Hayvansal Üretim 55(2): 1-8, 2014

Araştırma

Comparing Growth and Carcass Traits of Slow Growing Chicken Parents with Pure Egg Type Parents and Commercial Broilers

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Abstract

In this study, growth and carcass traits of slow growing parents were compared with commercial broilers and pure parents. Two egg type parents and a commercial meat parent were used in crossings. Male-female mixed 144 chickens per genotype were reared on litter in a house divided into 1.5 x 1.5 m pens. Live weight, carcass weight, carcass part ratios, abdominal fat and edible inner organ weights were determined in four dam and three sire line chickens. Colour as measured by L*, a*,b* values and pH were assessed in meat of thigh and breast. According to growth, feed efficiency, and carcass characteristics, crossbred chickens exhibited values between pure egg parents and broilers.

Key words: Slow growing chickens, cross-breeding, meat colour, meat pH, carcass parts

Yavaş Gelişen Etlik Piliç Ebeveynlerinin Büyüme ve Karkas Özelliklerinin Ticari Etlik Piliç ve Saf Yumurtacı Hatlarla Karşılaştırılması

Özet

Bu çalışmada yavaş gelişen ebeveynlerin ticari broiler ve saf hatlar ile büyüme ve karkas özellikleri karşılaştırılmıştır. Melezlemelerde iki yumurtacı bir etlik ebeveyn kullanılmıştır. Her genotipten erkek-dişi karışık 144 civciv 1.5x 1.5 m ölçülerindeki bölmelerde altlıklı sistemde yetiştirilmiştir. Canlı ağırlık, karkas ağırlığı, karkas parka oranları, abdominal yağ ve yenilebilir iç organ ağırlıkları 4 ana 3 baba hattında belirlenmiştir. But ve göğüs etlerinde et renginin L*, a* ve b* değerleri ile pH belirlenmiştir. Büyüme, yemden yararlanma oranı ve karkas özelliklerine göre, melez genotipler saf yumurtacı hatlar ile etlik piliçler arasında değerlere sahip olmuştur.

Anahtar kelimeler: Yavaş gelişen piliçler, melezleme, et rengi, et pH'sı, karkas parçaları

Introduction

Intensive broiler meat production in the world is growing and broiler meat has an important share of total meat consumption. In addition to this, there are developments in new products and production systems in parallel with the changes in consumer demands. Consumers also accept to pay more money for poultry products from semi-intensive, extensive, free-range and organic systems. The demand for these products is increasing due to public opinion that they are produced in natural, healthier, and animal friendly systems (Yang and Jiang, 2005; Sarica and Yamak, 2010a).

Early slaughter age of chickens which are used in conventional production, metabolic disorders related to fast growth, and criticisms of seeing the conventional system as "production like factories" have led to new investigations. For this purpose, use of slow growing coloured feathered chickens fed with low-quality feed and slaughtered at a delayed age have become widespread (Rizzi *et al*., 2007; Dou *et al*., 2009; Almeida and Zuber, 2010). Dark meat and skin colour and consumer preferences about the flavour are the main factors affecting choice of slow growing chicken strain (Zaho *et al*., 2007, Sarıca *et al*., 2010). Slow growing chickens are more adapted for organic or free-range production systems; as they reach 2-2.5 kg live weight in 80-120 days. Fast growth may cause physiologic and metabolic disorders (Julian, 1993; Whitehead et al., 2003). Prevalence of disorders reduces if all body parts grow in harmony (Sarica *et al*., 2009; Sarica and Yamak, 2010a). With this aim, slow growing chickens have developed in the different regions of the world. "Assured chicken production" in United Kingdom, "Qualitat und Schereit" in Germany, "IKB Chicken" in Netherlands, "Label de Qualite Wallon and Belplume" in Belgium, "Polo Corral" in Spain, "Label Rouge" in France and "Three Yellow" in China are the best known slow growing chickens (Yang and Jiang, 2005; Magdelaine *et al*., 2008). The Label Rouge program has been a model for slow growing genotype breeding in all parts of the world. Label Rouge chickens

are about two times more expensive than conventional chickens because production period is longer than conventional broilers and feed conversion ratios of conventional broilers are better than Label Rouge chickens. Despite this price they have reached 30% share in the chicken market of France (Westgren, 1999; Fanatico and Born, 2002; Magdelaine *et al*., 2008). Europe is leading the production of slow growing commercial hybrids while Hubbard and Sasso are the best known commercial companies. These companies produce parents of different colour and quality, suitable for slow growing chickens.

