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# EFFECT OF GENOTYPE, SEX AND AGE ON PLUMAGE MATURITY, AND BODY WEIGHT OF GUINEA FOWL *(NUMIDA MELEAGRIS)**

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**Abstract**

**The objective of this study was to investigate the effect of genotype and sex on the degree of maturity of the plumage of guinea fowl. The experimental materials comprised 300 slow-growing (Label group) and 300 fast-growing (Standard group) gray guinea fowl. At 12, 14 and 16 weeks of age, 12 birds from each group (six ♂ and six ♀) were slaughtered. Dry feathers were collected from the dorsal area on both sides of the spine, in the interscapular and thoracic region, and from the outer side of the left thigh. The percentages of feathers at five stages of development were determined for each bird: I – pinfeathers covered in sheaths, II – beginning of vane development, III – feathers unsheathed by half of rachis length, IV – feathers unsheathed by more than half of rachis length, V – fully developed vanes and afterfeathers. Feather weight was determined and expressed as a percentage of a bird's total body weight. At 12 weeks of age, guinea fowl were characterized by the lowest (68.23%) percentage of mature feathers. The percentage of mature feathers increased to 79.36% in week 14 and to 83.20% in week 16. In weeks 14 and 16, the proportion of feather weight in total body weight was significantly lower (9.95 and 10.20%, respectively) than in week 12 (11.88%). Genotype had no effect on feather development, but it influenced feather weight and percentage. Significant ($P<0.05$) genotype × sex × age interactions were observed in percentage of stage I feathers. Label group guinea fowl were characterized by higher feather weight and a higher proportion of feathers in total body weight than Standard group guinea fowl (267.0 g and 11.01%, 248.9 g and 10.34%, respectively). The percentage of feather weight was lower in females than in males.**

**Key words: guinea fowl, Label, Standard, plumage**

The meat of guinea fowl is highly appreciated by consumers due to its specific flavor and dark color (Gilewski et al., 1990; Ajang et al., 1993; Alli et al., 2011).

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In countries of West Africa, after chicken eggs, guinea fowl eggs are most popular. In many supermarkets they are sold as hardboiled. In Nigeria and other African countries they are considered to be an aphrodisiac by some social groups. Guinea fowl eggs are also quite important in France and in Italy, although mainly used as hatching eggs in order to produce meat. Fast-growing and slow-growing guinea fowl breeds, which differ with respect to their performance characteristics, have been selected to meet the needs of large-scale commercial farming. Fast-growing guinea fowl become heavier than their slow-growing counterparts already on day 28 of age, and on day 96 the difference in body weight between the groups reaches 6.6%. Fast-growing guinea fowl accumulate larger deposits of fat and their wings have a higher share of the total carcass weight. Slow-growing guinea fowl are characterized by higher percentages of leg and breast muscles in the carcass (Baéza et al., 2001).

Fast-growing and slow-growing chickens differ also with regard to carcass tissue composition. Slow-growing chickens have smaller muscle fiber diameters and better developed internal organs than fast-growing birds (Dransfield and Sośnicki, 1999; Murawska, 2004). Remiges, dorsal feathers and tail feathers in fast-growing chickens are longer than in slow-growing chickens (Ajang et al., 1993).

According to Nahashon et al. (2006 c, d), sex has no significant effect on the body weight of guinea fowl, whereas Baéza et al. (2001) demonstrated that in selected strains the body weight of guinea fowl was considerably affected by sex from 11 weeks of age. Carcass tissue composition is also determined by sex in guinea fowl. The percentages of abdominal fat and skin with subcutaneous fat are higher in females than in males (Baéza et al., 2001), and a similar trend can also be observed in chickens (Gous et al., 1999). The growth rate of osseous tissue is faster in guinea fowl males, compared with females. Males have longer breastbone crests, and longer and thicker shank bones, which makes them more massive than females (Kozaczyński, 1998).

