PAT December, 2024; 20(2): **40-50** *ISSN: 0794-5213*

Online copy available at www.patnsukjournal.org

Publication of Nasarawa State University, Keffi

ORIGINAL ARTICLE

IMPACT OF SLAUGHTER AGE ON BODY GROWTH, CARCASS AND MEAT QUALITY TRAITS OF BROILER CHICKENS

*§Kaye, J., †Idahor, K. O. and ϕFinangwai, H. I.

§Department of Animal Production, Faculty of Agriculture, University of Jos, Nigeria
†Department of Animal Science, Nasarawa State University, Keffi, Shabu-Lafia Campus, Nigeria
ϕDepartment of Animal Science, Faculty of Agriculture, Plateau State University, Bokkos, Nigeria
*Corresponding author e-mail: kayej@unijos.edu.ng

Abstract

The research aimed at investigating the effects of slaughter age on body growth, cut-up pieces of carcasses and meat quality. A total of 120 day-old marshal broiler chickens were obtained from reputable hatchery factory at Ibadan. The birds were divided into two treatments of 60 birds each based on age at slaughter (6 and 8 weeks) 30 birds were randomly selected from each treatment at the end of the study. Data on body growth, cut-up pieces of carcasses and meat quality were collected and analysed by analysis of variance with broiler line, and age at slaughter as main effect. The live broiler body weights were significantly ($p \leq 0.05$) heavier than fresh and boiled carcass weight. At 8-week of age, there were increase in live body weight, boiled carcass weight, fresh carcass weight and breast meat weight at rate of 1051g, 841g, 405g and 108g, respectively. There was no significant difference between boiled carcass yield (BCY) and fresh carcass yield (FCY). However, there was significant difference ($p<0.05$) in age at slaughter between 6 and 8 weeks. The pH and R-values differed significantly ($p<0.05$) at 24 h., with mean pH values of 5.88 and 5.79 for the Body and Breast broilers, respectively. The differences in pH at 24 h PM between strains significantly influenced the colour and water holding attributes of breast parts. The correlation between pH at 6 h and pH at 24 h was significant but small (0.22). It was ascertained that at 6 weeks of age, the Marshal broiler reached market sized weight, therefore the farmers can make profit and also good quality broiler meat can be obtained at 6 weeks for good taste.

Key words: Body weight, carcass quality, post-mortem, pectoralis muscle

Introduction

In recent times, there is increased demand for cut-up carcass pieces and processed products, production of broiler chickens with good carcass traits, in other words, with high body weight, has also increased. As a result of the targeting of higher growth rates and breast meat yields in broiler chicken production, standard broiler chickens are reared for longer time periods as stated (Baeza *et al*., 2012). In broiler chicken production, the extension of the growth period affects profitability, due to several reasons, including altered feed conversion rates and reduced numbers of broiler chickens being able to be reared per unit area. Meat quality has always been a major factor, which defines consumer preference. In line with the changes that have occurred in consumer preferences, in recent years, chicken meat has started to be presented in the form of cut-up pieces and processed products rather than as whole carcasses.

Thus, the quality traits of cut-up pieces, including breast fillets, whole legs, chicken leg special and chicken drumsticks, have gained increased importance, and quality criteria such as colour, texture and pH have attained greater importance. The colour of poultry meat, which varies with the myoglobin level contained in the muscle tissue, depending on species, genotype, age and muscle type (Joo *et al*., 2013), is a quality attribute, which influences consumer preference. The water-holding capacity affects both the texture and tenderness of raw meat and the sensory properties of cooked meat. Drip loss and pH value are

further quality criteria of poultry meat and are affected by several factors, including among others, pre-slaughter conditions, feeding and genotype. Alterations in the pH value of the muscles at the time of slaughter and the pH value of the carcass following slaughter define the level of drip loss. Furthermore, meat texture is defined by growth, slaughter and carcass traits of broiler chickens, and also by the muscle width and volume of connective tissue produced, depending on the level of growth (Bouton *et al.,* 1975). The research aimed at investigating the effects of slaughter age, body growth and breast part, cut-up pieces of carcasses, boiled and fresh meat, and meat quality of marshal broiler chickens.

