Effects of stock, sex, and muscle type on carcass characteristics and meat quality attributes of parent broiler breeders and broiler chickens

E. O. S. Hussein,[*,1] G. M. Suliman,[*,†] A. N. Al-Owaimer,[*] S. H. Ahmed,[‡] A. M. Abudabos,[*] M. E. Abd El-Hack,[§] A. E. Taha,[#] Islam M. Saadeldin,[*] and A. A. Swelum[*,‖,1]

*Department of Animal Production, College of Food and Agricultural Sciences, King Saud University, P.O Box 2460, 11451, Riyadh, Saudi Arabia; †Department of Meat Production, Faculty of Animal Production, University of Khartoum, Khartoum 11114, Sudan; ‡Department of Basic Sciences, College of Veterinary Medicine, Sudan University of Science and Technology, Khartoum 11116, Sudan; §Department of Poultry, Faculty of Agriculture, Zagazig University, Zagazig 44511, Egypt; #Department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University, Edfina 22758, Egypt; and ‖Department of Theriogenology, Faculty of Veterinary Medicine, Zagazig University, Zagazig 44511, Egypt

ABSTRACT This study aimed to investigate the effect of using breeder parents (434-days-old) and broiler chickens (37 D of age) from Ross 308 on meat quality parameters and carcass characteristics; sex and muscle type were also estimated. Carcass assessment involved hot carcass weight, carcass yield, and cuts (breast, legs, wings, back, and shoulder). A total of 120 birds were divided into 2 groups (60 birds from each stock), each stock contain equal number of sexes (30 males and 30 females), and further divided into 6 replicates, so that there were 5 birds in each replicate. The birds were fed ad libitum. A sample of 30 birds (male, n = 15 and female, n = 15) from each group was slaughtered for assessing carcass and physical characteristics. Sensory analysis was carried out on each group after boiling or roasting the bird. Live weight, carcass weight and yield, breast weight, legs, wings, and back weights and yield were higher ($P < 0.001$) for breeder parents when compared to broilers, with the exception of breast percentage. Moreover, better carcass characteristics were observed in males than in females. Parent stock had better water-holding capacity and myofibrillar fragmentation whereas broilers had more tender meat than breeders. Moreover, cooking loss and other sensory characters were not significant between the two groups; however, females had more tender pectoral muscles and more myofibrillar fragmentation than males. We concluded that parent breeders had better carcass characteristics than broiler chickens. The broiler chickens of Ross 308 and female birds had better meat quality than parent breeders.

Key words: breeder stock, broiler, sex, muscle type, carcass

2019 Poultry Science 98:6586–6592
http://dx.doi.org/10.3382/ps/pez464

INTRODUCTION

According to the US Department of Agriculture's Foreign Agricultural Service, broiler meat production in Saudi Arabia is predicted to increase by 4.4% between 2016 and 2017. In 2017, Saudi Arabia's broiler meat (poultry) production was 765 metric tons (**mt**), compared to 427 mt in 2008. A growing demand for poultry reflects its high nutritive and dietary value, and favorable price when compared with that of other meat (Augustyńska-Prejsnar and Sokołowicz, 2014). This increase in poultry production and demand has led to increasing efforts to enhance meat quality. Important criteria in evaluating the slaughter value of broiler carcasses are dressing percentage (**DP**), share of culinary parts, and carcass muscle content. Broiler chickens possess a high DP, accounting for 74.81% (Shewita and Taha, 2018). This indicator is considered significant because it determines the amount of material for sale. Similarly, carcass composition is also important, as high muscle content, especially of breast muscle, and a low fat content, enhance desirability to consumers. Whereas meat quality is made up of a number of traits, consumers are most concerned about the sensory quality; the color, tenderness, taste intensity (intensity and desirability), juiciness and aroma (intensity and desirability) (Augustyńska-Prejsnar and Sokołowicz, 2014). Meat color is both important to consumers, and an easy criterion to evaluate. Changes in color are often the first observable indicators of quality deterioration and declining nutritive value. Fresh poultry meat should be light red in color. Tenderness is

Received May 21, 2019.
Accepted July 26, 2019.
[1]Corresponding authors: shessin@ksu.edu.sa (EOSH); aswelum@ksu.edu.sa (AAS)

