10 BGN, and 10.32 BGN, followed by those of group I with respective profits of 7.48 BGN, 9.54 BGN and 10.81 BGN. The highest profits were registered by the birds of group V with grill mass of 2.830 kg, followed by group IV with 2.248 kg, and group II with 2.179 kg. The profits from the mass of the edible offal plus the neck preserved this trend. The parameters were superior in group V with 0.52 BGN, with a yield of 0.202 kg, followed by group IV - 0.47 BGN and group II 0.42 BGN with respective amounts of 0.181 kg and 0.163 kg.

Table 4. Profit per chicken, BGN

<table>
<thead>
<tr>
<th>Parameters, BGN</th>
<th>I Group</th>
<th>II Group</th>
<th>III Group</th>
<th>IV Group</th>
<th>V Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>price, BGN/kg</td>
<td>price, BGN/kg</td>
<td>price, BGN/kg</td>
<td>price, BGN/kg</td>
<td>price, BGN/kg</td>
</tr>
<tr>
<td>Grill</td>
<td>3.60</td>
<td>4.65</td>
<td>5.30</td>
<td>3.60</td>
<td>4.65</td>
</tr>
<tr>
<td>Quantity, kg</td>
<td>1.963</td>
<td>2.179</td>
<td>1.875</td>
<td>2.248</td>
<td>2.830</td>
</tr>
<tr>
<td>Edible offal and neck/2.60BGN/kg</td>
<td>0.157</td>
<td>0.163</td>
<td>0.145</td>
<td>0.181</td>
<td>0.202</td>
</tr>
<tr>
<td>Quantity, kg</td>
<td>0.41</td>
<td>0.42</td>
<td>0.38</td>
<td>0.47</td>
<td>0.52</td>
</tr>
<tr>
<td>Value, BGN</td>
<td>0.41</td>
<td>0.42</td>
<td>0.38</td>
<td>0.47</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Table 5 presents the economic parameters from the fattening of a single chicken. The profit is calculated across the three levels of grill sale price.

At a level of grill sale of 3.60 BGN/kg, the profit achieved was +1.48 BGN only for the fattening of the chickens from group V. The other groups registered loss -1.60 BGN, which was the highest in group III.

At a level of grill sale of 4.65 BGN/kg, profit was achieved in all analysed groups, with its amount being the highest in group V +4.45 BGN, followed by group IV +2.21 BGN, and the lowest in group III +0.37 BGN.

An analogous trend was observed in the third and highest level of sale price 5.30 BGN/kg. The profit for group V was 6.29 BGN, followed by group IV 3.67 BGN, and group II with 3.48 BGN, while the lowest profit from fattening chickens was registered in group III 1.59 BGN.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>I Group</th>
<th>II Group</th>
<th>III Group</th>
<th>IV Group</th>
<th>V Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>At a price of:</td>
<td>At a price of:</td>
<td>At a price of:</td>
<td>At a price of:</td>
<td>At a price of:</td>
<td>At a price of:</td>
</tr>
<tr>
<td>3.60 4.65 5.30</td>
<td>3.60 4.65 5.30</td>
<td>3.60 4.65 5.30</td>
<td>3.60 4.65 5.30</td>
<td>3.60 4.65 5.30</td>
<td>3.60 4.65 5.30</td>
</tr>
<tr>
<td>Production expenses, BGN</td>
<td>7.97</td>
<td>8.49</td>
<td>8.73</td>
<td>8.71</td>
<td>9.23</td>
</tr>
<tr>
<td>Profit, BGN</td>
<td>-0.49 1.57 2.84</td>
<td>-0.23 2.06 3.48</td>
<td>-1.6 0.37 1.59</td>
<td>-0.14 2.21 3.67</td>
<td>1.48 4.45 6.29</td>
</tr>
<tr>
<td>Profitability norm, %</td>
<td>-6.14 19.70 35.63</td>
<td>-2.71 24.26 40.98</td>
<td>-18.32 4.24 18.21</td>
<td>-0.15 25.37 42.13</td>
<td>16.03 48.21 68.14</td>
</tr>
</tbody>
</table>

The profitability norm is an integral economic parameter for the activity (Figure 2). At a level of sale prices of 3.60 BGN/kg the group with a positive profitability value was 16.03%, per group V. For all other groups, the profitability norm was negative, i.e. the fattening was economically ungrounded.

At a level of sale prices of 4.65 BGN/kg, the highest profitability was observed in the chickens from group V – 48.21%, followed by group IV - 25.37%, while the lowest efficiency was registered in group III - 4.24%.

In the variant with sale prices of 5.30 BGN/kg, the sustainability norm was the highest in group V - 68.14%, followed by group IV - 42.13% and group II - 40.98%, and the lowest in group III - 18.21%.

**Conclusion**

The share of expenses for feeds within the general production expense structure for the different groups varied within the range of 53.45% - 59.88%. The highest profits were achieved with the fattening of broiler chickens from group V (control group), and the lowest – in group III (M x NHG). At a level of sale price for 3.60 BGN/kg, it is economically justified to fatten only the chickens from group V. At a price of produce sale of 4.65 BGN/kg and 5.30 BGN/kg, the fattening of broiler chickens was economically justified for all groups, with the highest efficiency being registered in group V, and the lowest - in group III.

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