Materials and Methods

Experimental site

The study was conducted at the Federal College of Forestry Jos – Plateau State. The state is located on latitude and longitude 9.8965° N, 8.8583° E and has average temperatures range from 15.5 - 18.5°C in the coolest months to 27.5 - 30.5 °C during the hottest months usually occur in the dry season months of March and April. Rainfall ranges from 2,000 mm per year in the southwest to 1,500 mm or less in the drier northeast. Rainfall for the town of Jos averages 1,411 mm per year (Onimisi, 2014*).*

Selection of Broiler chickens for the study

A total of 120 day-old Marshal broiler chickens were obtained reputable hatchery factory at Ibadan from and raised at Federal College of Forestry Jos – Plateau State. The birds were divided into two treatments of 60 birds each based on age at slaughter (6 and 8 weeks). 30 birds were randomly selected from each treatment at the end of the study to determine fast growth (Body) and high meat yield (Breast) at 6 and 8 weeks.

Formulation of Diets

The diets were formulated to enhance growth rate and meat yield. Starter (1 to 8 d), grower (19 – 41) and finisher (42 – 56 d) diets for three phases of the growing period. The ingredient and nutrient composition of the diets are presented in Table 1. The crude protein contents of the diets were starter (23%), grower (21%) and finisher (19%). All diets were corn and soybean-based and formulated to meet the NRC recommendation for broilers.

A total of 120 day-old male broilers were used in the experiment. The birds were housed in floor pens with wood shavings in group of 60 birds / pen providing a stocking density of 0.08 M2 per bird. The birds were provided with constant water ad-libitum and required quantity of feed intake daily, and a light availability for 23h during the entire growing period.

Sixty (60) each of the marshal broilers were selected at 6 and 8 weeks of age, respectively, to evaluate meat quality characteristics. The day before processing, 3 birds were randomly picked for each of 6 and 8 weeks, wing banded, weight and placed in pen 10 h prior to slaughter. During the period, the birds were deprived of feed and water and placed in a ventilated area within the house until transported and processed the next day. The birds were slaughtered in groups of eight birds at 15 min intervals to allow for post-mortem (pm) sampling. Birds were weighed before slaughter, stunned and slaughtered in accordance to normal practices. Following stunning, all birds were exsanguinated within 15 s by severing both the caroid artery and jugular vein on one side of the neck and were allowed to bleed for 150 s.

After bleeding, birds were sub scalded at 54ºC for 120 s in a rotary scalded 2, defeathered in a rotary drum picker3 for 35 s, and manually eviscerated. At 15 min PM, birds were weighed to record hot carcass weight, and tissue samples were taken for further analysis. In order to collect tissue samples, a scalpel blade was used to make a lengthwise incision in the skin covering the cranial portion of the left breast muscle. After each sampling, the skin covering the fillet was pulled together and clamped4 to avoid direct water contact with the muscle. Tissue samples were cut parallel to the muscle fibres from the cranial portion of the left fillet of each carcass at 0.30, 6, and 24 h PM.