the most important meat quality parameter. It is subjectively evaluated as a sense of firmness, flexibility or elasticity, and is influenced by age. Young birds, due to a relatively low muscle fiber diameter, are tenderer than older ones (Zdanowska-Sąsiadek et al., 2016). The average taste intensity is a combination of 2 sensory sensations: flavor and aroma (Nowak and Trziszka, 2010, Zdanowska-Sąsiadek et al., 2016). Broiler chicken meat has a poor flavor-aroma profile, which develops after thermal treatment. The meat of older birds has a more typical flavor and aroma. Various muscles of the same bird differ in taste intensity and breast muscles have low taste intensity (Augustyńska-Prejsnar and Sokołowicz, 2014). Thigh muscles, on the other hand, have greater flavor and aroma intensity (Szkucik et al., 2007). Juiciness, sensed as the dryness or moisture of meat, is also a quality-determining trait. A positive juiciness score is recorded for meat with adequate moisture (Zdanowska-Sąsiadek et al., 2016). The ability of meat to hold its own water, either completely or in part, is termed water-holding capacity (**WHC**) (Honikel and Hamm, 1994). Water-holding capacity is one of the most important parameters of meat quality and directly affects sensory parameters, final product appearance, and product yield (Offer and Trinick, 1983; Trout, 1988). WHC of the pectoralis major is influenced by pre-slaughter conditions (Petracci et al., 2009; Dadgar et al., 2010), processing techniques (Zhuang et al., 2008), and post-chilling conditions (Lee et al., 2008; Zhuang and Savage, 2008). Moreover, carcass quality and composition are also determined by the sex of birds, which affects drumstick yield, breast yield, and abdominal fat (Holcman et al., 2003).

Current research provides a comparison of slaughter value and meat quality for male and female breeder parents and broiler chickens from Ross 308. The hypothesis of current study assumes differences between breeder parents and broiler chickens for body weight, DP, carcass composition, and physiochemical and sensory meat properties. Moreover, assessments the differences of sex and muscle type on meat characteristics.

MATERIALS AND METHODS

Birds, Housing, and Feeding Management

Two groups of day-old broiler chickens (female, n = 30 and male, n = 30) were raised at the Agriculture Research Unit affiliated to King Saud University and randomly sorted into 6 replicates for each sex, containing 5 birds per replicate. The birds were housed in electrically heated battery brooders and the chicks were reared up to 37 D on diets containing 17% CP and 3100 kcal of ME/kg. Water and feed were supplied ad libitum and nutrient content followed NRC (1994) recommendations (Table 1). The Ross 308 breeder stock [female (n = 30) and male (n = 30)] was obtained from ALWADI Farm Company in Riyadh at 434-days-old.

Table 1. Feed specification of diets.

Items	Breeder female	Breeder male	Broiler 308
Energy kcal/kg	2,800	2,700	3,050
Crude protein %	13.00	11.50	20.00
Arginine %	0.80	0.58	1.37
Lysine %	0.58	0.49	1.1
Methionine + cystine %	0.59	0.48	0.90
Methionine %	0.36	0.31	0.56
Threonine %	0.51	0.38	0.86
Valine %	0.57	0.42	0.93
Tryptophan %	0.14	0.09	0.25
Calcium %	3.20	0.70	1.00
Available phosphorus %	0.33	0.35	0.45
Sodium %	0.18 to 0.23	0.18 to 0.23	0.20
Chloride %	0.18 to 0.23	0.18 to 0.23	0.32
Potassium %	0.6 to 0.9	0.6 to 0.9	0.81
Choline mg/kg	1,050	1,000	1,529

Carcass Composition

At 37 D (Ross 308 broiler chickens) and 434 D (Ross 308 breeder stock) of age, A sample of 30 birds (male, n = 15 and female, n = 15) from each group were weighed to the nearest gram. Before slaughtering, the birds were subjected to feed withdrawal for 10 h, however, drinking water was provided ad libitum during feed withdrawal time. Then, birds were slaughtered and cut according to the law of animal welfare. After slaughtering by cutting of the jugular veins, birds left for complete breeding (1.5 to 2 min.), birds were defeathered, plucked, and eviscerated. Carcass cuts weights (back, breast, wings, legs, and shoulders) were recorded. Hot carcass weights were calculated after removal of shanks, neck, head, and abdominal fat from bled, plucked, and eviscerated birds. Carcass yields were determined according to the main commercial parts of breast meat (including *pectoralis minor* (**PMN**) and *pectoralis major* (**PMJ**)) and the leg (including drumstick and thigh meat), both of which were weighed; these weights were expressed relative to carcass weight.

Meat Physical Measurements

Muscle pH Both pectoral muscles; PMJ and PMN from the left side of the breast were dissected, weighed and their pH and color components determined at 0 and 24 h. The pH was measured using a microprocessor pH-meter (Hanna Instruments, Model PH 211; Woonsocket, RI, USA). Three pH readings for each sample were taken and the mean weight was calculated for both PMJ and PMN for each carcass.

Color Measurements Color measurements were assessed at 0 and 24 h after slaughter on the different areas of the internal surface of the cranial position of the pectoral muscles. The redness (a^*), yellowness (b^*), and lightness (L^*) CIE scales were assessed using a Minolta CR-300 chromameter (Minolta, Osaka, Japan) as described by Combes et al. (2003). Three readings were taken.