Guinea fowl differ in feather growth rates, which has important practical implications (Pal and Singh, 1997). The incidence of rapid feathering allele (k+) is higher in populations selected for high body weight compared with unselected populations (Pal and Singh, 1997). In the strains of male broilers, similarly as in guinea fowl, the rapid feathering gene is associated with increased body weight at the second (Khosravinia, 2008) or first (Özkan et al., 2002) stage of rearing. However, there is no conclusive research linking feathering rates with other growth performance traits in birds.

Feather weight increases with age. In 7-week-old broiler chickens weighing 1.7–2.0 kg, the weight of feathers was determined at 51.8–61.8 g (Fisher et al., 1981). In broiler breeder chickens, feathers weigh around 220 g in females with the mature live weights of 4.7 kg, and they are around 60–70 g heavier in males (Gous et al., 1999). In 16-week-old female turkeys weighing 5.7 kg, feathers account for 6.41% of total body weight, and in male turkeys weighing 7.9 kg – for 6.15% of total body weight (Mróz and Faruga, 1982). There is no published information available on feather weight in guinea fowl in growing period, while this information is important because it determines the growth performance of birds.

Correlations have been found between plumage color, production traits and genetic structure in guinea fowl. From 10th week of age, pearl gray guinea fowl consistently show higher body weight than black, white and ash varieties. Pearl gray guinea fowl are characterized by a higher growth rate and body weight gain than white guinea fowl (Bawej, 2010; Fajemilehin, 2010). The breast muscles of gray guinea fowl have more white fibers that are thicker than in white guinea fowl (Bawej, 2010). In many poultry species, plumage differences support early sex identification. Such differences have not been observed in guinea fowl (Gous et al., 1999).

The degree of plumage maturation is an important consideration while determining the optimum slaughter age. After plucking, the dark pigment released from the germs of immature feathers negatively affects the visual appearance of guinea fowl carcasses, thus decreasing consumer acceptance. Guinea fowl are slaughtered between 8 and 16 weeks of age to ensure adequate feather development (Baéza et al., 2001; Nahashon et al., 2005, 2006 b; Bawej, 2010). Guinea fowl have plumage of adults birds in age 8-12 weeks. In Poland, guinea fowl are slaughtered between 12th and 16th weeks of age. However, the length of the plumage maturation period varies greatly in other species (Kozłowski et al., 1976; Kalinowski et al., 2003; Sikur et al., 2004). The small number of publications on plumage maturation assessment in guinea fowl and the fact that they were published long ago has prompted us to undertake this research.

The aim of this study was to investigate the effect of genotype and sex on the degree of maturity of the plumage of guinea fowl. Another objective of this study was to evaluate the age of the birds with the highest maturity plumage.

## Material and methods

### Experimental design

A total of 600 one-day-old Label guinea fowl and Standard guinea fowl (150 males and 150 females in each group), purchased from Galor (Amboise, France), were raised at the Animal Research Laboratory at the University of Warmia and Mazury. The experiment was conducted from hatch to 16th week of age. The birds were weighed, tagged and kept in 12 pens (each measuring 2.0 × 3.2 m), on litter, 50 birds per pen, with three replicates of males and females in the Label and Standard groups. During the first 3 days of life, the birds were exposed to light for 24 hours per day. In the following days, light exposure was reduced by 0.5 h each day to reach 19 hours on day 17. Light intensity was set at 20 lx during the first 3 days, after which it was gradually reduced to reach 5 lx on day 17. Remiges were clipped in week 3. The housing conditions and feeding regimes were consistent with the relevant standards for guinea fowl (Bernacki, 2012). The birds had free access to feed and water throughout the rearing period. All birds were fed identical complete diets. A starter diet was fed until week 3, a grower diet was administered between weeks 4 and 8, and a finisher diet was fed from week 9 to 16 of life. The nutritional value of guinea fowl diets is given in Table 1.

