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Research Article

The Influence of Body Weight on Carcass and Carcass Part Yields, and Some Meat Quality Traits in Fast- and Slow-Growing Broiler Chickens [1]

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Abstract

This study aimed to compare the carcass and meat quality of fast- and slow-growing (FG and SG) broiler chicken genotypes in different slaughter weight as 1.5, 2.0, and 2.5 kg [light (L), medium (M), and heavy (H), resp.]. Totally 460 chicks from genotypes were raised, and 30 chicks (15 female, 15 male) from each genotype slaughtered when they reached each slaughter weight category (in total, 180 chicks). Carcass and part yields, and breast meat pHU, in addition color parameters (L*, a*, and b*) of breast skin and also meat were determined.As a result of, SGs reached the L, M, and H weight 20-24 days later. The slaughter weight increase, carcass and fat pad yields increase but wing and giblets yields decreased. In all weight categories, higher carcass and breast, but lower wing and fat pad yields were determined for FGs. H group showed higher L* and a* values than L one for skin, and FGs' skin had higher a*. Nevertheless all pHU and breast meat L* values were accepted "normal", the breast meat of SGs seems to be having lower meat quality because of slightly higher L* and lower pHU. We can conclude that, SG broilers have also some disadvantages for carcass and meat qualities, even they compared with FGs slaughtered in same slaughter weights. However, SGs' breast meat may be more attractive for consumer because of their reddish and yellowness (higher a* and b*) appearance.

Keywords: *Breast skin and meat carcass parts, Color parameters, Ultimate pH*

Hızlı ve Yavaş Gelişen Etlik Piliçlerde Canlı Ağırlığın Karkas ve Karkas Kısım Verimleri ve Bazı Et Kalite Özelliklerine Olan Etkisi

Özet

Bu çalışma farklı kesim ağırlığına [1.5, 2.0 ve 2.5 kg, sırasıyla hafif (H), orta (O) ve ağır (A)] sahip hızlı- ve yavaş-gelişen (HG ve YG) etçi piliç genotiplerinde karkas ve et kalitesini karşılaştırmayı amaçlamıştır. Genotiplerden toplam 460 civciv yetiştirilmiş ve hedeflenen ağırlıklara ulaştıklarında her bir genotipte yer alan ağırlık grubundan 30'ar piliç (15 dişi, 15 erkek) kesilmiştir (toplam 180 adet). Karkas ve parçalrın oranı, göğüs eti pHU'sı, ayrıca göğüs derisi ile etinin renk parametreleri (L*, a* ve b*) belirlenmiştir. Araştırma sonunda YG'ler H, O ve A ağırlıklarına 20-24 gün daha geç ulaşmışlardır. Kesim yaşı arttıkça karkas ve karın yağı oranı artmış, ancak kanat ve sakatat oranı azalmıştır. Tüm ağırlık gruplarında HG'lerde daha yüksek karkas ve göğüs oranı ile daha düşük kanat ve karın yağı oranı saptanmıştır. A grubun derilerinde, H grubuna göre daha yüksek L* ve a* değeri ölçülmüştür ve HG'lerin derileri daha yüksek a* değeri göstermiştir. Ölçülen tüm pHU ve L* değerleri "normal" kabul edilebilir olmakla beraber; YG'lerin göğüs etleri, hafifçe yüksek L* ve düşük pHU değerleri nedeniyle, daha düşük kaliteye sahip gibi görünmektedir. YG'lerin aynı ağırlıkta kesilmiş HG'ler ile karşılaştırıldıklarında, karkas ve et kalitesi bakımlarından bazı dezavantajlara sahip olduğu sonucuna varılmıştır. Ancak, YG'lerin göğüs etlerinin daha kırmızımsı ve sarımsı (daha yüksek a* ve b*) görünümleri tüketicinin ilgisini çekebilir.