Demand for natural or organically produced products has increased in recent years in Turkey. Nevertheless, it is important to use economically profitable chickens instead of low productive chickens in back yard poultry production system (Sekeroglu and Sarica, 2007). Furtherance, slow or medium growing chickens slaughtered at the ages of 56-84 days have been successfully used in organic and free-range meat production systems. Producing the parents of these kinds of chickens is possible with selection and breeding practices (Yang and Jiang, 2005). New lines and breeds could be improved by incorporation of commercial broiler breeders or heavy egg type parents and selection of local genotypes (Emmerson, 2003; Yang and Jiang, 2005; Sarica and Yamak, 2010a, b).

In this study, growth and carcass traits of slow growing parents were compared with commercial broilers and pure parents. Slow growing parents were produced by using two heavy egg type parents (BARII and RIRII) and fast growing ROSS parents. Thus, the broiler performance of the material produced by pure or two-way crossing was executed.

Material and Method

The study was aimed to improve slow growing parents by using two heavy egg type parents and a commercial broiler breeder. The trial was conducted at the University of Ondokuz Mayis Agricultural Faculty Research Farm, Samsun, Turkey from February 2010 to July 2010. The project was supported by the Scientific and Technological Research Council of Turkey (Project No:109O334). All procedures were approved by the local Ethical Committee of Ondokuz Mayis University for Experimental Animals. Rhode Island Red II (RIR II) and Barred Plymouth Rock II (BAR II) obtained from the Poultry Research Institute (Ankara, Turkey) were used as egg type parents. Commercial Ross broiler breeder genotype was purchased from Aviagen. Males of sire line and females of dam line were used as broiler parents. Four dam lines and three sire lines were produced by two-way crossing and selection in the live weights of egg type parents. RIR II and BAR II lines were selected according to live weight at the ages of 6, 8 and 12 weeks and RIRII♂xROSS♀ and BARII♂xROSS♀ crosses were produced as dam lines. ROSS♂xBARII♀ and ROSS♂xRIRII♀ crosses and ROSS were used as sire lines.

A total of 144 male-female mixed chickens per genotype were reared on litter in a house divided into 1.5 x 1.5 m pens. For each genotype, 4 replicates of 36 chickens in the same environment conditions were used in the experiment. Chicks were wing banded at hatching to determine sex and individual live weight differences.

A 23 hours light regime was applied in the first 6 weeks, with 14 hours lighting additional to natural lighting applied for the remainder of the experiment. Chickens were fed ad libitum as follows; 0-10 days: broiler starter diet (12.8 MJ ME/kg, 220g crude protein/kg), 11-25 days: broiler growing diet (13.2 MJ ME/kg, 200g crude protein/kg), 26 days to slaughter: broiler finisher diet (13.4 MJ ME/kg, 200g crude protein/kg). Feeds were purchased from a commercial mill. Chickens were vaccinated against New Castle and Gumboro diseases according to the advice of a local commercial broiler company. Feed consumptions and mortality were determined per pen. Feed conversion ratio (FCR) was calculated as feed intake divided by weight gain. Fast growing ROSS broilers were slaughtered at 46 days, while RIRII and BARII chickens were slaughtered at 84 days old age. Crossbred parents were slaughtered at three different ages (63, 70 and 84 days). Three male and three female chickens from each replicate were slaughtered on each slaughter day under similar conditions to minimize external factors. An 8h fasting period was applied before slaughter, chickens were weighed individually at the plant where they were weighed and identified as male or female according to wing bands.

