ISTANBUL UNIVERSITY CERRAHPASA

Proximate Composition of Leg Meat of Slow and Fast-Growing Broiler in Different Housing Systems

Melahat ÖZBEK[1], Metin PETEK[1], Enver ÇAVUŞOĞLU[1], Ece ÇETİN[2], İsmail ÇETİN[3]

[1]Department of Animal Science, Bursa Uludağ University, Faculty of Veterinary Medicine, Bursa, Turkey
[2]Department of Food Hygiene and Technology, Tekirdağ Namık Kemal University, Faculty of Veterinary Medicine, Tekirdağ, Turkey
[3]Department of Animal Nutrition and Nutritional Diseases, Tekirdağ Namık Kemal University, Faculty of Veterinary Medicine, Tekirdağ, Turkey

Cite this article as: Özbek, M., Petek, M., Çavuşoğlu, E., Çetin, E., & Çetin, İ. (2022). Proximate composition of leg meat of slow and fast-growing broiler in different Housing systems. *Acta Veterinaria Eurasia*, 48(1), 78-82.

ORCID IDs of the authors: M.Ö. 0000-0002-5491-1788, M.P. 0000-0003-4560-2438, E.Ç. 0000-0002-9018-3511, E.Ç. 0000-0002-8763-5507, İ.Ç. 0000-0001-7589-4852.

Abstract

The aim of this study was to evaluate the proximate composition of leg meat of slow- and fast-growing male broilers raised in different housing systems as conventional deep litter floor housing, indoor slatted floor housing, and indoor deep litter floor housing with range access (free-range). After slaughter at 56 days of age, 10 leg muscle samples of each 6 treatment group (2 × 3) were randomly selected and used to assess the meat quality properties. Compared to fast-growing chickens, slow-growing chicken meat had less protein content and higher fat content ($p < .003$, $p < .05$). There were significant differences in the water holding capacity of the meat between the slow- and fast-growing broilers ($p < .05$). The moisture content of the broiler meat produced from deep litter was found to be significantly greater than those of slatted floor housing and free-range ($p < .041$). The genotype × housing systems interaction for the fat content of leg meat of broiler was significant ($p < .044$). In conclusion, it can be said that genotype is more effective on proximate composition of broiler leg meat quality than the housing system.

Keywords: Broiler, genotype, housing, leg meat, proximate composition

Introduction

As a result of consumer demand for welfare-friendly, safer, and higher quality broiler meat, conventional deep litter housing system and fast-growing broiler genotypes are criticized intensively in chicken meat production. Based on this, the use of alternative systems and the use of slow-growing broiler instead of conventional deep litter system and fast-growing broiler are increasingly widespread in commercial broiler meat production (Ceylan, 2018; Jung et al., 2016; Mir et al., 2017; Sánchez et al., 2020; Stadig et al., 2016). With the effects of the latest technological improvements, cage housing systems have recently been used again in broiler production (Özhan et al., 2016; Shields & Greger, 2013). But the restricted movement of animals in the cage system is one of the big concerns for animal welfare. Therefore, a slatted floor system may be used in commercial chicken meat production (Çavuşoğlu & Petek, 2019). As a result of the discussion on animal welfare and consumer demand for natural products, free-range housing in broiler meat production is rapidly becoming widespread, especially in a small capacity in the World (Sánchez et al., 2020). Fast-growing broiler genotypes are generally used in conventional chicken meat production, whereas slow-growing ones are usually preferred in some special productions such as organic, Label Rouge, and free-range (Graumans, 2019; Hartcher & Lum, 2020; Mulder & Zomer, 2017; Taylor et al., 2017).

The broiler chicken meat quality is affected by many factors such as housing system, slaughter age, feeding treatment, genotype, pre-slaughter handling, transport to the slaughterhouse, etc. (Mir et al., 2017; Özbek et al., 2020). Depending on countries and cultures, chicken legs as whole or upper and lower leg pieces are the most valuable and preferred meat after breast meat. In Turkey, the leg meat of broiler is in great demand from consumers. In general, studies on the determination of meat quality have been done on breast meat (Wideman et al., 2016). The structure of broiler leg muscle is very different between slow- and fast-growing broiler, and it can probably affect meat quality (Žikić et al., 2016). Therefore, there is a great need for studies on broiler leg meat quality of different genotypes and related factors affecting it. This study aimed to investigate the proximate composition of leg meat of slow- and fast-growing broilers raised in different housing systems.

