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Differences in performance, carcass characteristics and meat quality between fast- and slow-growing broiler genotypes

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Summary. This study was conducted to determine the differences in performance, carcass characteristics and meat quality between fast- and slow-growing broilers. Ross-308 genotype was used as the fast-growing genotype, while local T2-Y2 genotype was used as the slow-growing genotype. The study continued until both genotypes reached acceptable market weight (2 kg). Both genotypes consisted of 4 subgroups, each containing 50 broiler chicks. Fast-growing broilers reached market weight (2 kg) on day 38, while slow-growing broilers reached the same weight on day 72. Fast-growing broilers consumed less feed to attain 2 kg live weight compared with slow-growing broilers. The feed conversion ratio of the fast-growing broilers was 1.63, while that of the slow-growing broilers was 2.67. Significant differences were observed between the genotypes with regard to the percentage weights of the gizzard, liver, leg and breast. The percentage weights of the leg and abdominal fat were higher in slow-growing broilers, while the percentage weight of the breast was higher in fast-growing broilers. No difference was observed between the genotypes with regard to cooking loss in leg and breast meats, whereas differences were recorded with regard to the water holding capacity (%) in leg meat. The slow-growing genotype had lower pH values in breast and leg meats. The values of leg meat brightness (L*), redness (a*) and yellowness (b*) were higher in the slow-growing broilers, but the differences were not statistically significant. The L* and a* values of breast meat were found to be higher in slow-growing broilers. These results showed that in the slow-growing genotype, breast and leg meat color L, a and b value are enhanced. However, the fast-growing genotype has better performance and carcass characteristics compared to the slow-growing genotype.

Key words: growing performance, feed conversion rate, water holding capacity, meat brightness

Introduction

Poultry production is one of the fastest growing sectors in animal production business at present. The fast growth of this sector has led to an increase in the production of poultry meat. The growth was brought about by the improvement efforts aimed at increasing productivity in broilers. With the application of genetic selection in broilers, a steady increase was achieved in growth performance, time taken to reach market weight, edible muscle and breast meat. However, such improvements achieved through genetic selection caused some unwanted changes with regard to animal health, welfare and, to some extent, muscle quality (1) and sensory and functional quality of the meat negatively (2).

As a result of fast growth and increased stress, problems like skeletal system and circulatory system disorders, over fattening, and increasing sensitivity to

environmental conditions and diseases, leading to lower survival ability, have appeared in broilers (3). This situation has a serious public reaction in western countries with high sensitivity to animal welfare. Both the economic losses associated with the mentioned problems (4) and the concerns and sensitivity of consumers towards animal welfare and safe food production led to the development of suitable genotypes (5).

Fast-growing chickens have a fast-growing rate, high feed efficiency, and high meat yield. Although the growth performance of slow-growing genotype is less efficient than that of fast-growing genotype, slow-growing genotype are more adapted to natural systems, and the quality of their meat is more appropriate for a specialty or gourmet market (6). Slow-growing genotypes reach slaughter weight later, and their feed conversion ratio, carcass yield and breast weight percentage are lower compared with fast-growing genotypes (7,8). However, in recent years, slow-growing genotypes have become the preferred choice for consumers because of their product quality and animal welfare (9,10).

Previous studies on T2-Y2 (slow-growing) chickens have mainly focused on the protection, feeding management of this breed. However, so far, little information is known about the meat characteristics. This study was conducted to determine the differences in performance, carcass characteristics and meat quality of slow-growing genotypes at same conditions that have been provided for fast-growing broilers. For this purpose they were slaughtered at same live weight and compared in terms of meat quality and carcass characteristics.

Material and Method

The experiment was performed at the Research and Application Farm Poultry Unit R&D group, Faculty of Agriculture, Çukurova University. Four hundred fast- and slow-growing broiler chicks were used in the experiment. The slow-growing genotype comprised of chicks hatched from eggs gathered from the broiler parent line produced at the Research and Application Farm Poultry Unit (T2-Y2). Ross-308 broiler chicks were used as the fast-growing broiler genotype. Each genotype consisted of 4 subgroups comprising 50 chicks each (25 males and 25 females), and each subgroup was randomly allocated to a 4 m^2 compartment enclosed by wire in a windowed housed. Round feeders, round drinkers and thick wood shavings, as litter material, were placed in each compartment. Throughout the first week, electrical heaters were used to provide 33°C temperature, as required by chicks; thereafter, the temperature was reduced by 3°C every week until 24°C was reached, where it was kept stable. Throughout the experiment, feed and water were provided *ad-libitum*, and a constant photoperiod of 24 h was provided.