Meat Quality Measurements Both pectoral muscles; PMJ and PMN of the breast left side were dissected and stored at −20°C prior to performing meat quality analyses.

The frozen samples were thawed at 4°C for 24 h before determination of WHC, cooking loss (**CL**), myofibrillar fragmentation index (**MFI**), and sensory evaluation.

Water-Holding Capacity WHC of the frozen left side of the pectoral muscles (PMJ and PMN) was measured immediately after thawing at 4°C for 24 h following the method illustrated by Sun and Luo (1993). A muscle sample of 0.3 g was pressed onto an oven dried Whatman 125-mm filter paper (Maidstone, Kent, UK) at 207 bar. The WHC values were calculated as the ratio of the area of expressed water to the area of the pressed meat sample as measured with a planimeter (Model 4236, Keuffel and Esser, Hoboken, NJ).

Measurement of Cooking Loss For CL, samples were placed in a commercial indoor counter top grill (Kalorik GR 28,215; Kalorik, Miami Gardens, FL, USA) and cooked to an internal temperature of 70°C. A thermocouple thermometer probe was inserted into the geometric center of the muscle samples for monitoring the temperature (Ecoscan Temp JKT; Eutech Instruments, Singapore). Semi-analytical scales were used to record the weight of muscles before and after cooking (Mettler MP1210; Mettler-Toledo Ltd., Leicester, UK) to determine CL percentage as the difference between the initial and final muscle weights *100/initial weight.

Measurement of Myofibril Fragmentation Index

The methods described by Culler et al. (1978) were used to determine the myofibril fragmentation (MFI) of the muscle samples as follows; scissor-minced muscles (4 g) were homogenized in a blender containing 40 ml of cold MFI buffer (2°C). After several washes, the absorbance of the resultant 0.5 mg/ml solution was evaluated at 540 nm. The MFI of each sample was determined by multiplying the absorbance at 540 nm by 200.

Assessment of Sensory Properties of Cooked Meat

We tested the tenderness of cooked meat that had been prepared for shear force measurements; the assessment was carried out in a room at ambient temperature and in daylight. The quality of cooked meat was evaluated according to an 8-point scale as described by AMSA (1995). A team of 8 semi-trained panelists evaluated tenderness, aroma (intensity and desirability), juiciness and taste (intensity and desirability). Each descriptor was scored from 1 (minimum) to 8 (maximum). The assessors received 2 cm^3 samples cooked in disposable plastic containers with lids in a dry oven at 120°C for 30 min. The carry-over effect was avoided by encoding the sample names. The assessments were performed twice. To neutralize the taste the assessors drank hot unsweetened tea between tastings.

STATISTICAL ANALYSIS

We analyzed the data using GLM procedures (SAS, 2002). Carcass composition traits, MFI, CL, WHC and sensory parameters were analyzed according to the following model—$Xtfk = \mu + B_t + S_f + B_t{*}S_f + e_{tfk,}$ where Xtfk = value of any observation, μ = population mean, Bt = stock type effect (parent and broiler stock), Sf = sex effect (male and female effect), $B_t{*}S_f$ = the interaction between stock type and sex, e_{tfk} = random error. Whereas pH_i, L*, a* and b* were analyzed using the following model—$Xtfjk = \mu + B_t + S_f + M_j + B_t{*}S_f{*}M_j + e_{tfjk,}$ in which Xtfjk = value of any observation, μ = population mean, Bt = stock type effect (parent and broiler stock), Sf = sex effect (male and female effect), M_j = muscle type (PMJ and PMI), $B_t{*}S_f{*}M_j$ = the interaction between stock type, sex, and muscle type, etfjk = random error.

RESULTS

Carcass Composition of Broiler Chickens

The data on carcass characteristics (live weight, carcass composition, and carcass yield) of parents and broiler chickens from Ross 308 are presented in Table 2. It was reported that parent stock showed higher significant weights of live birds, carcass, breast and leg as well as weights and yields of back and shoulder than those recorded for broiler stock. Broiler stock had significantly higher breast and wing percentages than parent stock. Males of both parent and broiler stock showed significantly higher live weight, carcass weight, dressing percentage, breast weight, leg weight and percentage, wing weight and percentage as well as back weight than females of both stocks; on the other hand females had higher significant back percentages than those of males of both stocks. Moreover, sex had no effect ($P > 0.05$) on both breast and shoulder percentages of the studied stocks. Regarding the stock*sex interaction; there were significant effects ($P < 0.05$) for all traits except for breast, back and shoulder percentages ($P > 0.05$).