Table 1. Composition and nutritional value of guinea fowl diets

| Nutrients | Weeks of age | | |
|---|---|---|---|
| | 0–3 | 4–8 | 9–16 |
| Wheat (g/kg) | 302.7 | 285.5 | 384.5 |
| Maize (g/kg) | 200.0 | 200.0 | 200.0 |
| Soybean meal (g/kg) | 402.9 | 363.7 | 274.0 |
| Rapeseed (g/kg) | - | 50.0 | 50.0 |
| Soybean oil (g/kg) | 47.3 | 62.1 | 57.4 |
| Sodium chloride (g/kg) | 3.5 | 3.5 | 3.6 |
| Calcium carbonate (g/kg) | 16.5 | 13.5 | 12.8 |
| Monocalcium phosphate (g/kg) | 18.0 | 13.5 | 11.3 |
| DL-methionine 99 (g/kg) | 2.6 | 2.2 | 1.5 |
| L-lysine 99 (g/kg) | 1.5 | 1.5 | 1.0 |
| Premix (vitamins and trace minerals) (g/kg) | 5.0 | 4.5 | 4.0 |
| Metabolizable energy (MJ/kg) | 12.46 | 13.17 | 13.32 |
| Crude protein (g/kg) | 241.0 | 232.0 | 197.0 |
| Crude fiber (g/kg) | 32.4 | 35.0 | 33.0 |
| Ash (g/kg) | 28.3 | 27.9 | 24.1 |
| Fat (g/kg) | 65.6 | 98.6 | 94.9 |
| Na (g/kg) | 1.6 | 1.6 | 1.6 |
| Ca (g/kg) | 12.0 | 10.0 | 9.0 |
| Total P (g/kg) | 7.7 | 6.8 | 6.2 |
| Available P (g/kg) | 5.5 | 4.5 | 4.0 |
| K (g/kg) | 10.02 | 9.43 | 7.06 |
| Lysine (g/kg) | 13.5 | 13.0 | 10.5 |
| Methionine (g/kg) | 6.0 | 5.6 | 4.5 |
| Methionine + cystine (g/kg) | 10.0 | 9.5 | 8.1 |
| Tryptophan (g/kg) | 3.0 | 2.9 | 2.5 |
| Threonine (g/kg) | 8.6 | 8.3 | 7.1 |
| Arginine (g/kg) | 15.4 | 14.8 | 12.5 |

**Analysis of feather quality**

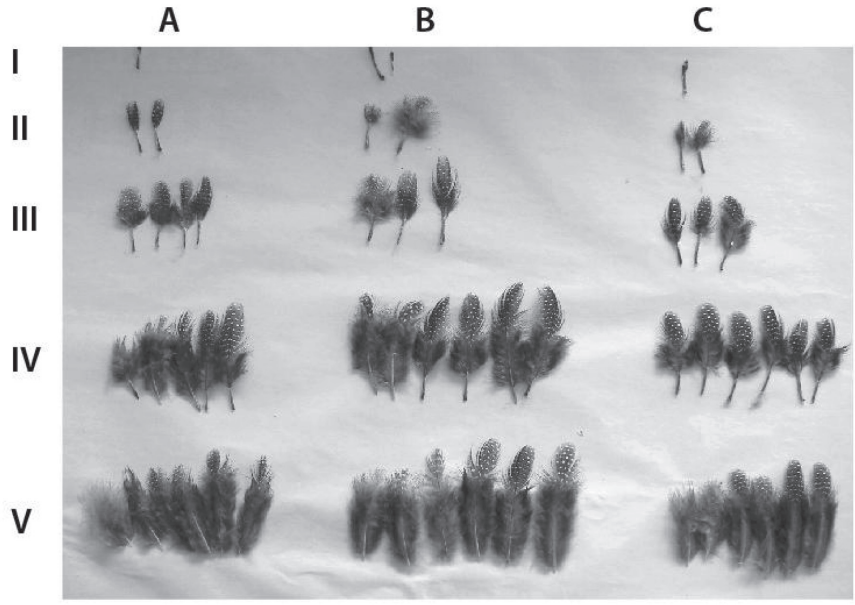
At 12, 14 and 16 weeks of age, 12 birds from each group (six males and six females) were randomly selected for slaughter. The quality of feathers collected from the dorsal and thigh regions was analyzed. The above body regions are characterized by a slower rate of feather growth and development (Deręgowski and Jusik, 1973; Kubińska et al., 2015). After bleeding, all feathers were collected manually from the interscapular and thoracic region on both sides of the spine, 2 cm wide, and from the outer side of the left thigh. The feathers were dried for 7 days at room temperature (21°C).