Corresponding Author: Metin PETEK • **E-mail:** petek@uludag.edu.tr
Received: June 10, 2021 • **Accepted:** August 13, 2021 • **Available Online Date:** November 26, 2021 • DOI: 10.5152/actavet.2021.21046
Available online at actavet.org

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Methods

In this study, the samples of *slow- and fast-growing broilers* raised in *free-range (indoor, deep litter, and range access), indoor deep litter, and indoor fully slatted plastic floor* were collected after slaughter. The ethical permission for this study was obtained from the Local Ethic Committee on animal care and welfare (Bursa Uludag University, September1, 2015; 2015-10/14).

Animals, Management, and Meat Samples

During the study, 150 one-day-old male chicks from each genotype (*150 slow growing and 150 fast growing*) were raised in the experimental units in the Veterinary Faculty farm of Bursa Uludag University, thus each group consisted of 50 birds. There were five replicates in each group and ten birds in each replicate. Continuous lighting consisting of daylight and artificial light was used in the first weeks of the study. Subsequently, continuous daylight and intermittent night lighting including 2 hours light + 2 hours darkness, in a total of 16-hour darkness period in each day, was applied until the end of the study. The birds in all groups in the experiment were fed a diet as starter (0–10 days), grower I (11–23 days), grower II (24–36 days), and finisher (37–56 days), which was produced by a local feed producer. The birds in all groups were slaughtered at 56 days of age, and the feed was removed about 12 hours before the slaughter. The slaughter, scalding, and defeathered process were performed according to Barbut (2016), Löhren (2012), and TS-5925 (2014). After the whole carcasses were chilled for 3 hours at 4°C, the legs were removed from the carcass by the working team (TS-5890, 2014). In total, 60 leg meat samples of the chickens (10 legs from each group) were collected to compare meat quality analysis. Once sampled, the right legs of the carcass were placed in a plastic bag, covered with ice pieces, and brought to the laboratory within 15 minutes after the chilling process. The samples were kept in a refrigerator during the analysis. The quality analysis of meat samples was made in carcass evaluation and meat quality analysis laboratory.

Laboratory Analysis

The proximate composition analysis was evaluated using the AOAC guidelines and procedures (AOAC, 2019). Crude protein determination in meat samples obtained from the groups was carried out in three stages with the Kjeldahl method: digestion, neutralization, and titration with the distillation stage (AOAC, 2019: method 992.15). Crude fat analysis in meat samples was made according to the Soxhlet method (AOAC, 2019: method 960.39). Methods described by AOAC (2019) were also used for the calculation of moisture (method 950.46), crude ash (method 942.05), and water holding capacity (method 973.08). The cooking loss values of meat samples were calculated by the method reported by Kondaiah et al. (1985).

Statistical Analyses

The analysis of variance and subsequently Duncan tests were performed to analyze the effects of and interactions between the main factors and multiple comparisons (Snedecor & Cochran, 1989) using the SPSS® Computer Software 13.00 (IBM Corp. Released, 2011) with the following model:

$$Y_{ijk} = \mu + A_i + B_j + A \times B + e_{ijk}$$

where A, housing effects, B, genotypic effects; $A \times B$ interaction; $i = 1, 2, 3$ (1, conventional deep litter; 2, slatted floor; and 3, free-range), $j = 1, 2$ (1, fast-growing broilers and 2, slow-growing broilers), μ, constant, and e error term.

Results

The effects of genotype and housing system on proximate composition of broiler leg meat were presented in Table 1. The effects of genotype, housing system, and genotype × housing system interactions on the crude ash and moisture levels of leg meat were found to be not significant. Broiler genotype significantly affected crude fat, crude protein, and water holding capacity of the thigh meat ($p < .05$, $p < .003$, and $p < .05$). In this study, there were no significant differences for crude ash, crude fat, crude protein, and water holding capacity of the leg meat of the birds raised in three different housing system, whereas the moisture content of the meat samples was significantly different ($p < .041$). It was found that a significant genotype × housing system the crude fat content of leg meat ($p < .044$).