Stock Type, Sex, and Muscle Type Effects on pH and Muscle Color

Results of the effects of stock type, sex and their interaction on muscle pH, lightness (***L****), redness (***a****) and yellowness (***b****) are given in Table 3. Stock type had no effect ($P > 0.05$) on muscle pH and redness (a^*) of the muscle, whereas broiler birds showed a significant ($P < 0.0001$) increase in muscle lightness (L^*) (54.48 vs. 47.98). Parent stock expressed higher ($P < 0.0001$) muscle yellowness (b^*) than those of

Table 2. Factors affecting carcass composition for Ross 308 broiler parents at 62 wk (434 D) of age and broilers at 37 D of age.

Item		Number	Live weight (g)	Carcass weight (g)	Carcass yield (%)[1]	Breast (g)	Breast (%)[2]	Leg (g)	Leg (%)[2]	Wings (g)	Wings (%)[2]	Back (g)	Back (%)[2]	Shoulder (g)	Shoulder (%)[2]
Stock effect															
Parent stock		30	$4,763^A$	$3,709^A$	77.47^A	1159^A	24.38^B	458^A	24.35^A	167^A	3.49^B	458^A	9.80^A	178^A	3.76^A
Broiler stock		30	$2,056^B$	$1,530^B$	74.36^B	547^B	26.55^A	168^B	23.24^B	77^B	3.76^A	168^B	8.15^B	69^B	3.37^B
Sex effect															
Male		30	$4,036^A$	$3,167^A$	77.32^A	$1,002^A$	25.29	1046^A	25.14^A	150^A	3.76^A	348^A	8.53^B	144^A	3.49
Female		30	$2,783^B$	$2,077^B$	74.51^B	704^B	25.65	616^B	22.44^B	95^B	3.49^B	279^B	9.42^A	103^B	3.64
Interaction effect															
Stock	Sex	15													
Parent	Male	15	5,832	4,657	79.85	1410	24.12	1572	27	215	3.69	507	8.66	214	3.66
	Female	15	3,694	2,762	74.87	908	24.65	798	21.69	120	3.29	410	10.94	142	3.86
Broiler	Male	15	2,240	1,677	74.80	594	26.45	520	23.29	85	3.82	189	8.4	74	3.31
	Female	15	1,872	1,383	73.92	500	26.65	434	23.19	69	3.7	148	7.9	64	3.43
SEM			92	74	0.70	30	0.45	23	0.35	3	0.04	19	0.38	6	0.12
P-value															
Stock			<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	0.0056	<0.0001	0.0002	<0.0001	0.0002	<0.0001	0.0038
Sex			<0.0001	<0.0001	0.0005	<0.0001	0.4360	<0.0001	<0.0001	<0.0001	0.0003	0.0016	0.0495	<0.0001	0.2158
Stock x Sex			<0.0001	<0.0001	0.0118	<0.0001	0.7228	<0.0001	<0.0001	<0.0001	0.0349	0.1856	0.0014	<0.0001	0.6769

SEM: standard error of the mean. In the same column, and within the same effect, means with different superscripts differ significantly ($P < 0.05$).
[1]Dressing percentage = (carcass weight/Live weight)*100; [2] Percentage from live weight.

broiler birds (3.75 vs. 1.29). It was evident that female muscle had a higher pH ($P < 0.0001$) than that of males (6.25 vs. 6.11), moreover females recorded higher values ($P < 0.0001$) for muscle $a*$ than males. Pectoralis muscles of males recorded higher ($P < 0.0001$) $b*$ values than those of females (3.75 vs. 1.29). Concerning muscle type, PMJ had a higher pH than PMI whereas there were no differences in their $b*$ ($P > 0.05$). On the other hand $b*$ and $a*$ of MNP were higher ($P < 0.05$ and $P < 0.0001$, respectively) than those of MJP. The stock*sex effect was significant for pH, $a*$ and $b*$, moreover stock*MS was significant for pH, $L*$ and $b*$. Sex*MS and stock*sex*MS effects were significant for $a*$.

Effects of Stock Type and Sex on Muscle Quality

Data on the effects of stock type, sex and their interaction on muscle quality parameters (MFI, CL, WHC, flavor, tenderness, juiciness and acceptability) are presented in Table 4. The data revealed that MFI and WHC of the parent stock muscle were higher ($P < 0.0081$ and $P < 0.0001$, respectively) compared with those of broiler muscles. Meanwhile, broiler muscles had significantly higher flavor and acceptability ($P < 0.014$ and $P < 0.0493$, respectively). Cooking loss, tenderness and juiciness did not vary with stock type ($P > 0.05$). Sex effects were clear for MFI and tenderness, where female muscles had higher values (6.25 and 4.53, respectively) than those recorded for males (6.11 and 3.97). Other meat quality parameters including CL, WHC, flavor, juiciness and acceptability were not affected by sex differences ($P > 0.05$). The stock*sex interaction was non-significant for all traits.