The nutrient contents of the diets used during the experiment (purchased from a commercial mill) are given in Table 1. All broiler chicks were provided with the same diets, which included starter diet, grower diet

Table 1. Ingredients and chemical composition of diets

Ingredients	Starter	Grower	Finisher
		(%)	
Corn	51.77	47.5	52.25
Soybean Meal	31.50	28.00	22.00
Full Fat Soybean	7.80	15.00	16.25
Meat-Bone Meal	3.00	3.00	4.00
Vegetable oil	3.00	4.25	3.50
Dicalcium phosphate	1.20	0.80	0.75
Limestone	0.55	0.55	0.50
DL- Methionine	0.35	0.25	0.20
Lysine	0.20	0.10	-
Threonine	0.20	0.05	0.05
Salt	0.23	0.30	0.30
Vitamin-Mineral Premix*	0.20	0.20	0.20
TOTAL	100.00	100.00	100.00
Calculated Nutrient Contents			
Metabolizable energy (kcal/kg)	3010	3100	3200
Crude Protein, %	23.00	22.00	20.12
Crude Cellulose, %	3.65	3.36	3.38
Calcium, %	1.00	0.95	0.82
Available Phosphorous,%	0.53	0.50	0.47
Methionine,%	0.67	0.71	0.55
Lysine,%	1.40	1.35	1.19

*Per kg vitamin- mineral premix includes 15.000 IU Vitamin A, 5000 IU vitamin D_3, 50 mg vitamin E, 10 mg vitamin K_3, 4 mg vitamin B_1, 8 mg vitamin B_2, 5 mg vitamin B_6, 5mg vitamin B_{12}, 50 mg niacin, 50 mg pantothenic acid, 20 mg folic acid, 0,25 mg biotin, 175 mg choline chloride, 100 mg manganese, 100 mg iron, 150 mg zinc, 20 mg copper, 1,5 mg cobalt, 0,20 mg selenium.

and finisher diet. Starter, grower and finisher diet was provided to slow growing genotype for 4, 4 and 2 wk, to fast growing genotype for 2, 2 and 1.5 wk respectively. All diets contained adequate nutrient levels as defined by the NRC (11).

During the experiment, feed was weighed daily, using a scale with a sensitivity of ± 5 g, before being given to the animals. Also, every week, the leftover in the feed trough was weighed to calculate the feed consumption per week. Further, chicks were weighed individually every week, using a scale with a sensitivity of ±0.5 g, to determine their live weights. Weekly feed consumption and live weight gain were used to determine weekly feed conversion ratio.

When the slow- and fast-growing genotypes reached 2 kg live weight, 10 males and 10 females from each group were slaughtered to determine carcass characteristics. The fast-growing broilers reached 2 kg market weight on day 38, while the slow-growing local stock (T2-Y2 parent line) reached the same weight on day 72.

Before slaughter, the broilers were subjected to a total feed withdrawal of 8 h. Live weights before slaughter were measured after bird selection for slaughter. Afterwards, the 12 selected broilers from each group (6 males and 6 females) were slaughtered, plucked using a plucking machine and their internal organs were removed, after which their warm carcass weights were measured. Carcasses were kept in the refrigerator at + 4 ˚C for one day and weighed again to determine the cold carcass weight. Abdominal fat was removed by hand and weighed and the weight of surrounding the gizzard was added to abdominal fat. The abdominal fat was compared with the carcass weight to determine the percentage. The carcass yield was determined by comparing the carcass weight to the live weight. The carcasses were cut into parts according to the recommendation of the Turkish Standards Institute (TS 5890). The leg, breast, back, and wing weights were measured, and these weights were compared with the carcass weight to calculate their percentages.

The left leg and breast were removed from each carcass to determine the meat quality characteristics. Meat samples were taken from different parts of the leg and breast and were homogenized by using a blender. pH values, color (Lab) values, cooking loss and water holding capacity were measured in the homogenized leg and breast meat samples.

To determine the pH values of the leg and breast meats, 10 g of meat was taken from the homogenized samples; 100 ml of pure water was added; the resulting mixture was homogenized for 1 min in a homogenizer, and the pH values were measured using a pH meter (12).