Anahtar sözcükler: *Göğüs deri ve eti, Karkas kısımları, Renk parametreleri, Son pH*

INTRODUCTION

Broiler chickens, which have been obtained as a result of genetic selections for many years, reach the slaughter weight of 2.5 kg when they are 40 days-old. Intensive feeding programs, full-controlled environment, and all day lighting have been implemented to these broilers grown in the conventional system. These broilers, which are also called fast-growing (FG), face health problems resulting from respiratory, circulatory, and skeletal system

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anomalies. These problems which are associated with rapid growth have led to serious reactions in Western public having high sensitivity to farm animal welfare issues [1-6]. The broiler sector now consists of two sections: "Conventional production" which targets mass and cheap production and "alternative production" prioritizing animal welfare and sustainability. The alternative poultry production systems have been ranked from the simplest to the complex as extensive indoor, free feeding, free range, traditional free range, and organic [7]. Each system has its own limitations [4,7,8]. The extensive indoor system has the lowest criteria in terms of rearing conditions in which the earliest slaughtering age is 56 days, and maximum stocking density is 12 broiler/m^2 or 25 kg/m^2 live weight [7,9-11].

Comparing the different broiler chicken genotypes with respect to growth, it is well known that SG broilers are disadvantaged according to standart FG birds. For example, Grashorn [12] and Aksoy et al.[2] who slaughtered FGs and SGs at same age (84th and 56th days, respectively), concluded that FG birds showed higher body weight and carcass yield (in all, P<0.05). According to those researches, FG birds were advantaged also in breast or breast meat yield. Grashorn [13] observed only small differences for proportions of thight yield, whereas Aksoy et al.[2] determined higher leg yield for SG (P<0.05). In addition, FG birds had superior feed conversion ability [2,10], but SGs had less mortality and improved bone health, which are important in an alternative system [10]. On the other hand, it should not be ignored that a substantial part of consumers is ready to pay higher prices for alternative chicken meat because of animal welfare issues and special taste [3].

The color of raw broiler chicken meat varies from pale tan to pink while many factors affect poultry meat color. Such factors can be grouped as the myoglobin content of meat, pre-slaughter factors (genetic, feeds, stress, etc), and slaughtering-chilling processes. Increased hemoglobin content of the meat results in higher redness (high a* value) and hence yields darker color (lower L* value). In addition, it is observed that darker broiler meat is associated with lower muscle ultimate pH (pHU or pH24); pHU is measured at 24 h after killing. It has been demonstrated that there is a high correlation between breast muscle ultimate pH and L* value [11,14-18]. As pH increases, the L* value decreases; a high-pH of muscles, therefore, has darker color than those of low-pH.

The meat tenderness (firmness, juiciness), taste, and aroma (smell) which are defined as "organoleptic characteristics" are closely related to the ultimate pH and also L* values. The breast meats, having pHU values between 5.7-6.1 are considered as "normal", and these meats do not reveal any quality problems. Barbut et al.[19] reported that the poultry meats with the pH value over 6.1 has been considered as "dark, firm, and dry (DFD)" and, that they are risky in terms of microbial activity and therefore have a limited shelf life, although having higher water holding capacity which is desired especially for industry because of further processing. According to Zhang and Barbut [18], the poultry meats with the pH values lower 5.7 have been accepted as "pale, soft, and exudative (PSE)". These kind of meats are less risky in terms of microbial activity but they have been known to be drier when they are cooked because of their low water holding capacity; it means that they have lower technological quality [18]. Besides, poultry meats are classified according to their L* values, because of a strong relationship between pHU and L*. For ideal broiler chicken meat quality, the L* values should be between 46 and 53, and meats with an L* value below 46 are called DFD; if L* values is higher than 53, these meats are accepted PSE [18].