Table 1. Percentage composition and nutrient content of the experimental diets

Ingredients	Starter	Grower	Finisher
		(%)	
Ground yellow corn	64.38	69.97	76.34
Soybean meal	26.70	21.15	14.06
Denosumab	5.00	5.00	5.00
Animal fat	0.50	0,50	1.65
Phosphate	1.76	1.64	1.43
Vitamin-Mineral premix1	0.70	0.70	0.70
Limestone	0.42	0.46	0.37
Salt	0.26	0.28	0.27
DL-Methionine	0.23	0.27	0.19
Lysine	0.00	0.00	0.00
Bacitracin salicylate	0.05	0.05	0.05
	Nutrient Composition Calculated		
ME, kcal/kg	1406.69	1420.63	1474.66
Crude protein	21.10	16.96	16.10
Crude fibre	2.06	1.97	1.86
Arginine	1.28	1.12	0.91
Lysine	1.20	1.04	0.84
Methionine	0.59	0.60	0.49
Methionine & cysteine	0.91	0.89	0.74
Tryptophan	0.23	0.20	0.16
Leucine	1.77	1.62	1.43
Isoleucine	0.77	0.68	0.56
Threonine	0.84	0.74	0.63
Valine	0.94	0.85	0.73
Calcium	0.95	0.91	0.80
Total phosphorus	0.58	0.52	0.45
Available phosphorus	0.48	0.45	0.40
Sodium	0.21	0.21	0.20
Potassium	0.80	0.69	0.56
Chloride	0.24	0.25	0.24

1 Composition of vitamin-mineral premix provided per kilogram of diet: Fe, 60mg; Cu, 5 mg; Zn, 51.4 mg; Mn, 60.8 mg; Se, 0.2 mg; I, 0.6 mg; vitamin A, 12,000 IU; cholecalciferol, 3,000 IU; vitamin E, 49 IU, vitamin B1, 2.1 mg; vitamin B2, 6.6 mg; vitamin B6, 4.1 mg; vitamin B12, 20.7 µg; pantothenic acid; 15 mg; nicotinic acid 36 mg; folic acid, 1 mg; biotin, 102 mg; choline chloride, 700 mg; ethoxyquin, 120 mg.

Immediately after sampling, muscle tissues were wrapped in wax paper and aluminium foil, frozen in liquid nitrogen, placed in labelled plastic bags, and stored in dry ice until transported to the laboratory. Samples were stored in an ultra-low freezer at – 80° C until analysed. After tissue sampling, carcasses were chilled and held in water-ice slush for 24 h. After aging for 24 h, carcasses were removed from the water-ice slush, sampled, weighed, and the Pectoralis major muscles removed and weighed. The intact right fillet was kept for further analysis, while the remaining left fillet was discarded. For birds killed at 6 weeks, colour was evaluated only on the dorsal surface. However, at 8-week, colour measurements were made on the cranial portion of the dorsal and ventral surfaces of the right fillet. Colour measurements of the skinless muscle surfaces were determined using colour meter for both colour and luminance measures surface colours of the meat which read the difference in colour in L d*a*b*, L*C*H* and Delta E*ab according to requirements. The colour meter was programmed to calculate the average of three separate colour readings (L* = 97.91, a* = -0.68, b* =2.45). Immediately after colour evaluation, the right fillet was placed in zip-lock plastic bags and kept frozen at –20° C until used.

Temperature profile

Breast muscle temperature was monitored from 0.30 to 10 h PM. After evisceration (0.30 h), thermocouples prepared with 2.54 cm 18 gauge hypodermic needles were inserted into the cranial end of the left Pectoralis major muscle and secured in place with binder clips. Temperature was recorded for each

bird using an automatic data recorder programmed to read and record each thermocouple temperature at 1 min intervals from .30 to 6 h PM and every 15 min from 6 to 10 h PM. Data from each processing day were downloaded to a computer and prepared for analysis.

Measurement of pH

Tissue samples collected from the Pectoralis major muscle at .30, 6, and 24 h were used for pH determination. Breast meat pH values were determined in duplicate using the iodoacetate method as described by Jeacocke, (1977) and Sams and Janky (1986). Muscle pH was evaluated by homogenizing8 3 g of tissue in 30 ml of a .005 M sodium iodoacetate solution (1:10 weight (g) to volume mixture (ml)) at 14,600 rpm for 40 s. After homogenization, the pH of the slurry was measured using a pH meter9 equipped with a Fisher pH electrode.