To determine the breast meat, leg meat and skin color density, L*a*b* (L: brightness, a: redness and b: yellowness) values were determined using a colorimeter (Konica Minolta Colorimeter CR-300) (13).

To determine the water holding capacity, 1 g of sample was placed on a filter paper and centrifuged at 1500 rpm for 4 min. After centrifugation, the filter paper + sample were dried at 70˚C overnight.

Water holding capacity (WHC) was calculated using the following formula:

- WHC= (M1-M2)/m x 100
- M1: filter paper + sample weight;
- M2: filter paper + post-drying weight;
- m: initial sample weight (14).

Cooking loss was determined on homogenized breast and thigh meat sample of about 20 g of sample was weighed and placed in a polyethylene bag. The meat was kept in an 80˚C water bath until the internal temperature reached 72˚C. The cooked meat was removed from the water bath, cooled, and weighed. The cooking loss was estimated as the percentage of the weight of the cooked samples (cooled and dried on the surface with a paper towel) with respect to the weight of the raw samples. (15).

The analysis of the data collected from the study was analyzed using the SPSS 18.0 (Statistical Package for Social Sciences) software. The data was analyzed by the two-sample t test to determine the significance of the difference between two mean values. The significance level at which differences were considered was $P< 0.05$. Mean ± standard error was written in tables.

Results and Discussion

The fast-growing broilers (Ross-308) reached market weight (2 kg live weight) on day 38, while the slow-growing (T2-Y2) broilers reached the same weight on day 72. As shown in Table 2, the fast-growing broilers consumed 3355.83 g of feed to attain 2 kg live weight, while the slow-growing broilers consumed 5140.72 g of feed to attain the same weight ($P<0.05$). The feed conver-

Table 2. Feed consumption and feed conversion ratio in fast- and slow- growing genotypes

Genotypes	Total Feed Consumption (g)	Feed Conversion Ratio (feed g:gain g)
Fast Growing	3355.83± 47.284[b]	1.63 ± 0.006[b]
Slow Growing	5140.72±100.675[a]	2.67 ±0.044[a]
t	-14.693	-20.428
P-value	0.000	0.000

[a,b] Means within a column with no common superscript differ significantly ($P < 0.05$).
t = Independent Samples "t" test, p-value = significance level ($\alpha = 0.05$)

sion ratio of the fast-growing broilers was 1.63 , while that of the slow-growing broilers was 2.67 (P<0.05). In many studies performed with fast- and slow-growing genotypes, it was determined that feed conversion ratio was better in fast-growing genotype (7, 8,10,16). Mikulski et al. (17) stated that based on live weights on day 65, the slow-growing genotype had 17% lower live weight compared with the fast-growing genotype, and that the feed conversion rate was similar. Sarica et al. (7), in their study on slow- and fast-growing genotypes, fed slow-growing broilers until day 49 and fast-growing broilers until day 42 and 49, and determined that the live weights of the slow-growing broilers were lower than those of the fast-growing broilers (P<0.05). The feed consumption of the slow-growing broilers was similar to that of the fast-growing broilers slaughtered on day 42, and the feed conversion ratio was better in fast-growing broilers compared with slow-growing broilers (P<0.05). On the other hand, Fanatico et al. (8) reported that slow-growing broilers consume less feed compared with fast growing broilers, and that the feed conversion ratio was better in fast growing broilers.

To determine the carcass characteristics, the ratio of the weight of carcass parts and internal organs to the weight of the whole carcass was taken into consideration (Table 3). No difference was observed between the genotypes with regard to carcass yield (P>0.05). The leg, wing, back, neck, gizzard and abdominal fat weight ratios were higher in slow-growing broilers compared with fast-growing broilers (P<0.05).

In this study, there were significant differences among the carcass characteristics of fast- and slow-growing genotypes except heart weight, breast weight and carcass yield (Table 3). The carcass yield was not significant among the groups. However the fast growing broiler had better carcass yield than slow-growing broilers. Similar results were reported by Sarica et al. (7,18), Fantico et al. (8,10) and Mikulski et al. (17). The leg, wing, back, neck, gizzard and abdominal fat weight ratios were higher in slow-growing broilers compared with fast-growing broilers (P<0.05). Similar results were reported by Sarica et al. (7,19) and Fanatico et al. (8). The high leg weight percentage in the slow-growing genotype in this study is similar to the high leg weight percentage in slow-growing genotypes found in different studies (8-10,18,20). Previous studies established that as a result of fast growth, carcass performance and breast weight percentage increased, while abdominal fat levels decreased in fast-growing genotypes (17,18,21,22). In fast-growing genotypes, large breast weight percentage and low abdominal fat weight percentage are results of long term selection (7-9, 23). Coneglian et al. (16), Sarica et al. (18), and Fanatico et al. (8,10,24) stated that slow-growing broilers had lower breast weight percentage and higher leg, back and wing weight percentages compared with fast-growing broilers. Mikulski et al. (17) stated that breast and leg weight percentages are higher in fast-growing broilers, while abdominal fat weight percentage is higher in slow-growing broilers.