In many countries, the broiler sector, either conventional or alternative, offers the carcasses at different weights. Of course, these carcasses belong to male and female birds slaughtered at different body weights. Bianchi et al.[20], who worked on FG birds, determined the differences in breast meat quality attributes in different market classes according to carcass weight (light, medium, and heavy). They concluded that light broilers produced breast meat with higher values of a* and lower pH, cooking loss, and tenderness (in all, P<0.05). As for that, in this study fast- and slow-growing broiler chickens, male and female mixed, were raised to three different slaughter weight categories (approximately 1.5, 2, and 2.5 kg), and their carcass and meat characteristics were determined and compared. The effect of gender factor was also examined.

MATERIAL and METHODS

The research was conducted at the facilities in the Research-Experiment Unit of the Department of Animal Science in the Faculty of Agriculture at Akdeniz University. The management and handling of the birds were performed according to the practices as required by the Akdeniz University. In the experiment, the principles of the extensive indoor production system in EU were applied [7]. Cobb 500 was used as FG genotype, whereas the SG was Hubbard ISA Red JA. Two hundered thirteen one day old chicks (male and female) from each genotype were supplied local hatchery. FG and SG chickens were weighed and equally distributed among the 14 floor pens (7 pens each genotype equally distributed within the poultry house). The chickens housed with a stocking density of 12 chicks per m^2 on the litter in floor pens (each of them 1.95x1.50 m, 2.93 m^2) located in the windowed type of concrete experimental room (11.6x7.9 m) during the experiment. Wing numbers were attached to each chicks on the first day. In order to ensure optimum temperature in the experimental unit, additional heating was provided for the first 4 weeks. The chicks were provided continuous lighting for the first day, then 22hL:2hD between the 2nd and 6th days and, thereafter, 18hL:6hD until the end of the trial [8]. The broilers were fed ad libitum a starter feed containing 21.5% CP and 2.850 kcal/kg of ME (1-21. Days), while a grower feed containing 19.0% CP and 2.850 kcal/kg of ME was used between the 21st and slaughter days [7].

When the FG and SG broilers reached different body weights [about 1.5, 2.0 and 2.5 kg; respectively light (L), medium (M) and heavy (H)], they were slaughtered. For different categories, about 30 birds were selected randomly from each genotypes for slaughtering and we tried to take equal number birds from each genders. Total number of chickens evaluated was 180 (3 weight categories x 2 genotypes x 2 gender x 15 birds). Feed was removed for 10 h before killing. After the slaughtering and the bleeding, wet plucking and manually eviscreating was done, meanwhile the sex for each broiler was confirmation by making a sex-determination again. Following the immersion in cold water and draining, the carcasses were placed in labeled plastic bags and left in the +4°C for along the night [21]. On the next day, firstly carcass weight was determined and then, the pH_U of muscle was measured (24 h after the slaughter) from the left breast by directly inserting the glass electrode of pH-meter (Testo-206-pH2). Then the carcasses were torn apart by experienced practitioners. The weights of breast, leg, wing, abdominal fat and edible inner organs (giblets) as liver, gizzard (empty) and hearth were determined. The basic color parameter (L*, a*, b*) of the breast skin and meat samples (3 mm thick) from the left *pectoralis major* muscle was measured by using a spectrocolorimeter (Minolta CR 200).

Data collected in this completely randomized design study were subjected to an analysis of variance [22]. A factorial arrangement for main effects (slaughter weight category, genotype, and sex) was used. The unified interactions (subgroups) of main effects were analyzed separately. The means were separated using Duncan's Multiple Range test. The level at which differences were considered significant was P<0.05.

RESULTS

The ages of reaching the targeted slaughter weights as light (L,1.5 kg), medium (M, 2 kg) and heavy (H, 2.5 kg) were determined as 41st, 53rd, 58th days for FGs and 62nd, 73rd, 82nd days for SGs. In fact, the average body weight (means of male and female) of FG birds in three categories were exactly 1479, 2183 and 2640 g respectively, while 1564, 2155 and 2513 g for SGs (data did not shown in a table). The cold carcass, breast, leg, wing, abdominal fat and edible inner organ ratios to body weight of the SG and FG broilers in different slaughter weight categories determined according to the sex are presented in *Table 1*.