The growth stage of each feather was determined according to the method proposed by Deręgowski and Jusik (1973). Based on the appearance of feathers collected from the dorsal and thigh regions, each feather was classified into one of five growth stages. Feathers at different growth stages are presented in Photographs 1

and 2. Growth stages I to IV represent immature feathers, and stage V feathers are mature. Immature plumage differed from mature plumage in the thickness and length of the sheath covering pinfeathers, the length and shape of vanes and afterfeathers. The percentage of feathers at each growth stage was calculated for each bird as follows:

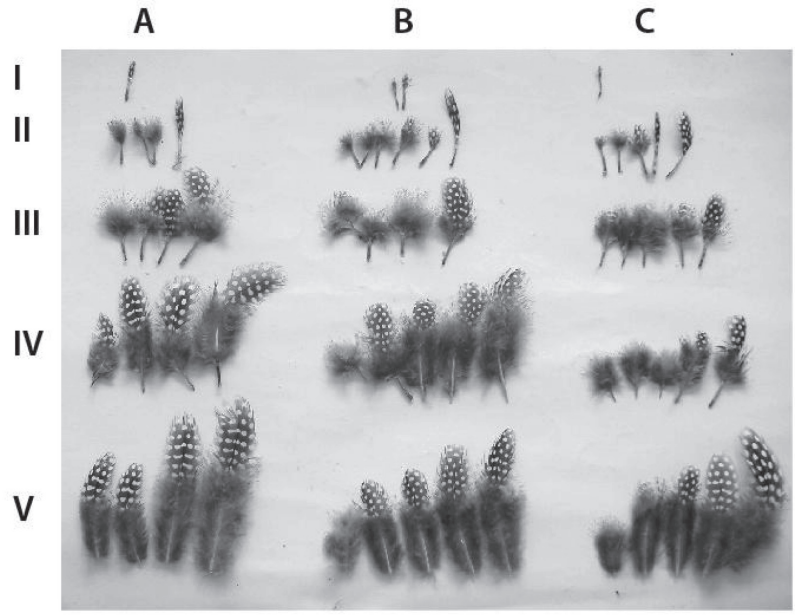
*Feathers at a given growth stage (%) = (number of feathers at a given growth stage / total number of feathers) * 100*

The results were used to determine the average percentage of feathers in successive growth stages in view of the birds' genotype, sex and age.




Photograph 1. Feathers at different growth stages collected from the interscapular and thoracic region: A, B, C – 12, 14, 16 weeks of age; growth stages I, II, III, IV – immature feathers, growth stage V – mature feathers; stage I – pinfeathers covered in sheaths, stage II – beginning of vane development, stage III – feathers unsheathed by half of rachis length, beginning of afterfeather development, stage IV – feathers unsheathed by more than half of rachis length, stage V – fully developed vanes and afterfeathers

The study was carried out in accordance with the experimental protocols approved by the Ethics Committee at the University of Warmia and Mazury in Olsztyn (decision No. 16/BZ/2009).




Photograph 2. Feathers at different growth stages collected from the outer side of the left thigh: A, B, C – 12, 14, 16 weeks of age; growth stages I, II, III, IV – immature feathers, growth stage V – mature feathers; stage I – pinfeathers covered in sheaths, stage II – beginning of vane development, stage III – feathers unsheathed by half of rachis length, beginning of afterfeather development, stage IV – feathers unsheathed by more than half of rachis length, stage V – fully developed vanes and afterfeathers