After slaughtering, carcasses were pre-chilled at 12 ºC for 15 min and chilled at 4-5 ºC for 45 min. After being chilled, carcasses were matured at 4ºC for 12 h, abdominal fat and chilled carcass weight was recorded, carcass weights, breast, back, wings, neck, legs (thighs and drumstick) were recorded (Sarica *et al*., 2009). Heart, liver and empty gizzard were weighed as edible inner organs. Carcass parts and edible inner organs were expressed as a percentage of chilled carcasses. Abdominal fat was expressed as a percentage of live weight. Shank lengths were measured as the distance

between hock and foot pad of left legs. The skins of breast and thigh samples were stripped away, values of meat representing lightness (L*), redness (a*), and yellowness (b*) were measured 12 h post-mortem using a Konica Minolta CR 400 Chroma Meter. Two replicate measures were made on both breast and thigh meats. The pH was measured with a pH meter (Model PC 510, Cyberscan, Singapore) equipped with an insertion electrode calibrated with pH 4.01 and 7.01 buffers at ambient temperature. Three replicate measures were performed on breast and thigh meats.

Feed consumption and feed efficiency data were analysed by Analysis of variance and one way ANOVA model and other data were analysed by Analysis of variance and presented as consequence of each of the factors in the study: genotype, sex and genotype x sex interaction effects. Statistical analysis was conducted using the General Linear Model of SPSS software (SPSS Inc., 1999, Release 16.0). All percentage data were transformed by taking arcsine square roots prior to analysis. Mortality was analyzed by chi-square tests. When the F-test was significant, treatment means were compared using Duncan's multiple range tests. The level at which differences were considered significant was $P<0.05$. Results are presented as means and a pooled SEM (unless otherwise stated).

Results and Discussion

Significant differences in live weights of the chickens among genotypes were found at various slaughtering ages ($P<0.05$). Fast growing ROSS genotype reached mean live weight of 2797.60 g at 46 days while crossbred genotypes reached these values at 70-84 days. RIRII and BARII genotypes never reached these values. It is expected that acceptable slow growing genotypes reach 2.5 kg in 80-85 days. But some of the crossbred genotypes in this study reached marketing weight earlier than expected date (Table 1). Particularly, live weights of the ROSSxRIRII and ROSSxBARII crossbreds at 63 and 70 days showed that these two genotypes could be characterized as medium growing genotypes. These findings are similar to those of Fanatico *et al*. (2005a) who found 2.3-2.4 kg weight at 67 days. Berri *et al*. (2005) described chickens as medium growing chickens when they reached 2.65 kg at 8 weeks. Also, chickens that reached 2.10-2.88 kg at 12 weeks in the same study were termed as slow growing. In our study, the marketing weight of 2.7 kg obtained in the naturally mated RIRIIxROSS and BARIIxROSS genotypes could be acceptable for alternative production systems.

Dressing percentages of all genotypes were found to be between 70.17% and 73.85% ($P<0.05$). These results are similar to the findings of Fanatico *et al.* (2005a), Abdullah *et al.* (2010) but greater than the findings of Dou *et al.* (2009). Dressing percentage increased with increasing age that was consistent with findings of Abdullah *et el*. (2010) but in contrast to Castellini *et al*. (2002a) (Table 1). Females had lower dressing percentage than males at all slaughter ages ($P<0.05$). Comparison of shank length to live weight (SL/LW) was given in Table 2. RIRII and BARII pure lines had the highest SL/LW values. These genotypes were egg type parents and layers have long shanks. It is thought that being egg type parents had effect on the highness of this value. Crossbred groups where egg type parents were used as sire lines had the second highest SL/LW values. The other crossbreds had higher values than ROSS genotype. While female chickens had shorter shanks; SL/LW value was found higher in females of some genotypes (Table 1).