The statistically significant differences between slaughter weight categories were determined in terms of carcass, wing, abdominal fat and edible inner organs ratios (P<0.05 and *Table 1*). Also, statistically significant differences were determined between the SG and the FG broilers in terms of all slaughtering characteristics (P<0.05 and *Table 1*), excuding the edible inner organ yield. On the other hand, remarkable differences were formed between male and female broilers only in terms of the breast and leg yields (P<0.05). As the slaughter weight increased the carcass yield increased, and the FG broilers had higher values than the SG broilers (P<0.05). The slaughter weight categories are the only main effect that significantly affects the edible inner organ yields (P<0.05) and as the slaughter weight increased, the edible inner organ ratios decreased *(Table 1)*. On the contrary, the carcass yield increased in parallel with the slaughter weight (P<0.05).

The means and the statistical analyzes' results of the breast meat pHU, skin and meat color parameters (L*, a*, b*) are shown in *Table 2*. When it comes to skin color, lightness was affected by only slaughter weight category factors and, light (L) birds showed lower L* value mean than medium (M) and heavy (H) counterparts (P<0.05). The merely factor which affected the redness of skin was genotype and, higher a* values deteremined for FG broilers' skin (P<0.05, and *Table 2*). In contrast with, significant differences were detected between the slaughter weight groups and the sexes in terms of the yellowness of the yellowness (b*) of skin (P<0.05); the females showed higher means especially *(Table 2)*. The slaughter weight significantly affected the pHU *(Table 2)*; the highest mean was determined in the L group carcass. The FG broilers showed higher pHU mean than the SGs. When it comes to breast meat color, the effects of slaughtering weight categories and genotype factors have been found statistically significant in terms of the bright-ness. Genotype had also significant effect on L* and, SGs' breast showed higher values (P<0.05). Breast meat redness significantly effected by only genotype as also for skin a*. However, the SG broilers' meats showed higher a* values (in all P<0.05) contrarily the situation observed for the skin. All three factors have led to statistically significant differences in terms of the meat yellowness (P<0.05, for all).

DISCUSSION

As expected, SGs reached to similar body weights lately. Santos et al.[23] stated that FG and SG birds reached 2.5 kg live weight at 42nd and 77th days. But, in this current research, FG and SG birds arrived to this weight lately (58 and 82 days of age). According to Fanatico et al.[4], FG, MG and SG birds gained the approximately 2.5, 2.4 and 2.1 kg body weight until 53, 67 and 81 days of age, respectively. The feeds which were used in that researches contained rather low density nutrient as our feeds, but they did not applied low period lighting (18 h/day), unlike us. The reason for this differences against our findings may be lighting application diversity.

Table 1. *Carcass and different parts' yields (%)*
Tablo 1. *Karkas ve farklı parçaların verimleri (%)*