**Analysis of body weight and feather weight**

At 12, 14 and 16 weeks of age, all birds were weighed (RADWAG, Olsztyn, Polska) accurate to ± 0.1 g. After this 12 guinea fowls from Label and Standard group (six males and six females) were slaughtered. After bleeding and plucking, the carcasses were weighed to determine feather weight and feather weight expressed as a percentage of a bird's total body weight, using the following equations:

*Feather weight (g) = body weight after bleeding (g) – body weight after plucking (g)*
*Feather weight (%) = (feather weight (g) / live body weight of guinea fowl (g)) * 100*

**Statistical analysis**

The results in respect of genotype, sex and age were analyzed by three-way ANOVA. The significance of differences between means was verified by Duncan's test at $P \leq 0.05$. The interactions between sex and age were analyzed. Statistical calculations were performed in STATISTICA 10 package (STATISTICA, 2011).

## Results

### Feather quality

No differences in the structure and color of feathers or plumage pattern were found between Label and Standard groups of guinea fowl, or males and females. The dorsal and thigh plumage of guinea fowl was characterized by the highest percentage of stage V feathers and the lowest percentage of stage I feathers (Table 2). Genotype did not influence feather proportions in the analyzed stages, whereas sex exerted a significant effect on the percentage of stage IV feathers. The proportion of stage IV feathers in males was over 3 percentage points higher than in females. In week 16, the percentage of stage I feathers reached 1.68% and was lower ($P<0.05$) than in weeks 12 and 14. The proportion of stage II feathers was the highest in week 12 (Table 2). Between weeks 12 and 16, the percentage of stage III feathers decreased by 4.69 percentage points, and the percentage of stage IV feathers – by 7.47 percentage points. The average content of mature feathers increased from 68.23% to 83.20%, an increase of 21.97% was observed in Label males.

The percentage of stage II feathers was not affected by sex, but a significant sex × age interaction for the proportion of stage II feathers (Table 2) was observed. In week 16, unlike in the previous weeks, the percentage of stage II feathers was higher in females than in males (Figure 1).

### Body weight and feather weight

Body weight increased with age in all examined groups (Table 3). Genotype had no significant effect on the average body weight of guinea fowl. In the analyzed rearing stages, the average body weights of guinea fowl differed significantly, and females were heavier than males.

Average feather weight was determined in the range of 215.8 g to 288.1 g (Table 3). Label guinea fowl were characterized by significantly higher feather weight and a higher proportion of feathers in total body weight than Standard birds. Sex had no significant effect on feather weight, but the percentage of feathers in total body weight was significantly higher in males (by 1.17 percentage points) (Table 3). Age did not influence feather weight, but it significantly affected the proportion of feather weight in total body weight of guinea fowl. The percentage points of feather weight in total body weight was the highest in week 12.

Significant sex × age interactions were noted for feather weight and its percentage of total body weight (Figures 2 and 3).

## Discussion

The proportions of immature feathers in 12-week-old guinea fowl are indicative of the growth of new feathers in this rearing stage. The lower percentage of immature feathers in week 16 than in week 12 points to the end of feathering in guinea fowl. In chicken broilers, duck broilers, a high percentage of immature feathers (Kozłowski et al., 1976; Fisher et al., 1981; Hu et al., 1999), in particular stage I feathers (12–19%) (Kubińska et al., 2015), was observed during rapid feathering.

Table 2. Characteristics of guinea fowl feathers at five growth stages (*%, ± SE)*