With regard to the pH level in the breast and leg meats, slow-growing genotype had lower pH values (P<0.05) (Table 4). The values of leg and breast meat cooking loss percentage and water holding capacity (%) were found to be similar between the genotypes (P>0.05). However, the only difference was found in average leg meat water holding capacity (P<0.05) (Table 4). In contrast to the findings of this study, Mikulski et al. (17) stated that there was no difference between the genotypes with regard to breast meat pH values, but leg meat pH values in slow-growing broilers kept indoors were lower than those of fast-growing broilers; the difference was statistically significant. Sarica et al. (19) stated that leg and breast meat pH were lower in fast-growing broilers, while Fanatico et al. (25) and Quentin et al. (21) found that breast meat pH was higher in fast-growing broilers compared to slow-growing broilers, similar to this study. The values of leg and breast meat cooking loss percentage and water holding capacity of breast meat were similar between the genotypes (P>0.05). Lonergan et al. (26) stated that cooking loss in slow-growing broilers was

Table 3. Carcass characteristics of fat- and slow- growing genotypes

Carcass Characteristics		Fast Growing	Slow Growing	t	P-value
Slaughter Weights (g)	Male (n=10)	2014.00 ± 23.09	2026.60 ± 20.65	-0.407	0.695
	Female (n=10)	2005.00 ± 22.52	1921.00 ± 31.71	2.159	0.063
	Average (n=20)	2009.50 ± 15.28	1973.80 ± 25.06	1.216	0.240
Carcass Yield, %	Male (n=10)	75.98 ± 0.555	75.16 ± 1.251	0.598	0.566
	Female (n=10)	77.04 ± 0.986	75.35 ± 1.566	0.914	0.387
	Average (n=20)	76.51 ± 0.562	75.25 ± 0.945	1.141	0.269
Gizzard Weight, %	Male (n=10)	2.95 ± 0.360^{b}	4.35 ± 0.230^{a}	-3.285	0.011
	Female (n=10)	3.26 ± 0.225^{b}	4.88 ± 0.307^{a}	-4.245	0.003
	Average (n=20)	3.11 ± 0.207^{b}	4.62 ± 0.201^{a}	-5.232	0.000
Liver Weight, %	Male (n=10)	3.399 ± 0.295^{a}	2.596 ± 0.113^{b}	2.535	0.035
	Female (n=10)	3.130 ± 0.095^{a}	2.392 ± 0.218^{b}	3.093	0.015
	Average (n=20)	3.265 ± 0.153^{a}	2.494 ± 0.120^{b}	3.948	0.001
Heart Weight, %	Male (n=10)	0.959 ± 0.035^{a}	0.809 ± 0.020^{b}	3.624	0.007
	Female (n=10)	0.829 ± 0.085	0.780 ± 0.022	0.552	0. 596
	Average (n=20)	0.894 ± 0.048	0.795 ± 0.015	1.951	0.067
Leg Weight, %	Male (n=10)	38.938 ± 0.585^{b}	41.502 ± 0.497^{a}	-3.336	0.010
	Female (n=10)	37.304 ± 0.387^{b}	40.686 ± 0.271^{a}	-7.151	0.000
	Average (n=20)	38.121 ± 0.428^{b}	41.094 ± 0.299^{a}	-5.684	0.000
Breast Weight, %	Male (n=10)	34.326 ± 1.011^{a}	24.541 ± 0.515^{b}	8.618	0.000
	Female (n=10)	36.189 ± 1.032^{a}	24.683 ± 0.526^{b}	9.930	0.000
	Average (n=20)	35.258 ± 0.748^{a}	24.612 ± 0.348^{b}	12.882	0.000
Wing Weight, %	Male (n=10)	10.073 ± 0.270^{b}	11.855 ± 0.270^{a}	-4.660	0.002
	Female (n=10)	9.914 ± 0.242^{b}	12.150 ± 0.310^{a}	-5.681	0.000
	Average (n=20)	9.993 ± 0.173^{b}	12.003 ± 0.200^{a}	-7.591	0.000
Neck Weight, %	Male (n=10)	4.715 ± 0.184	5.456 ± 0.371	-1.788	0.112
	Female (n=10)	4.278 ± 0.266^{b}	5.697 ± 0.128^{a}	-4.802	0.001
	Average (n=20)	4.496 ± 0.168^{b}	5.577 ± 0.189^{a}	-4.253	0.000
Back Weight, %	Male (n=10)	10.176 ± 0.472^{b}	12.555 ± 0.313^{a}	-4.190	0.003
	Female (n=10)	10.295 ± 0.575^{b}	12.917 ± 0.342^{a}	-3.916	0.004
	Average (n=20)	10.235 ± 0.351^{b}	12.736 ± 0.227^{a}	-5.972	0.000
Abdominal Fat Weight, %	Male (n=10)	2.176 ± 0.147	5.145 ± 0.709	-4.100	0.003
	Female (n=10)	2.344 ± 0.082	6.247 ± 0.523	-7.366	0.000
	Average (n=20)	2.260 ± 0.084	5.696 ± 0.454	-7.437	0.000