Main Effects	Carcass[1]	Breast[2]	Leg[2]	Wing[2]	Abdominal Fat Pad[2]	Edible Inner Organs[2,3]
Category[4]						
L	72.88^{c}	26.79	30.90	13.29^{a}	1.39^{b}	4.27^{a}
M	74.18^{b}	26.86	30.88	12.53^{b}	1.73^{a}	3.79^{b}
H	75.29^{a}	27.03	30.92	12.52^{b}	1.74^{a}	3.54^{c}
Genotype[5]						
FG	74.86^{a}	29.67^{a}	30.63^{b}	11.78^{b}	1.54^{b}	3.82
SG	73.37^{b}	24.11^{b}	31.17^{a}	13.78^{a}	1.69^{a}	3.92
Sex						
♀	74.11	27.54^{a}	30.38^{b}	12.86	1.66	3.92
♂	74.12	26.24^{b}	31.42^{a}	12.70	1.57	3.82
Subgroups						
L-FG-♀	73.29^{d}	29.19^{bcd}	30.65^{bc}	12.43^{d}	1.46^{c}	4.21^{abc}
L-FG-♂	73.38^{d}	28.37^{d}	31.20^{ab}	12.12^{de}	1.37^{c}	4.11^{bcd}
L-SG-♀	73.07^{e}	25.37^{e}	30.64^{bc}	14.49^{a}	1.34^{c}	4.32^{ab}
L-SG-♂	71.79^{g}	24.22^{ef}	31.10^{ab}	14.11^{ab}	1.37^{c}	4.45^{a}
M-FG-♀	75.41^{b}	31.07^{a}	29.70^{c}	11.23^{f}	1.61^{bc}	3.78^{ef}
M-FG-♂	74.95^{b}	30.03^{abc}	31.14^{ab}	11.40^{f}	1.58^{bc}	3.86^{de}
M-SG-♀	72.66^{f}	24.01^{f}	30.75^{abc}	13.74^{bc}	1.74^{abc}	3.99^{cde}
M-SG-♂	73.69^{c}	22.34^{g}	31.95^{a}	13.75^{bc}	1.97^{ab}	3.55^{fg}
H-FG-♀	76.16^{a}	30.37^{ab}	29.80^{c}	11.85^{def}	1.72^{abc}	3.47^{fg}
H-FG-♂	75.99^{a}	29.00^{cd}	31.30^{ab}	11.65^{ef}	1.47^{c}	3.46^{g}
H-SG-♀	74.09^{c}	25.25^{e}	30.73^{abc}	13.41^{c}	2.09^{a}	3.75^{efg}
H-SG-♂	74.94^{b}	23.49^{f}	31.85^{ab}	13.15^{c}	1.66^{bc}	3.48^{fg}
SEM	0.17	0.12	0.11	0.06	0.04	0.03
Main Effects		***P Values***				
Category	0.000	0.694	0.992	0.000	0.001	0.000
Genotype	0.000	0.000	0.017	0.000	0.028	0.062
Sex	0.979	0.000	0.000	0.189	0.232	0.076

*[1] Carcass weight (cold, included neck and fat pad and excluded edible organs)/body weights (after 10 h fasting) x 100; [2] Related part wights /body weights (after 10 h fasting) x 100; [3] Liver, gizzard and hearth; [4] Category for slaughter weight; **L:** Light, **M:** Medium and **H:** Heavy; [5] Genotypes; **FG:** Fast-growing and **DG:** Slow-growing, Values in the same column of category or subgroups with no common superscript are differ (P<0.05)*

In this study, as the slaughter weight increased in both genotypes, the yield of carcass increased. This results are in line with conclusions of other many researches' results [24-26]. On the other hand, Grashorn [13] and Aksoy et al.[2] who salaughtered FG and SG broilers at same age (84th and 56th days, respectively) concluded that FG broilers had higher carcass performance (4 and 5%, respectively) compared to the SGs (P<0.05, P<0.05). This result is normal because of the well known relationship between live weight and carcass yield. But, Fanatico et al.[4] who raised the different broiler genotypes to market weight in the extensive indoor condition, concluded that FG broilers had reached to 2.5 kg body weight at 53th days of age showed only numerically higher carcass yield than SG birds had arrived 2.1 kg at 81st days. Again, same researchers [10] determined the higher (P<0.05) carcass yield for FG broilers were slaughtered at 63rd days of age with 3.4 kg body weight than SGs slaughtered at 91st days with 2.3 kg body weight. In fact, in this two research FG and SG birds were not closely body weights.

The question to be answered that whether the carcass yield of SG and FG broilers slaugtered at same body weight is different. In this research, we tried to slaughter two genotypes on closely body weights, because of finding the answer of this question. When we examined the subgroups means for carcass yiled in detail, it is obvious that FG birds showed higher yields than SG birds in each weight categories and sex groups. We can concluded that, they are slaughtered even very similar body weight, FG broilers again showed higher carcass yield.