R-Value

Absorbance or R-value was determined according to the method described by Thompson *et al*. (1987) on muscle samples collected at .30, 6, and 24 h PM from the right breast fillet. The R-value is the ratio of the concentration of inosine monophosphate (IMP) to adenosine triphosphate (ATP) and is used as an indicator of ATP depletion in the muscle. Approximately 3 g of muscle tissue was homogenized8 in 20 ml of 1 M per chloric acid solution for 1 min at 14,600 rpm. Following homogenization, the solution was filtered through Fisher P810 filter paper. A 0.1 ml aliquot of the acid filtrate was added to 4.0 ml of 0.1 M phosphate buffer solution (pH 7) and mixed thoroughly for 10 s with a Vortex mixer. The absorbance of the solution was determined at 250 nm for IMP and at 260 nm for ATP using a spectrophotometer11. The R-value was calculated as the ratio of absorbance at 250 nm divided by the absorbance at 260 nm.

Determination of Water Holding Capacity

Water holding capacity (WHC) was determined according to the procedure described by Wardlaw *et al*. (1973). The frozen right parts were thawed at 4° C for 8 h in a refrigerator. The cranial ends were cut and ground for 1 min in a food processor12 to achieve the desired particle size of approximately 3 mm of diameter. Five-gram portions of the ground meat were weighted and placed in 35 ml assay tubes containing 8.0 ml of 0.6 M NaCl. The solution was mixed with a vortex for 30 s, incubated for 30 min at 4° C and centrifuged13 at 7000 x g for 15 min. After centrifugation, the volume of the supernatant was measured using a 10 ml volumetric cylinder and the results were reported as the proportion the fluid retained by the sample according to the following equation: WHC = ((Initial volume -Volume of supernatant)/Initial volume) x 100.

Determination of Expressible Moisture

Expressible moisture (EM) was determined according to the procedure described by Earl *et al*. (1996). The ground cranial portion of the right breast part used for determination of WHC was analysis, thus: Three pieces of Whatman paper (5.5 cm) and one piece of Whatman filter paper (7.0 cm) were formed into a thimble by shaping the filter papers around the outer round bottom of an inverted 16 * 150 mm test tube with the filter paper as the internal surface of the thimble. The filter paper thimble was weighed, and approximately 1.5 g of ground meat wrapped and folded in a 15 cm2 piece of 0.1 mm mesh white tulle netting was placed inside the thimble. The meat-netting and thimble package was inserted into a 50 ml polycarbonate centrifuge tube and centrifuged12 at 30,900 x g for 15 min at 4° C. After centrifugation, the thimble package was removed with tweezers and the meat discarded. The filter paper with moisture was weighed and expressible moisture was reported as the percentage weight lost from the original samples according to the following equation: EM = ((Filter paper weight after centrifugation - Filter paper weight before centrifugation)/ Meat sample weight) x 100.

Statistical Analysis

Data were analysed by analysis of variance with broiler line, age at slaughter as main effects using General Linear Models. Data were subsequently analysed for the effect of the breed using SAS (statistical program package, 2001). Significant differences were assessed using the least significant difference procedure.

Results and Discussion

The Body Weight during the Growth Period

The body weight at 1, 2, 4, 6, 8 weeks at age during the growing period are summarized in table 2. The live broiler body weights were significantly ($p \leq 0.05$) heavier than fresh and broiler carcass weight. At 8 weeks, there was an increase in live body weight, boiled carcass weight, fresh carcass weight and breast meat weight at rate of 1051g, 841g, 405g and 108g, respectively. The result indicated that increased in age of the broilers led to increase in live body weight and breast parts of the birds. In previous research on growth performance of broiler chickens, it has been indicated that maximum income is obtained with 6weeks to 8 weeks-old broiler chickens, and that profitability decreases with extended growth periods (Baeza *et al*., 2012).