^{a,b}Means within a line with no common superscript differ significantly ($P < 0.05$).
t - independent samples (t test); P-value - significance level ($\alpha = 0.05$).

higher compared with fast-growing broilers. Fanatico et al. (27) reported that due to the thickness of the large breast muscles, the water loss in them is lower compared with thin breast muscles. Sante et al. (28) reported that at high pH values, the water holding characteristic of myosin would be higher. In this study, leg and breast pH values were high in fast-growing broilers, and their water holding capacity was higher than slow-growing broilers. Mikulski et al. (17) stated that breast meat water holding capacity was lower in slow-growing broilers, while leg meat water holding capacity was higher, in contrast to this study. However, the differences between the geno-

Table 4. Meat quality characteristics in fast and slow growing genotypes

Parameters		Fast Growing	Slow Growing	t	P-value
Breast, pH	Male (n=10)	6.120±0.070	5.874±0.142	1.547	0.160
	Female (n=10)	6.104±0.032[a]	5.588±0.037[b]	10.362	0.000
	Average (n=20)	6.112±0.036[a]	5.731±0.084[b]	4.145	0.001
Leg, pH	Male (n=10)	6.492±0.085	6.122±0.145	2.187	0.060
	Female (n=10)	6.472±0.022	6.370±0.077	1.260	0.243
	Average (n=20)	6.482±0.041[a]	6.246±0.088[b]	2.417	0.026
Water Holding Capacity, % (Breast)	Male (n=10)	63.399±1.079	60.093±1.404	1.867	0.099
	Female (n=10)	61.430±0.770	60.470±1.183	0.679	0.516
	Average (n=20)	62.414±0.706	60.281±0.868	1.906	0.073
Water Holding Capacity, % (Leg)	Male (n=10)	64.218±1.657	60.159±1.513	1.809	0.108
	Female (n=10)	62.579±0.982	61.272±0.361	1.248	0.247
	Average (n=20)	63.399±0.948[a]	60.715±0.756[b]	2.211	0.040
Cooking Loss, % (Breast)	Male (n=10)	19.833±0.850	19.939±0.515	-0.106	0.918
	Female (n=10)	19.610±2.093	19.692±1.001	-0.035	0.973
	Average (n=20)	19.722±1.065	19.815±0.532	-0.079	0.938
Cooking Loss, % (Leg)	Male (n=10)	27.213±1.268	25.581±2.159	0.652	0.533
	Female (n=10)	26.576±1.731	24.270±1.385	1.040	0.329
	Average (n=20)	26.895±1.017	24.925±1.229	1.234	0.233

[a,b]Means within a line with no common superscript differ significantly ($P < 0.05$).
t = Independent Samples "t" test, P-value = significance level (α= 0.05)

types were not statistically significant. In the study by Fanatico et al. (25), it was found that slow-growing broilers had lower water holding capacity, while Sarica et al. (19) found that the leg and breast meat water holding capacities were lower in fast-growing broilers, in contrast to this study.

With regard to leg meat L*, a* and b* values, the slow-growing genotype had higher values, but no significant difference was found between the genotypes (P>0.05) (Table 5). Some differences were observed in leg skin with regard to a* value, with the fast-growing genotype demonstrating a redder skin color compared with the slow-growing genotype (P<0.05). Leg skin L* and b* values were found to be higher in the slow-growing genotype (P>0.05).