We can say that FG males and females did not differ in their carcass yields and this results agrees with the some studies [4,12,27]. In spite of this, SG males showed lower carcass yield in light weight group but higher yields in medium and heavy groups (in all, P<0.05). SG broilers reached to 2 and 2.5 kg body weight at 73 and 82nd days of age, therefore it is thought that the reason of SG females' lower carcass yields than male had been caused from their newly developing reproduction organs.

Many researchers [24,28-30] stated that older chickens which have higher body weight, had more breast and thigh parts. But we found the slaughter groups similar, with regard to breast and leg yields. On the other hand, this parts of yields were affected genotype (P<0.05 and P>0.05) and FG showed higher breast yield, whereas SG had higher leg yield. Fanatico et al.[4] reported that the FG broilers grown in extensive indoor system had higher breast proportion (23.2% for FG and 17.8% for SG), while the SG broilers had a higher thigh proportion (31.1% *vs.* 33.6%). Also Aksoy et al.[2] determined that breast yield were higher in FGs, however SGs showed higher means for legs percent. In addition, the results of this study were the females had higher percentages of the breast than males, and males had greater leg yield than females (P<0.05). These findings agree with the works of Young et al.[29] and Fanatico et al.[9].

The wing and giblet yields decreased with increasing slaughter weights. This findings agree with the data deal

Table 2. *Skin color and breast meat quality parameters*
Tablo 2. *Deri renk ve göğüs et kalite parametreleri*

Main Effects	Skin[1]			Breast Meat			
	L*	a*	b*	pH_u	L*	a*	b*
Category[2]							
L	60.66^b	1.97	5.43^b	6.07^a	48.63^b	1.52	4.69^a
M	63.34^a	1.58	6.03^{ab}	5.84^b	50.27^a	1.33	4.93^a
H	62.24^a	1.8	6.50^a	5.85^b	49.44^{ab}	1.25	3.96^b
Genotype[3]							
FG	61.6	2.35^a	6.13	5.96^a	48.92^b	1.01^b	3.84^b
SG	62.56	1.22^b	5.84	5.89^b	49.97^a	1.72^a	5.22^a
Sex							
♀	62	1.88	6.42^a	5.91	49.74	1.37	4.85^a
♂	62.16	1.69	5.56^b	5.93	49.15	1.36	4.20^b
Subgroups							
L-FG-♀	60.67^d	2.39^b	6.38^c	6.08^a	49.24^c	1.28^d	4.62^c
L-FG-♂	59.99^e	2.86^a	6.62^c	6.11^a	48.16^d	1.20^d	3.66^e
L-SG-♀	60.70^d	1.20^e	4.30^d	6.05^a	49.29^c	1.75^b	5.66^b
L-SG-♂	61.27^c	1.42^d	4.42^d	6.05^a	47.81^d	1.86^b	4.84^c
M-FG-♀	62.84^c	2.11^c	6.87^b	5.85^c	49.66^c	0.77^e	4.18^d
M-FG-♂	62.79^c	1.45^d	6.16^c	5.93^b	47.63^d	0.90^e	3.45^e
M-SG-♀	64.08^a	1.56^d	5.84^c	5.83^c	51.40^b	2.11^a	5.99^a
M-SG-♂	63.64^b	1.18^e	5.26^c	5.75^d	52.38^a	1.53^c	6.11^a
H-FG-♀	61.14^c	3.02^a	6.29^c	5.87^c	49.37^c	0.77^e	3.65^e
H-FG-♂	62.17^c	2.24^c	4.47^d	5.89^c	49.44^c	1.14^c	3.47^e
H-SG-♀	62.56^c	0.98^f	8.84^a	5.79^d	49.48^c	1.53^c	5.03^c
H-SG-♂	63.09^c	0.96^f	6.41^c	5.85^c	49.47^c	1.55^c	3.70^e
SEM	0.26	0.1	0.21	0.01	0.23	0.06	0.12
Main Effects							
Category	0.000	0.281	0.021	0.000	0.024	0.194	0.000
Genotype	0.071	0.001	0.492	0.000	0.031	0.000	0.000
Sex	0.762	0.343	0.043	0.311	0.216	0.995	0.009