| Genotype | Sex | Week of age | Stage of feather growth | | | | |
|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | V |
| Label | ♂ | 12 | 4.10 abc±0.29 | 10.06 a±0.44 | 8.06 ab±0.45 | 15.46 a±0.84 | 62.32 c±0.93 |
| | | 14 | 3.51 abc±0.33 | 5.80 abc±0.53 | 4.57 bc±0.39 | 10.39 abc±1.39 | 75.74 ab±1.80 |
| | | 16 | 1.65 c±0.24 | 6.74 abc±0.32 | 3.19 c±0.28 | 4.13 bcd±0.59 | 84.29 a±0.79 |
| | ♀ | 12 | 1.44 c±0.34 | 5.88 abc±0.85 | 8.10 ab±0.66 | 11.37 ab±1.05 | 73.21 abc±1.60 |
| | | 14 | 6.29 ab±1.23 | 4.21 c±0.62 | 5.35 bc±0.99 | 6.18 bcd±1.18 | 77.97 ab±3.18 |
| | | 16 | 2.19 c±0.45 | 9.45 ab±1.32 | 4.63 bc±0.17 | 2.41 d±0.24 | 81.32 ab±1.57 |
| Standard | ♂ | 12 | 1.86 c±0.21 | 7.33 abc±0.45 | 10.14 a±0.59 | 11.45 ab±1.65 | 69.21 bc±1.90 |
| | | 14 | 3.18 bc±0.42 | 4.44 c±0.57 | 5.13 bc±0.75 | 7.26 bcd±0.60 | 79.99 ab±1.76 |
| | | 16 | 1.76 c±0.31 | 3.79 c±0.29 | 3.10 c±0.36 | 8.65 abcd±2.19 | 82.70 a±2.82 |
| | ♀ | 12 | 6.72 a±0.64 | 8.49 abc±0.73 | 6.29 bc±0.62 | 10.32 abc±1.08 | 68.18 bc±2.24 |
| | | 14 | 3.07 bc±0.85 | 4.86 bc±1.08 | 4.12 c±0.68 | 4.21 bcd±0.96 | 83.75 a±3.06 |
| | | 16 | 1.12 c±0.25 | 7.95 abc±0.60 | 2.91 c±0.35 | 3.53 cd±0.81 | 84.49 a±1.39 |
| Anova | Genotype | | NS | NS | NS | NS | NS |
| Means | Label | | 3.20±0.53 | 7.02±0.67 | 5.65±0.52 | 8.32±1.05 | 75.81±1.82 |
| | Standard | | 2.95±0.49 | 6.14±0.59 | 5.28±0.60 | 7.57±1.12 | 78.05±2.06 |
| Anova | Sex | | NS | NS | NS | 0.019 | NS |
| Means | ♂ | | 2.68±0.28 | 6.36±0.48 | 5.70±0.57 | 9.55±1.18 | 75.71±1.89 |
| | ♀ | | 3.47±0.66 | 6.81±0.76 | 5.23±0.56 | 6.34±0.91 | 78.15±1.99 |
| Anova | Age | | 0.009 | 0.009 | <0.001 | <0.001 | <0.001 |
| Means | 12 | | 3.53 a±0.58 | 7.94 a±0.68 | 8.15 a±0.62 | 12.15 a±1.19 | 68.23 a±1.81 |
| | 14 | | 4.01 a±0.79 | 4.83 b±0.70 | 4.79 b±0.69 | 7.01 b±1.10 | 79.36 b±2.45 |
| | 16 | | 1.68 b±0.31 | 6.98 a±0.83 | 3.46 b±0.32 | 4.68 b±1.23 | 83.20 b±1.70 |
| Interaction** | | | | | | | |
| Sex × Age | | | NS | 0.039 | NS | NS | NS |
| Genotype × Sex × Age | | | 0.003 | NS | NS | NS | NS |

** P – value is only given for significant interactions. a, b – different letters following mean values in columns indicate significant differences at P≤0.05.
NS – non significance.