Consumers pay attention to color while buying broiler products. Particularly, in whole carcass purchases, skin color has a significant effect on consumer preference. Skin color in chicken depends on the genetic ability to produce melanin pigments in the dermis and epidermis and the absorption and storage of carotenoid pigments in the epidermis (29). A study by Fanatico et al. (25) re-

Table 5. Leg meat and skin color in fast and slow growing (Lab values)

	Leg meat			Leg skin		
	L*	a*	b*	L*	a*	b*
FG	62.344±0.892	5.448±0.310	17.663±1.756	70.388±0.851	4.742±0.658[a]	11.843±0.885
SG	64.386±0.775	5.730±0.335	19.280±0.516	72.178±0.643	2.819±0.472[b]	11.945±0.842
t	-1.727	-0.617	-0.883	-1.676	2.373	-0.083
P-value	0.101	0.545	0.389	0.111	0.029	0.934

[a,b] Means within a column with no common superscript differ significantly ($P < 0.05$).
FG: Fast growing; SG: Slow growing; L: brightness; a: redness; b: yellowness
t = Independent Samples "t" test, P-value = significance level (α= 0.05)
* L: brightness, a: redness and b: yellowness

ported that L* and b* values in leg skin were higher in slow-growing broilers compared with fast-growing broilers, while a* value was higher in fast-growing broilers. Contrary to this study, Kucukyılmaz et al. (30) reported that leg meat redness values were higher in slow-growing broilers compared with fast-growing broilers. However, leg meat brightness and yellowness values were in accordance with this study. Mikulski et al. (17) stated that, similar to this study, leg meat L*, a* and b* values did not differ between slow- and fast-growing broilers.

In breast meat, L* and a* values were higher in slow-growing broilers. Breast skin L* value was lower in fast-growing broilers, and a* value was lower in slow-growing broilers (P<0.05) (Table 6). Even though breast meat and skin b* values did not show any significant difference between the genotypes, slow-growing broilers had yellower skin and meat color compared with fast-growing genotype (P>0.05). Contrary to this study, Nielsen et al. (31) found that breast meat was redder in fast-growing broilers, while Quentin et al. (21) determined that the brightness value of breast meat was lower in slow-growing broilers. Mikulski et al. (17) stated that breast meat yellowness value was higher in slow-growing broilers compared with fast-growing broilers (P>0.05). These findings are in accordance with the findings of this study. Quentin et al. (21) stated that the yellowness value of breast meat was higher in fast-growing broilers, while the redness value was higher in slow-growing broilers. Many studies stated that slow-growing broilers had lower redness in meat compared with fast-growing broilers (25,30).

Baeza et al. (32) as well as Gordon & Charles (33) stated that the heme pigment increased in poultry with age, while Gordon & Charles (32) reported that due to the older age and high myoglobin content of slow-growing broilers, they had a redder meat color compared with fast-growing broilers. Touraille et al. (34) stated that the myoglobin content of the breast muscle of broilers increased between weeks 9 and 12, and that the difference between the genotypes could be as a result of the slaughter age. The findings of these researchers are in agreement with this study.

Conclusion

In conclusion, our results show that in slow-growing broilers, breast and leg meat color are enhanced, but fast-growing broilers have better performance and carcass characteristics. Water holding capacity in breast and leg meat and cooking loss in leg meat was higher in fast growing broilers.

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Table 6 Breast meat and skin color in fast and slow growing (Lab values)

	Breast Meat			Breast Skin		
	L*	**a***	**b***	**L***	**a***	**b***
FG	60.858±0.852[b]	5.352±0.338[b]	19.555±0.531	67.673±0.475[b]	5.138±0.638[a]	14.363±0.958
SG	65.062±0.416[a]	6.569±0.242[a]	20.529±0.347	71.896±0.591[a]	2.838±0.319[b]	14.819±0.982
t	-4.431	-2.919	-1.533	-5.566	3.224	-0.332
P-value	0.000	0.009	0.143	0.000	0.005	0.744

[a,b] Means within a column with no common superscript differ significantly ($P < 0.05$).
FG: Fast growing; SG: Slow growing; L: brightness; a: redness; b: yellowness
t = Independent Samples "t" test, P-value = significance level ($\alpha = 0.05$)
* L: brightness, a: redness and b: yellowness

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