Discussion, Conclusion, and Recommendations

The nutrient content of chicken meat varies depending on many factors such as slaughter age, live weight, feeding, genotype, etc. (Park et al., 2021). In conventional deep litter floor housing system that is not well managed, breast meat myopathies, foot and hock joint lesions may occur, and meat quality may be adversely affected (Shields & Greger, 2013; Stadig et al., 2016). In this study, results regarding the proximate composition analysis of broiler meat showed that the leg meat of slower-growing broiler had higher water holding capacity ($p < .05$), crude fat ($p < .05$), and lower crude protein contents ($p < .003$) when compared to the faster-growing broiler leg meat. Similarly, Jung et al. (2015) showed that the protein contents of the meats were affected significantly by the broiler line. In contrast, Dalle Zotte et al. (2020) reported that Polverara, a slow-growing local bird, exhibited higher protein content than the faster-growing hybrid. The finding for protein content of broiler leg meat in this study was lower than the finding of the study done in faster-growing broilers' leg meat by Soyutemiz et al. (2000). In the study, the protein content of leg muscle was not affected significantly by the housing condition. In contrast, Da Silva et al. (2017) reported that the leg meat from free-range broiler showed significantly higher protein levels compared to conventional broiler leg meat.

In the current study, the slow-growing broiler housed in free-range had significantly higher crude fat, whereas no significant differences were observed for the crude fat content of the leg meat of slow- and fast-growing birds raised in conventional deep litter and slatted flooring (genotype × housing system interaction for fat level, $p < .044$). The higher fat content of leg meat of slow-growing broiler may attract more attention of consumers who want to barbecue. Jung et al. (2015) reported that the crude fat level of leg meat was significantly affected by the line from slower-growing chicken. Da Silva et al. (2017) reported that the leg meat from free-range broiler meat showed significantly lower fat levels compared to conventional leg meat. In another study, Soyutemiz et al. (2000) reported that the average total fat level of broiler leg meat was 2.93%.

In this study, differences were found to be not significant in terms of crude ash, crude fat, crude protein, and water holding capacity of

Table 1

The Proximate Composition of Broiler Leg Meat in Different Housing System (in %)

Factors	Crude Ash	Crude Fat	Crude Protein	Moisture	Water Holding Capacity	Cooking Loss
Genotype						
Fast-growing	1.07 ± 0.03	1.75 ± 0.46	20.67 ± 0.24	73.71 ± 0.86	9.48 ± 1.28	28.55 ± 0.9
Slow-growing	1.02 ± 0.03	2.75 ± 0.46	19.53 ± 0.24	73.14 ± 0.85	13.22 ± 1.28	27.47 ± 0.9
Housing system						
Free-range	0.99 ± 0.04	3.05 ± 0.56	19.61 ± 0.292	71.53 ± 1.05[b]	13.44 ± 1.57	29.27 ± 1.1
Slatted floor	1.10 ± 0.04	2.08 ± 0.57	20.55 ± 0.29	73.22 ± 1.05[b]	11.55 ± 1.57	26.27 ± 1.1
Deep litter	1.02 ± 0.41	1.62 ± 0.56	20.14 ± 0.29	75.52 ± 1.04[a]	9.05 ± 1.57	28.49 ± 1.1
Genotype × Housing system						
Fast-growing × Free-range	1.06 ± 0.06	1.24 ± 0.79[a]	20.75 ± 0.42	71.42 ± 1.48	10.10 ± 2.21	30.31 ± 1.5
Slow-growing × Free-range	0.93 ± 0.05	4.85 ± 0.80[A]	18.48 ± 0.41	71.64 ± 1.49	16.78 ± 2.22	26.42 ± 1.5
Fast-growing × Slatted floor	1.07 ± 0.05	2.39 ± 0.79	20.90 ± 0.41	72.99 ± 1.48	7.94 ± 2.22	28.94 ± 1.5
Slow-growing × Slatted floor	1.13 ± 0.06	1.76 ± 0.79	20.20 ± 0.41	73.44 ± 1.48	15.15 ± 2.21	28.24 ± 1.5
Fast-growing × Deep litter	1.07 ± 0.05	1.60 ± 0.80	20.35 ± 0.42	76.72 ± 1.49	10.39 ± 2.23	26.11 ± 1.5
Slow-growing × Deep litter	0.98 ± 0.06	1.63 ± 0.79	19.92 ± 0.41	74.32 ± 1.48	7.71 ± 2.22	28.05 ± 1.5
p						
Genotype	.258	.050	.003	.639	.050	.389
Housing system	.171	.229	.098	.041	.161	.140
Genotype × Housing system	.227	.044	.076	.573	.061	.839