Liver weight changed according to bodyweight of the bird and as an expected result, liver weight of the heavy groups was found to be heavier. RIRII and crossbred genotypes had higher gizzard weights. Edible inner organ ratios was found to be significantly greater in pure parents ($P<0.05$). The ratios of some body parts and carcass tissues changed with increased age (Murawska and Bochno, 2008). Contrary to this, there was a decrease with increased age in the crossbred groups of the study (Table 3). Gender had no significant effect on the edible inner organ ratios. It was previously reported by Berri *et al*. (2005) that in broilers, abdominal fat increased with increased production period. RIRII and BARII had the lowest abdominal fat percentage. ROSS chickens followed these genotypes. There were increases in the abdominal fat percentage of crossbred chickens with increased slaughter age ($P<0.05$; Table 3). But, this increase reached about 5% of total body weight in the medium growing ROSSxRIRII and ROSSxBARII, while it was about 3% in slow growing groups at 84 days. In all genotypes, it was found that females had lower abdominal fat percentages than males ($P<0.05$).

While feed conversion ratios of fast growing chickens could be greater than 2.10 (Fanatico *et al.*, 2005b), the ratio of 1.6 of ROSS chickens in the study could be accepted as a good result for conventional production systems. Crossbred chickens had different FCR at various ages. Feed conversion ratios increased with delayed slaughter age. These findings were in line with the results of Castellini *et al.* (2002a) who evaluated

Table 1. Live weight and some carcass traits of genotypes at different slaughter ages.

Genotype	Gender	Age (days)	Live weight (g)	Carcass weight (g)	Dress. per. (%)	SL/LW	EIO/CW	Abdominal fat (%)
	M	84	1870.8	1319.9	70.51	0.61	7.91	1.42
RIRII	F		1382.6	970.2	70.17	0.68	7.67	1.67
	T		1626.7h	1145.1	70.34d	0.65a	7.79a	1.55g
	M	84	1974.0	1397.0	70.77	0.61	5.95	2.13
BARII	F		1416.0	997.2	70.42	0.71	5.99	2.03
	T		1695.0h	1161.1g	70.59d	0.66a	5.97b	2.08fg
	M		3050.5	2180.9	71.48	0.36	5.63	1.91
ROSS	F	46	2544.8	1814.6	71.31	0.34	5.85	2.51
	T		2797.6b	1997.8	71.40cd	0.35h	5.74bc	2.21f
	M		2334.2	1702.6	71.16	0.44	5.41	3.62
	F	63	1859.4	1371.0	70.59	0.47	5.92	4.55
	T		2096.8f	1536.8ef	70.87cd	0.45cde	5.67bc	4.08bc
	M		2617.6	1861.9	71.77	0.42	5.77	3.66
ROSSxRIRII	F	70	2021.2	1429.1	71.39	0.46	5.90	3.83
	T		2319.4c	1645.5	71.58bcd	0.44de	5.84bc	3.74cd
	M		3376.7	2555.1	73.72	0.36	4.37	3.88
	F	84	2496.8	1836.3	72.88	0.43	4.55	4.80
	T		2936.7a	2195.7b	73.30 a	0.40g	4.46e	4.34 ab
	M		2233.2	1623.0	71.98	0.45	4.97	3.89
	F	63	1789.2	1325.2	71.23	0.47	5.01	4.06
	T		2011.2fg	1474.1f	71.60bcd	0.46bcd	4.99d	3.97bc
	M		2548.9	1835.1	71.92	0.41	4.88	3.89
	F	70	1998.9	1507.1	72.30	0.45	4.76	4.50
ROSSxBARII	T		2273.9cd	1671.1d	72.11bc	0.43def	4.82de	4.19b
	M		3400.4	2559.2	74.27	0.38	3.73	4.08
	F	84	2476.3	1896.1	73.42	0.44	3.84	5.59
	T		2938.3a	2227.6a	73.85a	0.41fg	3.79f	4.84a
	M		2288.8	1698.0	71.80	0.44	5.54	2.98
	F	63	1675.1	1233.2	71.97	0.51	5.70	3.20
	T		1982.0g	1465.6f	71.88bc	0.48 b	5.62bc	3.09e
	M		2555.7	1961.7	71.09	0.39	5.41	2.64
	F	70	1794.9	1355.1	70.73	0.49	5.67	3.09
RIRIIxROSS	T		2175.3de	1658.4d	70.91cd	0.44de	5.54c	2.86e
	M		3267.2	2225.5	72.89	0.39	4.52	2.70
	F	84	2280.3	1676.1	72.62	0.47	4.49	3.80
	T		2773.7bc	1950.8c	72.75ab	0.43def	4.51e	3.25de
	M		2239.7	1595.1	71.96	0.47	5.22	3.11
	F	63	1729.0	1294.5	72.02	0.49	4.99	3.90
	T		1984.3 g	1444.8f	71.99bc	0.48b	5.11d	3.50cde
	M		2532.8	1814.1	73.67	0.43	4.51	2.69
	F	70	1876.8	1388.4	71.94	0.46	4.48	4.31
BARIIxROSS	T		2204.8cd	1601.2de	72.80ab	0.44de	4.49e	3.50cde
	M		3236.3	2501.3	73.84	0.39	3.77	2.75
	F	84	2291.9	1742.6	73.39	0.46	4.31	3.29
	T		2764.1b	2121.9b	73.61a	0.43def	4.04f	3.02e
SEM			8.472	8.029	0.099	0.002	0.035	0.053
Effects								
Genotype			**	**	**	**	**	**
Sex			**	**	**	**	NS	**
Genotype x Sex			**	**	NS	**	NS	NS