DISCUSSION

The current study investigated the effects of stock type, sex, and their interaction on carcass parameters and meat quality of parent stock and broiler chickens. Carcass characteristics were significantly affected by stock type, and parent stock had significantly higher carcass trait values, with the exception of breast and wing percentage. Age-related differences in breast muscles were reported by Uhlířová et al. (2018) who recorded that breast percentage was 4% higher in older geese than smaller ones; Tilki et al. (2005) attributed these differences to age-related growth variations. Our results confirm those of Muth and Valle Zárate (2017) who found that age at slaughter significantly affected ($P < 0.0001$) slaughter weight, dressing percentage, breast weight, and breast percentage. Moreover, age at slaughter affects the yield of most carcass parts and is thus of commercial importance. Young et al. (2001) reported that older chickens had larger breasts. We showed higher DP for parent stock, and these results were confirmed by Połtowicz and Doktor (2012) who

Table 3. Main effects of stock type, sex, and muscle type on pHi, L^*, a^*, and b^*.

Item			Number	pHi	L^*	a^*	b^*
Stock effect							
Parent stock			30	6.16	47.98^B	2.51	3.75^A
Broiler stock			30	6.20	54.48^A	2.70	1.29^B
Sex effect							
Male			30	6.11^B	50.92	1.99^B	3.87^A
Female			30	6.25^A	51.53	3.22^A	1.17^B
Muscle type (MS)							
Major pectoralis (MJP)			30	6.34^A	50.27^B	1.99^B	2.20
Minor pectoralis (MNP)			30	6.03^B	52.19^A	3.23^A	2.84
Interaction effect							
Stock	Sex	MS					
Parent	Male	MJP	7	6.46	53.99	2.41	−1.83
		MNP	8	6.22	56.30	5.06	−1.29
	Female	MJP	8	6.17	51.18	1.89	4.74
		MNP	7	5.95	56.44	1.45	3.53
Broiler	Male	MJP	7	6.39	48.41	2.20	3.16
		MNP	8	5.94	47.43	3.21	4.63
	Female	MJP	8	6.33	47.48	1.44	2.72
		MNP	7	5.99	48.58	3.19	4.48
SEM				0.05	1.33	0.42	0.57
P-value							
Stock				0.2295	<0.0001	0.5162	<0.0001
Sex				<0.0001	0.5176	<0.0001	<0.0001
MS				<0.0001	0.0433	<0.0001	0.1155
Stock × Sex				<0.0001	0.4427	0.0052	<0.0001
Stock × MS				0.0114	0.0497	0.6488	0.0175
Sex × MS				0.3204	0.1840	0.0498	0.3675
Stock × sex × MS				0.4961	0.8212	0.0015	0.2088

SEM: standard error of the mean. In the same column, and within the same effect, means with different superscripts differ significantly ($P < 0.05$).

L^*: lightness; a^*: redness; b^*: yellowness.

Table 4. Effects of stock type and sex on myofibrillar fragmentation index (MFI), cooking loss (CL), water-holding capacity (WHC) and sensory parameters.

Item		Number	MFI	CL	WHC	Flavor	Tenderness	Juiciness	Acceptability
Stock effect									
Parent stock		30	73.73^A	25.13	7.74^A	3.83^B	4.13	3.97	3.93^B
Broiler stock		30	58.02^B	24.31	5.53^B	4.47^A	4.37	4.17	4.37^A
Sex effect									
Male		30	24.05^B	79.19	6.20	4.27	3.97^B	3.90	4.07
Female		30	25.40^A	52.56	7.07	4.03	4.53^A	4.23	4.23
Interaction effect									
Stock	Sex								
Parent	Male	15	73.71	24.11	5.32	4.67	3.93	3.93	4.13
	Female	15	42.33	24.51	5.74	4.27	4.80	4.40	4.60
Broiler	Male	15	84.67	23.98	7.08	3.87	4.00	3.87	4.00
	Female	15	62.79	26.28	8.41	3.80	4.27	4.07	3.87
SEM			5.72	1.55	0.45	0.25	0.22	0.23	0.22
P-value									
Stock			0.0081	0.5986	<0.0001	0.014	0.3027	0.3923	0.0493
Sex			<0.0001	0.3857	0.0571	0.3542	0.0144	0.1563	0.4429
Stock × sex			0.4094	0.5401	0.3106	0.5073	0.1865	0.5677	0.1697

SEM: standard error of the mean. In the same column, and within the same effect, means with different superscripts differ significantly ($P < 0.05$).