Note: [A-a]Significant genotype × housing systems interactions for fast *growing x free-range and slow growing x free-range* within columns.
[a,b]Means with different superscripts in the housing system that vary significantly within the columns.

leg meats obtained from broilers grown in free-range, conventional deep litter, and slatted floor system. The moisture level of broiler leg meat was significantly higher in the conventional deep litter system than that of the broiler raised in free-range and slatted floor housing. On the contrary to the finding of Jung et al. (2015), the genotype did not have a significant effect on leg meat moisture content, whereas the water holding capacity was significantly higher in meats of slow-growing broiler ($p < .05$). Poltowicz and Doktor (2011) showed that the water holding capacity of broiler meat varies between 9.92 and 10.29%. Soyutemiz et al. (2000) reported that the average moisture level of broiler thigh meat was 74.42%, and it was similar to the finding of the current study. The water holding capacity and water content of meat are important technological features for meat processing (Gökmen & Öztan, 1995), and it is desirable to keep the water in the carcass to minimize yield loss of meat. The water content of fresh meat varies depending on many factors, such as sex, age, nutrition, and muscle structure of the animal. Albrecht et al. (2019) reported that higher concentrations of methionine had a positive influence on the water holding capacity by lowering the cooking loss. Yang et al. (2020) showed that the water holding capacity and cooking loss were improved in broilers supplemented with plant extracts while there was no significant difference in the moisture content of the leg meat sample among the group. In that study, the cooking loss of broiler leg meat was significantly reduced by plant supplement, with the greatest cooking loss seen in the control group. After slaughter, the water content of meat is decreased due to the physical processes applied to the meat and biochemical changes (Ergezer & Serdaroğlu, 2008). Soyutemiz et al. (2000) reported that the average crude ash level of broiler leg meat was 1.12%, and it was similar to the current study. Jung et al. (2015) showed that the crude ash level of the meat was significantly affected by the line from Korean indigenous chicken. In that study, the ash content of thigh meat of male birds from different lines varied from 1.17 to 1.35%. On the contrary to the findings reported by Oblakova et al. (2017), the crude ash level of broiler leg meat was higher in the faster-growing broiler in the current study.

Although genotype, housing system, and genotype × housing system interactions significantly affected some broiler leg meat quality characteristics, it seems genotype is more effective on leg meat quality characteristics than the housing system. Further studies that will reveal the interactive effects of genotype and housing system with the other factors affecting meat quality, such as nutrition and slaughter age, would be beneficial.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Bursa Uludağ University (Date: September 1, 2015, Decision No: 2015-10/14).

Peer Review: Externally peer-reviewed.

Author Contributions: Concept – M.Ö., M.P.; Design – M.Ö., M.P.; Supervision – M.P.; Resources – M.Ö., M.P.; Materials – M.Ö., M.P.; Data Collection and/or Processing – M.Ö., M.P., E.Ç., E.Çetin, İ.Ç.; Analysis and/or Interpretation – M.Ö., M.P., E.Ç., E.Çetin, İ.Ç.; Literature Search – M.Ö., M.P.; Writing Manuscript – M.P.; Critical Review – M.Ö., E.Ç, E.Çetin, İ.Ç.

Acknowledgments: This study was summarized from the thesis titled "Effects of different housing system and genotype on meat quality, slaughter and carcass characteristics in broiler chickens." We would like to thank Dr. Ender Uzabacı, Cihan Ünal, and Dr. Ibrahima Mahamane Abdourhamane for their help during the experimental part of this study.

Conflict of Interest: The authors have declared that no conflicts of interest exist.

Financial Disclosure: The authors declared that this study has received no financial support.

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