**:P<0.01; NS: Differences are insignificant, P>0.05; a,b,c,d,e,f,g: Means with different letters in the same column are significantly different (P<0.05). SL/LW: Shank length/Live weight; EIO/CW: Edible inner organ/Carcass weight; Dress per: Dressing percentage; M: Male; F: Female; T: Female-Male mixed, SEM: Standard Error Mean

ROSSxRIRII and ROSSxBARII genotypes as medium growing chickens. Optimal slaughter age was found to be 63 or 70 days. These two genotypes had better feed conversion ratios than the findings of previous studies about medium growing chickens (Fanatico *et al.*, 2005b; Castellini *et al.*, 2002a). Feed conversion ratios at 84 days of both RIRIIxROSS and BARIIxROSS were found to be about 2.45, under the acceptable FCR 3.00-

Table 2. Feed consumptions, feed conversion ratios and mortalities of different genotypes at different slaughter ages.

Genotypes	Age (days)	Feed Consumption (g)	FCR	Mortality (%)
RIRII	63	2493.3 j	1.95 i	1.70 a
	70	3221.7 i	2.35 ef	2.00 a
	84	4412.9 f	2.71 a	2.00 a
BARII	63	2610.0 j	2.03 h	1.70 a
	70	3326.7 i	2.40 cde	2.00 a
	84	4605.4 e	2.72 a	2.00 a
ROSS	46	4511.7 ef	1.61 k	2.00 a
ROSSxRIRII	63	3981.6 g	1.90 j	1.10 a
	70	5406.2 c	2.33 f	1.10 a
	84	7026.7 a	2.39 de	1.80 a
ROSSxBARII	63	3802.9 h	1.89 j	1.50 a
	70	5167.8 d	2.27 g	1.60 a
	84	6985.1 a	2.38 def	1.60 a
RIRIIxROSS	63	3894.7 gh	1.97 i	0.00 b
	70	5267.4 d	2.42 bcd	0.00 b
	84	6808.2 b	2.45 bc	0.00 b
BARIIxROSS	63	3904.8 gh	1.97 i	0.00 b
	70	5277.5 d	2.39 de	0.00 b
	84	6818.3 b	2.47 b	0.00 b
SEM		186.61	0.039	0.001
Effect				
Genotype		**	**	*

**:P<0.01;*:P<0.05, a,b,c,d,e,f,g,h,i,j,k,l,m,n: Means with different letters in the same column are significantly different (P<0.05). ; FCR: Feed Conversion Ratio, SEM: Standard Error Mean

4.00 of slow growing chickens. This result was better than those of Castellini *et al.,* (2002b) and Dou *et al.,* (2009) who found values between 3.3 and 4.4. Pure lines RIRII and BARII had FCR higher than 2.45 but lower than 3.00. There was no significant mortality among all genotypes (Table 2).