MFI: myofibrillar fragmentation index; CL: cooking loss; WHC: water-holding capacity.

found that DP was significantly higher in birds slaughtered at 84 D than those slaughtered at 56 D. The same authors also reported that younger birds had poor muscle content and meat with the least favorable technological properties. Moreover, age, sex, genotype, and their interactions affected cold carcass weight, slaughter weight, and DP significantly in geese (Uhlířová et al. 2018). Males had higher significant carcass parameters (live weight, carcass weight and yield, breast weight, leg weight and yield, wing weight and yield and back and shoulder weight) compared with females, except for back percentages. Sex effects were also reported by

Lopez et al. (2011) who showed that broiler males had higher ($P < 0.05$) carcass weights, live BW and breast weights than females, but lower ($P < 0.05$) breast meat yield and DP. Fernandes et al. (2013) reported that carcass percentages were only significantly affected by broiler strain, whereas other traits were not affected; moreover, the same researchers reported sex effects only for carcass percentage, with nonsignificant interaction effects between strain, sex, and slaughter age.

Regarding muscle pH, stock type had no effect on pH value. Whereas the muscles of females had significantly higher pH values than those of males, PMJs had higher pH values than PMIs. Our results did not match those of Muth and Valle Zárate (2017) who reported that age at slaughter significantly affected carcass pH, and that fast-growing broilers had higher pH values compared with slower-growing lines. Glamoclija et al. (2015) reported that younger broilers (42-day-old) showed significantly higher pH than older ones (50-day-old). The differences in pH values in chicken muscles may be attributed to chicken genotype, time—pre-slaughter stress, transport, slaughtering method, post-mortem handling, storage time and the muscle type of the same bird (Glamoclija et al., 2015). Our results partially agreed with those of Uhlířová et al. (2018), who reported non-significant effects of age, genotype, and sex on carcass pH. Kirmizibayrak et al. (2011) reported that female breast muscles had higher pH than males. This may reflect differing pre-slaughter responses to stress, slaughter weights, and glycogen reserves at slaughter (Uhlířová et al., 2018). Female broilers had higher pH values than males for PMJ (Shafey et al., 2014).

Stock type affects muscle color, L^* and b^*, whereas muscle color is also affected by sex, i.e., females had higher a^* and lower significant b* compared with males. Połtowicz and Doktor (2012) reported that age did not affect muscle color, including L^*, a^*, and b^*. While totally agreed with Muth and Valle Zárate (2017); Uhlířová et al., (2018) who recorded significant effect for line-age of chickens on meat color (a^* and b^*). Our results also confirmed that PMN has high L^* and a^* values. Sex, strain, and their interactions do not affect PMJ and PMN muscle colors (a^*, L^* and b^*) in broilers (Lopez et al., 2011). Broiler great-grandparent genotype and fiber size differences could alter the texture and color of meat (Sogunle et al., 2010). Meat color differs as a result of pre-slaughter factors, stunning methods and cooling regimes (Karunanayaka et al., 2016). Moreover, Differences in meat color may be attributed to many factors such as heme pigments, moisture content, sex, strain, protein physical status, and stress (Mehaffey et al., 2006; Jaturasitha et al., 2008). The postmortem temperature and pH affects protein denaturation and physical appearance of meat that altered the reflected amount of light from the interior and exterior surface of the meat as the extent of protein denaturation is directly proportional to light scattering (Lawrie 1991). Furthermore, the scattering of light affect meat lightness (L*) as a result of heme pigment concentration, while a minimal effect on meat yellowness (b*) and redness (a*) was occurred.

High MFI and WHC values for parent as opposed to broiler stock partially confirm Hafid et al. (2016) who reported no affects for MFI in hens slaughtered at about 220 and 337 D, and a positive correlation (0.40) between WHC and age, whereas flavor of broiler muscle were higher than for parent stock. Uhlířová et al. (2018) reported that genotype significantly affects tenderness, juiciness, flavor pleasantness, and overall acceptance (0.043, 0.004, <0.001 and <0.001, respectively). Hafid et al. (2016) reported that age significantly affects tenderness but not juiciness, suggesting that differences in flavor may be due to the solubility of collagen during cooking and the age-related role of connective tissue in facilitating the migration of juice out of muscle cells. The differences in overall acceptability of the muscles of different genotypes may be attributed to the total body fat content and the muscle fiber size that could alter its tenderness (Uhlířová et al., 2018). Increase in the WHC in parent stock of muscles enhancing juiciness, firmness, tenderness, and appearance that subsequently improve the economic value and quality of meat (Mir et al., 2017). Concerning sex effects, females had high MFI and muscle tenderness values compared to males, and the interaction of stock type and sex was nonsignificant for all parameters. Abdullah and Matarneh (2010) reported non-significant effects for sex on WHC with non-significant interaction between aging*sex. In contrast, Damaziak et al. (2013) found that muscles of male turkeys had higher WHC than those of females.

CONCLUSION

We conclude that parent breeders have better carcass characteristics than their broiler offspring, but that Ross 308 broilers, and especially females, had better meat quality than parent breeders.