Table 3. Body weight (g) and feather weight (g, %) of guinea fowl (± *SE)*

| Genotype | Sex | Week of age | Body weight (g) | Feather weight | |
|---|---|---|---|---|---|
| | | | | g | % |
| Label | ♂ | 12 | 2165 ab±91.9 | 259.6 abc±12.9 | 11.98 ab±0.19 |
| | | 14 | 2424 bcd±77.1 | 288.1 a±11.3 | 11.89 ab±0.31 |
| | | 16 | 2536 def±60.6 | 273.6 ab±13.3 | 10.78 bc±0.43 |
| | ♀ | 12 | 2279 abcd±74.7 | 270.8 ab±20.5 | 11.93 ab±0.90 |
| | | 14 | 2498 cde±94.5 | 235.5 bc±13.3 | 9.36 cd±0.65 |
| | | 16 | 2718 ef±100.9 | 274.7 ab±14.5 | 10.13 cd±0.49 |
| Standard | ♂ | 12 | 2136 a±72.0 | 287.9 a±25.0 | 13.42a±0.89 |
| | | 14 | 2373 abcd±77.5 | 237.5 bc±8.6 | 10.04 cd±0.37 |
| | | 16 | 2514 def±56.3 | 236.2 bc±13.7 | 9.44 cd±0.64 |
| | ♀ | 12 | 2244 abc±64.5 | 228.1 bc±7.9 | 10.18 cd±0.31 |
| | | 14 | 2539 def±99.0 | 215.8 c±10.9 | 8.50 d±0.32 |
| | | 16 | 2766 f±109.5 | 287.8 a±16.8 | 10.44 bc±0.55 |
| Anova | | Genotype | NS | 0.038 | 0.037 |
| Means | | Label | 2437±43.9 | 267.0*±6.2 | 11.01*±0.3 |
| | | Standard | 2429±46.7 | 248.9±7.4 | 10.34±0.3 |
| Anova | | Sex | 0.003 | NS | <0.001 |
| Means | | ♂ | 2358±38.4 | 263.8±6.7 | 11.26*±0.3 |
| | | ♀ | 2507*±48.1 | 252.1±7.1 | 10.09±0.3 |
| Anova | | Age | <0.001 | NS | <0.001 |
| Means | | 12 | 2206 a±37.6 | 261.6±9.5 | 11.88 a±0.4 |
| | | 14 | 2459 b±43.0 | 244.2±7.6 | 9.95 b±0.3 |
| | | 16 | 2633 c±45.9 | 268.1±7.9 | 10.20 b±0.3 |
| Interaction** | | | | | |
| Sex × Age | | | NS | 0.008 | 0.014 |
| Genotype × Sex × Age | | | NS | 0.011 | 0.005 |

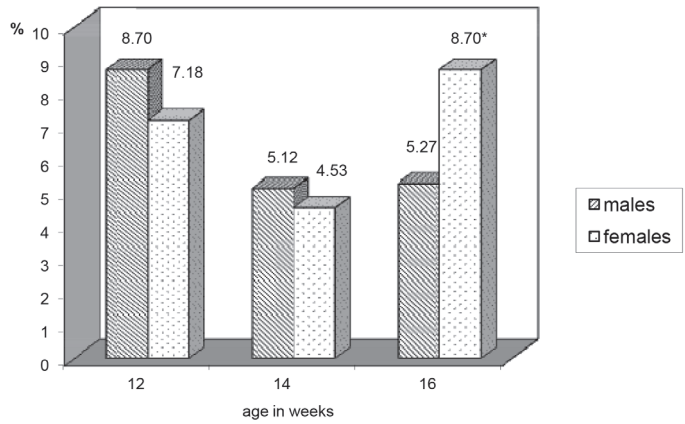
Feathers weight expressed as percent of total body weight.

a, b – different letters following mean values in columns indicate significant differences at P≤0.05.

* P – value is only given for significant difference.

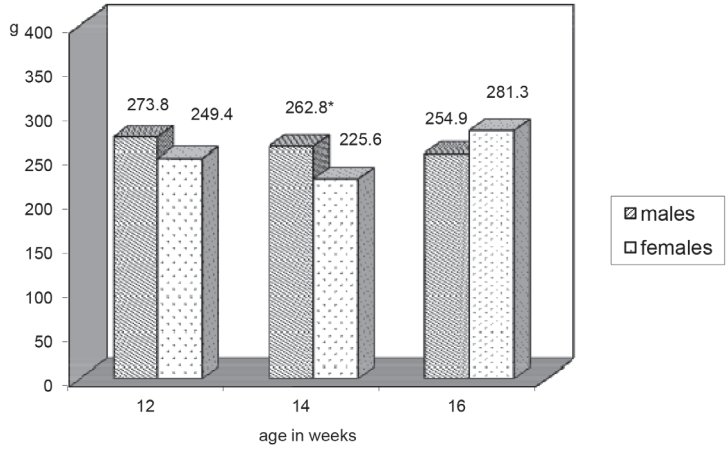
**P – value is only given for significant interactions.