[1] *Parameters were determined from breast skin,* [2] *Category for slaughter weight;* ***L:*** *Light,* ***M:*** *Medium and H: Heavy;* [3] *Genotypes;* ***FG:*** *Fast-growing and* ***SG:*** *Slow-growing, Values in the same column of category or subgroups with no common superscript are differ (P<0.05)*

with Poltowicz and Doktor [26] who also found that the giblet proportions of the SG broilers slaughtered at the age of 56, 70 and 84th days has steadly decreased (6.06%, 5.27% and 4.46%, respectively, P<0.05). Probably these decreasing caused by the increasing of neck and back yields. It was observed that the SG had higher wing values than the FG as parallel to data from Fanatico et al.[4], they concluded that the wings yield was 14.5% for SG and 12.8% for FG. In addition, Aksoy et al.[2] also determined higher wing yield (P<0.01) for SG according to FG slaughterd at same age (56th day), as 13.3 *vs*. 11.9. Males and females did not differ for wing yields. Also, Fanatico et al.[4] found that there is no difference between sexes.

The light slaughter weight group (L) showed lower fat pad yield than M and H groups (P<0.05). The fact that the fat pad yields rise with increasing age and body weight is acceptable normal. Despite the effect of genotype factor was found significantly (P<0.05) for fat pad yields, when judging by carefully into subgroups' means, it was clear that they were not highly remarkable differences. Thus, very different results were concluded in this regard. Santos et al.[31] who slaughtered different genotypes at 2.5 kg body weight, concluded that as parallel to us, reported that FG broilers showed lower abdominal fat yield than SG. As regards to researcher that slaughtered different genotype on the same age, according to Aksoy et al.[2] SG birds showed higher fat yields but Lewis et al.[32] and Castellini et al.[33] confirmed the opposite result. On the other hand, Grashorn [12] found similar fat pad yield for FG and SG birds. It is well-known that genetic studies have been conducted to decrease the abdominal fat ratio for many years; therefore, the lower fat pad yield for the FG broilers is an expected situation. In H group, SG-females showed higher (P<0.05) mean for fat fad yield but in other subgroups sexes were found similar.

Because the broilers produced in alternative systems are usually sold as whole-carcass, the packaging of the product is their natural skin. According to our results obtained herein, it can be said that L* and b* means increased depending on the slaughter weight. The medium and heavy group showed brighter and more yellow skin (P<0.05), it is thought that insufficient subcutaneous fat deposition caused to lower L* and b* values in the lightest body weight groups skin. Karaoğlu et al.[34] slaughtered FG birds at 35 and 42 days of age and they measured the carcass color from the back, breast and leg parts' surface after 24 h storing at +4°C. They concluded that older birds showed lower L* (63.48 *vs*. 65.89) but higher a* (3.34 *vs*. 1.88) and b* (10.76 *vs*. 9.09) values (for all, P<0.05). Only our result for skin yellowness is similar to their findings about skin pigmentation. Karaoğlu et al.[34] observed higher a* and b* values according to our data. But Huezo et al.[15] determined that L*, a*and b* values as 61.4, 1.5 and 1.0 for broiler carcass were removed from a commercial slaughter house after 24 h storage. The results obtained herein deal with skin color showed that a* values were lower at SG according to FG (P<0.05). On the other hand, females had higher b* values than males (P<0.05), this differences may be related that the females tend to be more fat deposition.