Carcass part ratios of all genotypes at different slaughter ages are given in Table 3. Breast ratio, which is economically important, was found highest in fast growing ROSS genotype, ROSS x BARII and other crossbred chickens followed ROSS respectively. RIRII and BARII had the lowest breast ratio compared to other chickens. Breast ratios of the crossbred chickens were found between 28-31 % which can be defined as acceptable in commercial markets. Ratio of ROSS chickens is a result of breeding strategies applied for long times. Leg cut percentages of the genotypes were diametrically opposite to breast ratios. RIRII and BARII chickens had the heavier leg cut percentages compared to other genotypes. As an expected result, breast and leg cut percentages were found between the values of ROSS, RIRII and BARII. It can be said that crossbred chickens improved in this study and had the leg and breast ratios that were expected for slow growing chickens. The findings of this study are similar to those of Fanatico *et al*. (2005b), Berri *et al*. (2005), De Marchi *et al.* (2005) and Dou *et al*. (2009). Also, gender had a significant effect on breast-leg ratios (P<0.05). The other carcass parts (back, wings and neck) percentages were found lowest in ROSS genotype.

A significant effect of genotype was observed on pH, L*, a* and b* values of breast and leg meat (P<0.01, Table 4). Breast and leg meat of ROSS genotype had higher L* values (paleness) than did those of RIRII and BARII genotypes, whereas crossbred genotypes had the lowest L* values. However, breast and leg meat of ROSS genotype had the lowest a* value (redness) while crossbred genotypes had the highest. b* (yellowness) values were found highest in ROSS genotype's breast and leg meats. The leg muscle from BARII and crossbred genotypes had higher pH values than RIRII and ROSS genotypes. Breast muscle pH values were found higher in some crossbred groups. Particularly, highness of a* value in the muscles of crossbred chickens is an expected quality trait in the meats of slow and medium growing chickens.

There is a negative correlation between the meat color and pH value of chicken meat. Meats with lower pH values have higher L* values.

According to the results of this study, genotypes improved as parents could be used as slow or medium growing chickens. Particularly, carcass and growth performances of two-way crossbreds at different

slaughter ages support this idea. Results of the second generation, chickens improved from the parents of this study, will execute healthier results about improving local slow growing chickens. According to whole results of the project, studies about these parents should be focus on reproductive traits such as; natural mating or artificial insemination, hatching properties and sexual maturation.

Table 3. The carcass weight (g) and parts cut-up characteristics (g/100g CW) of different genotypes