Similarly, Table 2. Live body weight1 (LBW), boiled carcass weight (BCW), fresh carcass weight (FCW) and breast meat weight (BMW)

Source of variation	LBW_1	BCW	FCW	BMW
		(g)		
$Body_2$	2725±0.11	1958±0.13	2075±0.31	364±0.36
$Breast_2$	2690±0.05	1964±0.42	2082±0.12	443±0.28
SEM	19.45	16.82	16.71	6.74
Age:				
6weeks	2182±0.22	1551±0.10	1677±0.24	323±0.21
8weeks	3233±0.18	2392±0.16	2082±0.31	431±1.01
SEM	19.21	19.17	16.23	6.21

1 Live body weight following feed and water deprivation for 10 h; 2 Line of commercial broilers selected for either growth rate (Body) or enhanced breast yield (Breast). It has been suggested that the highest profitability is achieved with growth up to 7 weeks and that profitability decreases as from 7 weeks of growth.

Carcass and Body Composition Traits

The result showed in table 3 indicated that there was no significant difference between BCY and FCY. Body weight, BCY, FCY, BMY. However, there was significantly increased at age of slaughtered increased from 6 and 8 weeks (Table 3). However, age, which resulted in significant reduction in water uptake of carcass at 8 week of age. There was dearth information comparing between boiled and fresh broiler carcass.

Table 3. Boiled carcass yield (BCY), fresh carcass yield (FCY), breast meat yield (BMY), and percent water uptake

Source of variation	BCY1	FCY1	BMY1	Water Uptake
			(g)	
$Body_2$	66.56±0.22	71.07±0.52	8.97±0.08	6.54±0.09
$Breast_2$	67.67±0.17	72.23±1.04	11.81±0.30	6.77±0.27
SEM	0.25	0.23	0.19	0.21
Age:				
6weeks	67.38±0.33	73.06±0.25	14.09±0.17	7.48±0.02
8weeks	69.48±0.11	72.34±0.11	14.37±0.19	5.02±0.11
SEM	0.23	0.21	0.15	0.19

1 Percentage of live body weight after feed and water deprivation for 10 h.
2 Line of commercial broilers selected for either growth rate (Body) or enhanced breast yield (Breast).

Meat Quality Traits

The studied showed in table 4 indicated that there were no significant differences in R-values at 0.30 and 6 h PM. The pH decreased to an average of 6.22 and 6.00 at 0.30 and 6 h PM, respectively. However, pH and R-values differed significantly at 24 h PM, with mean pH values of 5.88 and 5.79 for the Body and Breast broilers, respectively. The results of this finding

Table 4. Pectoralis major muscle pH and R-value1 at 0.30, 6, and 24 h post-mortem

Source of variation	Time post-mortem (h)					
	0.30		6		24	
	pH	R-value	pH	R-value	pH	R-value
Body[1]	6.22±0.03	1.26±0.02	6.00±0.10	1.36±0.20	5.89±0.10	1.42±0.22
Breast[1]	6.27±0.11	1.27±0.04	6.06±0.06	1.32±0.03	5.80±0.05	1.46±0.07
SEM	0.03	0.03	0.02	0.02	0.03	0.02
Age:						
6weeks	6.11±0.07	1.30±0.10	5.95±0.13	1.38±0.17	5.84±0.11	1.45±0.33
8weeks	6.38±0.06	1.23±0.12	6.14±0.01	1.37±0.11	5.86±0.27	1.45±0.41
SEM	0.03	0.03	0.03	0.02	0.03	0.02

1 Line of commercial broilers selected for either growth rate (Body) or enhanced breast yield (Breast).

Is similar to those of Owens *et al*. (2000) in which turkeys of a breast strain exhibited lower pH values at 0, 2, and 24 h than turkeys of a body strain. Wheeler *et al*. (1999) reported that pH at 0.25 and 1 h PM were significantly lower in a breast strain than in a body strain of turkeys; however, pH values at 24 h PM were not measured. The lack of pH differences at 0.25 and 4 h PM between lines can be attributed to the significant line by age at slaughter. Muscle tissue pH and R-value measurements were used as indicators of the development and state of rigor mortis, respectively (Calkins *et al*. 1982).