In fact, all pH_U means determined by us were within 5.75-6.11 range which is accepted "normal" [18,35]. The lower pH_U value was determined in L groups' breast meat (P<0.05). This result has been found consistent with the finding of Santos et al.[31]. Whereas, there are also some studies reporting opposite results [20,26,36]. Also, Bianchi et al.[20] who investigated the influence of the different slaughter weight on breast meat quality traits in only standard FG broilers, found that light (1.2 kg) carcass group showed the significantly (P<0.05) lower pH_U (5.92), than medium (1.8 kg) and heavy (2.4 kg) groups' pH_U (5.99 and 5.98, respectively).

It is well known that, there is high correlation between breast muscle ultimate pH and meat brightness (L*), as pH increased the L* value decreased, therefore a high-pH of muscles have darker color than those of low-pH [34,37]. Firstly, we able to say that all L* values were determined herein are in the normal range as between 46 and 53 [18,35]. Besides, the highest breast meat L* values were found for M group as 50.27, and the lowest value were determined for L group as 48.63 (P<0.05), as H group showed inter-medier L* values. The fact that high-pH of muscle deal with L group have darker color (lower L*) is parallel to well known correlation between pH and lightness. Also, lower pH and higher L* values were determined for SG breast meat than FG (P<0.05, P<0.05). Based on this, we concluded that SGs' breast meat seem to be having lower quality, because lower pH_U and higher L* means that lower water holding capacity. Fanatico et al.[9] who determined the L* of FG and SG broilers growed indoor condition as 48.2 and 49.4 (P>0.05), concluded that SG birds showed higher cooking loss than FG (P<0.05) and, this higher loss is an indicator of the lower water holding capacity. On the other hand, Debut et al.[38] suggested that SG broilers could be disadvantage for meat quality due to more struggle during shackling than FG birds.

The rednes (a*) value of broiler chicken breast meat ranges between -0.96 and 4.5 and yellowness (b*) were in the range of 6.7-13.5 [39-43]. According to Gordon and Charles [3], older birds have redder (higher a*) meat due to a higher content of myoglobin. But, in this current research, the highest a* values were determined in light group which was slaughtered at the earliest ages (P>0.05). On the other hand, Bianchi et al.[20] concluded that the breast meat from light birds was redder than medium and heavy birds' breast meat (2.14 *vs*. 1.52 and 1.59, P<0.05). Many researchers [44,45] agree that the tendency of breast meat to show a lower redness when lightness increases but our findigs were not exactly confirm this conclusion. Unlike redness, yellowness (b*) of meat were affected by slaughter age and the lowest value were determined by us for heavy group (P<0.05). According to Bianchi et al.[20], the higher b* values were determined for medium weight carcass (6.08 *vs*. 4.75 and 4.35, P<0.05).

In case of the impact of genotype factor on a* and b* values of breast meat, SG birds showed higher redness and yellowness (P<0.01, P<0.01). It was reported that the selection for meat yield results in a decrease in redness of chicken meat [43]. Fanatico et al.[9] also determined higher a* for SG birds than FG ones (P<0.05) and, they did not find remarkable difrence for yellowness among different genotypes when raised indoors. Meat redness were not affected sex factor but females showed higher (P<0.05) yellowness, in this research.

In conclusion, the results found herein indicate that as slaughter weight increased in two genotypes, carcass and fat pad yields increase but wing and giblets ratios decreased, breast and leg yields were not affected. FGs showed higher carcass and breast yields, and lower wing and giblets ratios, as similar to the results obtained when the genotypes slaughtered in the same age. While carcass yields were similar for genders but females showed higher breast and lower leg yields (P<0.05). Although all measured values were within normal limits, the increase for weight were resulted slightly lower ultimate pH and higher L* values for breast meat, and higher slaughter weight also lead to more brilliant and yellowish skin. In different weight groups, generally SGs' carcass color was found more shining and yellow, and less reddish. The breast meat of SGs seems to be having slightly lower quality because of slightly higher L* and lower pH_U, however we need new researches including more meat quality criteria for making accurate comparing. Also, the fact that brilliant and yellowish carcass of SGs could be attractive for consumers.

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