Genotype	Gender	Age (days)	Carcass Parts				
			Leg	Breast	Back	Wings	Neck
RIRII	M	84	34.88	23.58	20.76	12.87	7.31
	F		32.32	25.59	20.93	12.92	6.86
	T		33.60 a	24.59 h	20.84 cde	12.89 ab	7.08 cde
BARII	M	84	34.18	25.69	21.24	11.59	6.79
	F		32.39	27.86	21.11	12.12	6.25
	T		33.28 ab	26.75 g	21.17 cd	11.86 fg	6.53 ef
ROSS	M	46	30.28	34.96	17.67	10.46	6.25
	F		29.04	35.83	18.21	10.72	6.29
	T		29.66 f	35.39 a	17.94 g	10.59 i	6.27 f
ROSS x RIRII	M	63	34.62	28.44	19.43	12.29	8.71
	F		31.89	28.64	21.63	12.48	8.69
	T		33.26 abc	28.54 f	20.53 cde	12.39 cde	8.70 a
	M	70	33.62	27.47	21.60	12.39	7.94
	F		31.36	30.09	21.32	12.65	7.58
	T		32.49 abcd	28.78 ef	21.46 bc	12.52 bcd	7.76 b
	M	84	32.02	28.70	23.29	11.65	6.99
	F		30.26	31.41	23.52	11.79	6.56
	T		31.14 e	30.06 cd	23.41 a	11.72 gh	6.79 def
ROSS x BARII	M	63	32.43	29.49	19.04	11.85	8.31
	F		31.01	31.89	18.94	11.76	8.46
	T		31.72 de	30.69 bc	18.99 f	11.80 fgh	8.38 a
	M	70	33.45	27.86	19.66	12.36	8.94
	F		30.68	31.62	20.39	12.04	8.31
	T		32.06 cde	29.74 cde	20.03 def	12.20 cdef	8.62 a
	M	84	32.89	29.80	22.39	11.22	6.76
	F		29.93	31.28	22.59	11.58	6.51
	T		31.41 de	30.54 bc	22.49 ab	11.39 h	6.63 ef
RIRII x ROSS	M	63	32.52	28.46	19.69	12.45	8.22
	F		31.17	29.09	19.72	12.76	8.77
	T		31.85 de	28.77 ef	19.71 ef	12.60 bc	8.49 a
	M	70	32.45	28.12	20.69	12.88	7.66
	F		31.77	29.48	20.36	13.19	7.39
	T		32.11 bcde	28.80 ef	20.52 cde	13.04 a	7.52 bc
	M	84	31.94	28.88	22.37	12.48	8.05
	F		31.16	30.08	22.82	12.58	6.66
	T		31.55 de	29.48 def	22.59 a	12.53 bcd	7.36 bcd
BARII x ROSS	M	63	32.36	28.56	20.11	12.17	8.32
	F		31.32	30.39	19.46	12.03	8.64
	T		31.84 de	29.47 def	19.78 ef	12.10 defg	8.48 a
	M	70	32.36	29.72	20.42	12.19	7.84
	F		31.82	28.08	19.64	11.83	7.03
	T		32.09 bcde	28.90 ef	20.03 def	12.01 efg	7.44 bc
	M	84	32.67	29.86	21.98	11.96	6.29
	F		30.89	32.33	22.99	11.64	6.49
	T		31.78 de	31.10 b	22.49 ab	11.79 fgh	6.39 f
SEM			0.100	0.085	0.096	0.037	0.050
Effects							
Genotype			**	**	**	**	**
Sex			**	**	NS	NS	*
Genotype x Sex			NS	**	NS	NS	NS

**:P<0.01;*:P<0.05 NS: Differences are insignificant, P>0.05. a,b,c,d,e,f,g,h,i: Means with different letters in the same column are significantly different (P<0.05). M: Male; F: Female; T: Female-Male mixed; SEM: Standard Error Mean

Table 4. L*, a*, b* and pH values of leg and breast meat of genotypes.