SUPPLEMENTARY DATA

Supplementary data are available at *Poultry Science* online.

ACKNOWLEDGEMENTS

This research was supported by The Deanship of Scientific Research, King Saud University through the Research Group Project No.: RGP-VPP-267.

REFERENCES

Abdullah, A. Y., and S. K. Matarneh. 2010. Broiler performance and the effects of carcass weight, broiler sex, and post chill carcass aging duration on breast fillet quality characteristics. J. Appl. Poult. Res. 19:46–58.

AMSA. 1995. Research guidelines for cookery, sensory evaluation, and instrumental tenderness measurements of fresh meat. American Meat Science Association (AMSA) & National Live Stock and Meat Board, Chicago.

Augustyńska-Prejsnar, A., and Z. Sokołowicz. 2014. Czynniki kształtujące jakość sensoryczną mięsa kurcząt brojlerów (Factors affecting the sensory quality of broiler chicken meat). Wiad. Zoot. 2.

Combes, S., F. Lebas, H. Juin, L. Lebreton, T. Martin, N. Jehl, L. Cauquil, B. Darche, and M. A. Corboeuf. 2003. Comparison of standard rabbit and Bio rabbit: Sensory analysis and mechanical tenderness of the meat. Proc 10èmes Journ Rech Cunicole; 2003 Nov 19–20; Paris, France, 137–140 .

Culler, R. D., F. C. Parrish JR, G. C. Smith, and H. R. Cross. 1978. Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine longissimus muscle. J. Food Sci. 43: 1177–1180.

Dadgar, S., E. S. Lee, T. L. V. Leer, N. Burlinguette, H. L. Classen, T. G. Crowe, and P. J. Shand. 2010. Effect of microclimate temperature during transportation of broiler chickens on quality of the pectoralis major muscle. Poult. Sci. 89:1033–1041.

Damaziak, K.,, D. Pietrzak, M. Michalczuk, J. Mroczek, and J. Niemiec. 2013. Effect of genotype and sex on selected quality attributes of turkey meat. Arch. Geflügelk. 77:S206–214.

Fernandes, J. I. M., C. Bortoluzzi, G. E. Triques, A. F. Garcez Neto, and D. C. Peiter. 2013. Effect of strain, sex and age on carcass parameters of broilers. Acta. Scientiarum. 35:99–105.

Glamoclija, N., M. Starcevic, J. Janjic, J. Ivanovic, M. Boskovica, J. Djordjevic, R. Markovic, and M. Z. Baltic. 2015. The effect of breed line and age on measurements of ph-value as meat quality parameter in breast muscles (*m. Pectoralis Major*) of broiler chickens. Procedia. Food Sci. 5:89–92.

Hafid, K., M. Gagaoua, H. Boudechicha, S. N. Rabah, F. Z. M. Sellama, S. Becila, and A. Boudjellal. 2016. A comparison of the carcass and meat quality of ISA (F15) spent hens slaughtered at two different ages. Am. J. Food Tech. 11:134–142.

Holcman, A., R. Vadnjal, B. Zlender, and V. Stibilj. 2003. Chemical composition of chicken meat from free range and extensive indoor rearing. Archiv fur Geflugelkunde. 67:120–124.

Honikel, K. O., and R. Hamm. 1994. Measurement of water-holding capacity and juiciness. Pages 125–161 in Quality attributes and their measurement in meat, poultry and fish products. A. M. Pearson, and T. R. Dutson, ed. Blackie Academic and Professional, London, UK.

Jaturasitha, S., T. Srikanchai, M. Kreuzer, and M. Wicke. 2008. Differences in carcass and meat characteristics between chicken indigenous in northern Thailand (Black-Boned and Thai Native) and imported extensive breeds (Bresse and Rhode Islands Red). Poult. Sci. 87:160–169.

Karunanayaka, D. S., D. D. Jayasena, and C. Jo. 2016. Prevalence of pale, soft, and exudative (PSE) condition in chicken meat used for commercial meat processing and its effect on roasted chicken breast. J. Anim. Sci. Technol. 58:27. doi: 10.1186/s40781-016-0110-8.

Kirmizibayrak, T., K. Önk, B. Ekiz, and 2011. Effects of age and sex on meat quality of Turkish Native Geese raised under a free-range system. Kafkas Univ. Vet. Fak. Derg. 17:817–823.

Lawrie, R. A. 1991. Meat science. 5th edn. Pergamon Press, New York, pp 56–60.

Lee, Y. S., A. Saha, R. Xiong, C. M. Owens, and J. F. Meullenet. 2008. Changes in broiler breast fillet tenderness, water-holding capacity, and color attributes during long-term frozen storage. J. Food Sci. 73:E162–E168.