NS – non significance.




* Significant difference

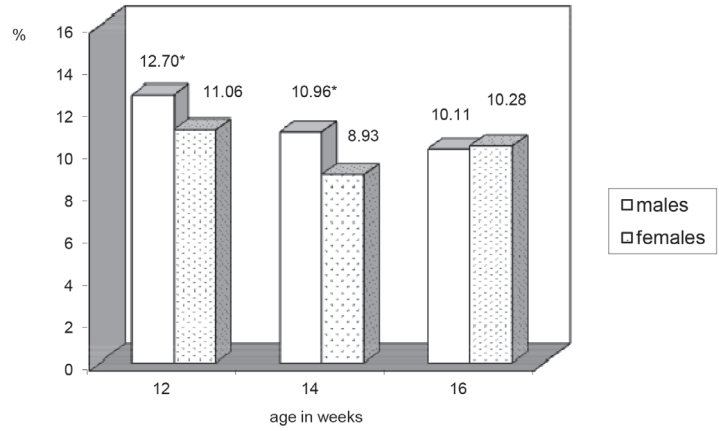
Figure 1. Percentage of stage II feathers in differently aged males and females (sex × age interaction, P≤0.05)




*Significant difference

Figure 2. Feather weight (g) in differently aged males and females (sex × age interaction) (P≤0.05)

Females were found to grow feathers faster than males. Higher feathering rates were determined in young hens than in cockerels by Fisher et al. (1981) and Stilborn et al. (1997).




*Significant difference.

Figure 3. Percentage of feathers in total body weight in differently aged males and females (sex × age interaction, $P<0.05$)

The age-related decrease in the percentage of feather weight in total body weight results from a higher proportion of mature feathers and testifies to higher slaughter quality of guinea fowl. The above correlation has also been observed in other poultry species (Fisher et al., 1981; Mróz and Faruga, 1982; Murawska, 2004). Mature feathers are lighter because they contain less water and blood (Deręgowski and Jusik, 1973).

Higher feather weight in Label group of guinea fowl indicates that genotype is correlated with feather quantitative traits. In chickens, feather weight is determined by genotype, and males have higher feather weight than females (Gous et al., 1999; Özkan et al., 2002). Feather weight expressed as a percentage of total body weight is lower in gallinaceous birds (chickens, turkeys) than in guinea fowl, therefore, this trait should not be compared across species (Fisher et al., 1981; Gous et al., 1982; Mróz and Faruga, 1982). The results of this study cannot be compared with other authors' findings due to an absence of publications investigating feathering patterns in guinea fowl.

In our study, genotype had no effect on body weight in guinea fowl. Females were heavier than males, which corroborates the results of previous research (Baéza et al., 2001; Bernacki et al., 2013). In our study, the body weights of guinea fowl were higher than those reported by other authors (Pudyszak et al., 2003, 2005; Nahashon et al., 2006 b, 2006 c), probably due to genetic differences between the investigated birds. Higher body weights in successive weeks of this experiment suggest that a prolonged rearing period could improve production results. Nahashon et al. (2011) also observed considerable body weight gains in guinea fowl in weeks 14 and 16.

It can be concluded that the plumage of guinea fowls was not fully mature in the analyzed rearing stages. The percentage of mature feathers (stage V) was lowest in

week 12. In comparison with week 12, guinea fowl are more suitable for slaughter in weeks 14 and 16 when they have a lower percentage of feathers in total body weight. Standard group of guinea fowl were characterized by lower feather weight and a lower proportion of feathers in total body weight than Label group of guinea fowl. Males feathered slower than females, and feathering was most delayed in Label males in the analyzed rearing stages.

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