Genotype	Gender	Age (days)	Leg Meat				Breast Meat			
			L*	a*	b*	pH	L*	a*	b*	pH
RIRII	M	84	61.04	5.00	6.35	5.99	59.19	2.04	4.46	5.75
	F		60.93	5.16	9.85	5.67	60.49	2.29	6.92	5.48
	T		60.99bc	5.08c	8.09b	5.83bc	59.84b	2.17d	5.69 b	5.61de
BARII	M	84	61.92	3.91	6.37	6.09	61.32	1.81	7.11	5.87
	F		61.07	3.97	7.72	5.79	58.90	1.26	7.92	5.58
	T		61.49b	3.94d	7.05b	5.94ab	60.11b	1.54e	7.51a	5.72cd
ROSS	M	46	65.59	3.25	10.96	5.72	64.25	1.39	6.23	5.46
	F		65.59	3.37	11.55	5.50	63.67	1.28	6.47	5.26
	T		65.59a	3.31d	11.25a	5.61e	63.96a	1.39e	6.35ab	5.36f
ROSS x RIRII	M	63	58.52	6.58	2.57	5.73	58.21	3.39	2.88	5.53
	F		59.27	5.97	2.67	5.68	60.17	2.99	3.86	5.49
	T		58.89de	6.28ab	2.62c	5.71cde	59.19bc	3.19abc	3.37cd	5.51e
	M	70	59.07	6.16	3.46	5.95	54.89	2.99	3.68	5.77
	F		58.57	5.42	2.97	5.91	52.98	2.98	2.17	5.71
	T		58.82de	5.79abc	3.21c	5.93ab	53.93fg	2.98bc	2.93cd	5.74bc
	M	84	60.29	6.21	2.94	6.04	54.22	3.68	3.49	5.88
	F		58.28	6.01	3.32	5.94	57.72	3.41	2.97	5.79
	T		59.29cde	6.11ab	3.13c	5.99a	55.97def	3.55ab	3.23cd	5.84abc
ROSS x BARII	M	63	57.91	6.19	3.67	5.76	58.67	2.93	3.19	5.56
	F		57.53	6.38	2.54	5.66	57.49	3.34	3.61	5.46
	T		57.72def	6.28ab	3.11c	5.71cde	58.08bcd	3.13abc	3.40cd	5.51 e
	M	70	57.82	6.39	3.17	5.97	52.55	3.46	3.07	5.80
	F		58.04	5.05	3.12	5.93	53.17	3.13	2.79	5.74
	T		57.93def	5.72abc	3.14c	5.95ab	52.86g	3.29 ab	2.93cd	5.77bc
	M	84	59.12	6.68	3.34	6.08	52.72	3.65	3.48	5.89
	F		57.84	6.03	2.67	5.96	54.12	3.39	2.03	5.69
	T		58.48de	6.36ab	3.01c	6.02a	53.42fg	3.52ab	2.76cd	5.79abc
RIRII x ROSS	M	63	57.65	6.63	3.55	5.77	59.23	3.18	3.99	5.55
	F		57.57	6.16	4.54	5.67	56.64	3.19	4.51	5.47
	T		57.61def	6.39ab	4.05c	5.72cde	57.93bcd	3.19abc	4.25c	5.51e
	M	70	60.19	5.58	3.01	6.00	53.44	3.56	2.19	5.82
	F		59.11	5.47	2.43	5.97	56.21	3.30	2.79	5.77
	T		59.65bcd	5.53bc	2.72c	5.99a	54.83efg	3.43ab	2.49d	5.79abc
	M	84	58.20	6.95	3.06	6.09	53.28	3.29	2.93	5.93
	F		58.05	6.24	2.84	5.98	53.56	3.75	2.02	5.80
	T		58.13def	6.59a	2.95c	6.03a	53.42fg	3.52ab	2.48d	5.86ab
BARII x ROSS	M	63	55.67	6.29	3.18	5.82	56.75	3.30	3.23	5.61
	F		56.77	6.46	4.17	5.72	57.56	3.67	4.61	5.55
	T		56.22fg	6.37ab	3.67c	5.77cd	57.16cde	3.49ab	3.92cd	5.58e
	M	70	58.28	5.71	2.83	6.04	53.22	3.07	2.17	6.04
	F		52.10	5.84	2.18	5.99	56.75	2.21	3.78	5.78
	T		55.19g	5.78abc	2.51c	6.02a	54.99efg	2.64cd	2.97cd	5.91a
	M	84	57.35	6.32	2.45	6.09	54.50	3.96	3.62	5.89
	F		57.45	6.30	2.30	6.01	51.85	3.40	2.65	5.81
	T		57.40ef	6.31ab	2.37c	6.05a	53.18g	3.68a	3.13cd	5.85abc
SEM			0.173	0.073	0.197	0.010	0.221	0.049	0.125	0.011
Effects										
Genotype			**	**	**	**	**	**	**	**
Sex			*	NS	NS	**	NS	NS	NS	**
Genotype x Sex			NS	NS	NS	**	NS	NS	NS	NS

**:P<0.01;*:P<0.05 NS: Differences are insignificant, P>0.05. a,b,c,d,e,f,g: Means with different letters in the same column are significantly different (P<0.05). M: Male; F: Female; T: Female-Male mixed, SEM: Standard Error Mean

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