Lopez, K. P., M. W. Schilling, and A. Corzo. 2011. Broiler genetic strain and sex effects on meat characteristics. Poult. Sci. 90:1105–1111.

Mehaffey, J. M., S. P. Pradhan, J. F. Meullenet, J. L. Emmert, S. R. McKee, and C. M. Owens. 2006. Meat quality evaluation of minimally aged broiler breast fillets from five commercial genetic strains. Poult. Sci. 85:902–908.

Mir, N. A., A. Rafiq, F. Kumar, V. Singh., and V. Shukla. 2017. Determinants of broiler chicken meat quality and factors affecting them: a review. J. Food Sci. Technol. 54:2997–3009.

Muth, P. C., and A. Valle Zárate. 2017. Breast meat quality of chickens with divergent growth rates. Arch. Anim. Breed. 60:427–437. https://doi.org/10.5194/aab-60-427-2017.

Nowak, M., and T. Trziszka. 2010. Zachowania konsumentow na rynku miesa drobiowego. Żywność Nauka Technologia Jakość. 17:114–122.

NRC. 1994. Nutrient Requirements of Poultry. Pages 155. Natl. Acad. Press, Washington, DC, USA.

Offer, G., and J. Trinick. 1983. On the mechanism of water holding in meat: the swelling and shrinking of myofibrils. Meat Sci.8:245–281.

Petracci, M., M. Bianchi, and C. Cavani. 2009. Pre-slaughter handling and slaughtering factors influencing poultry product quality. World Poult. Sci. J. 60:17–26.

Połtowicz, K., and J. Doktor. 2012. Effect of slaughter age on performance and meat quality of slow-growing broiler chickens. Ann. Anim. Sci. 12:621–631.

Statistical Analysis Systems. 2002. SAS Version 9.1. SAS Institute Inc., Cary.

Shafey, T. M., A. H. Mahmoud, E. Hussein, and G. Suliman. 2014. The performance and characteristics of carcass and breast meat of broiler chickens fed diets containing flax seed meal. Ital. J. Anim. Sci. 13:4, DOI: 10.4081/ijas.2014.3514.

Shewita, R.S., and A.E. Taha. 2018. Influence of dietary supplementation of ginger powder at different levels on growth performance, hematological profiles, slaughter traits and gut morphometry of broiler chickens. S. Afr. J. Anim. Sci. 48:997–1008.

Sogunle, O. M., L. T. Egbeyale, O. A.Alajo, O. O. Adeleye, A. O. Fafiolu, O. B. Onunkwor, J. A. Adegbite, and A. O. Fanimo. 2010. Comparison of meat composition and sensory values of two different strains of broiler chickens. Arch. Zootec. 59; 311–314.

Sun, Y. M., and M. Luo. 1993. Pages 284–293 in Livestock and Poultry Meat Science. Shandong Science and Technology Press, Jinan, China.

Szkucik, K., R. K. Pisarski, B. Nastaj, L. Pijarska, and H. Malec. 2007. Wpływ wieku ubojowego kurcząt na cechy rzeźne oraz jakość tkanki mięśniowej [Influence of chicken age at slaughter on carcass characteristics and on the quality of meat]. Med. Weter. 63; 1353–1356.

Tilki, M., M. Saatci, T. Kirmizibayrak, and A. Aksoy. 2005. Effect of age on growth and carcass composition of Native Turkish Geese. Arch. Geflugelkd. 69:77–83.

Trout, G. R. 1988. Techniques for measuring water binding capacity in muscle foods – a review of methodology. Meat Sci. 23:235–252.

Uhlířová, L., E. Tůmová, D. Chodová, J. Vlčková, M. Ketta, Z. Volek, and V. Skřivanová. 2018. The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of geese. Asian-Australas J. Anim. Sci. 31:421–428.

Young, L.L., J. K. Northcutt, R. J. Buhr, C. E. Lyon, and G. O. Waret. 2001. Effects of age, sex, and duration of postmortem aging on percentage yield of parts from broiler chicken carcasses. Poult. Sci. 80: 376–379.

Zdanowska-Sąsiadek, Ż., M. Michalczuk, E. Poławska, K. Damaziak, J. Niemiec, and A. Radzik-Rant. 2016. Dietary vitamin E supplementation on cholesterol, vitamin E content, and fatty acid profile in chicken muscles. Can. J. Anim. Sci. 96:114–120.

Zhuang, H., and E. M. Savage. 2008. Validation of a combi oven cooking method for preparation of chicken breast meat for quality assessment. J. Food Sci. 73:S424–S430.

Zhuang, H., M. E. Berrang, D. P. Smith, and E. M. Savage. 2008. Effect of dry-air chilling on Warner-Bratzler shear force and water-holding capacity of broiler breast meat deboned four hours postmortem. Int. J. Poult. Sci. 7:743–748.