It can also be deduced that there were significant differences on PM pH decline and R-value increase due to age at slaughter. These results suggest that rigor mortis and PM glycolysis occurred somewhat faster in younger than in older birds and are consistent with the significant line by age interaction observed for pH. However, this trend did not persist through 24 h PM, as pH and R-values were similar for both ages at 24 h PM. The lack of pH difference at 24 h was not expected because normally a faster decline in pH early PM is associated with lower muscle ultimate pH. Pietrzak *et al*. (1997) reported that breast muscle pH of turkeys categorized as fast glycolyzing was significantly lower at 20 and 60 min PM than in those of turkeys categorized as slow glycolyzing. However, by 180 min PM the pH values were no longer different between groups. Similarly, Rathgeber *et al*. (1999) reported no differences in breast meat ultimate pH values between normal and rapid glycolyzing turkey carcasses categorized on the basis of pH values at 15 min PM.

Colour attributes, water holding capacity (WHC), and expressible moisture (EM) of Pectoralis major muscles

The differences in pH at 24 h PM between strains significantly influenced the colour and water holding attributes of breast parts (Table 5). Breast parts of the Breast line exhibited higher L*, a*, and b* values than parts of the Body line. These results are consistent with previous reports indicating that lower ultimate muscle pH is associated with higher L* values (Barbut, 1993; Owens *et al*., 2000b). A similar relationship between ultimate pH and b* values has also been reported, with decreasing ultimate pH associated with increasing b* values (Allen *et al*. 1998; Wilkins *et al*. 2000).

There were no significant differences in breast meat lightness (L*) due to age at processing. The lack of L* value differences between 6 and 8 weeks processed broilers can be related to the lack of pH differences at 24 h PM, the time at which both traits were evaluated. An age-related effect in breast meat redness (a*) and yellowness (b*) was observed. Breast parts from broilers processed at 8 weeks were significantly redder and less yellow than those processed at

Table 5. Colour attributes of lightness (L*), redness (a*) and yellowness (b*), water holding capacity (WHC), and expressible moisture (EM) of Pectoralis major muscles

Variables	Color1			WHC	EM
	L*	a*	b*	(%)	(%)
Body	62.03±0.03	2.24±0.21	1.84±0.11	17.83±0.09	42.84±0.17
Breast	63.95±0.11	2.75±0.06	2.75±0.12	11.22±0.13	43.54±0.08
SEM	0.38	0.20	0.20	1.13	0.56
Age:					
6weeks	63.32±0.14	0.800±0.04	4.01±0.02	12.54±0.11	46.60±0.22
8weeks	64.02±0.03	4.176±0.21	0.542±0.04	16.94±0.02	41.01±0.06
SEM	0.46	0.19	0.20	1.13	0.52

1 Measured on the dorsal (skin side) surface of boneless, skinless breast fillets.
2 Line of commercial broilers selected for either growth rate (Body) or enhanced breast yield 6 weeks. These results coincide with previous reports indicating that meat redness (a*) increases with age due to an increase of myoglobin concentration in poultry muscles (Froning *et al*., 1968; Fleming *et al.*, 1991).

Qiao *et al.* (2001) reported that breast meat a* values were negatively correlated with b* values, thus as meat redness increases yellowness decreases. Breast meat water holding properties were significantly influenced by age at slaughter. Older birds (8 week) exhibited higher water holding properties, as indicated by the higher capacity to retain added water (WHC) and lower EM than breast muscles from younger birds (6 week). These differences were not expected considering that in the present study neither ultimate pH nor L* values differed due to age at processing. However, the differences in pH values at 0.30 and 4 h PM between 6 and 8 week processed birds indicate that the rate and extent of pH fall until 4 h was considerably faster in younger than in older birds. The calculated initial rate of pH decline from a physiological pH of 7.00 at 15 min PM was 0.07 and 0.04 units/min in broilers processed at 6 and 8weeks, respectively. These results are similar to those observed by Pietrzak *et al*. (1997) indicating that a rate of pH decline of .06 units/min observed in rapid glycolyzing turkeys resulted in PSE breast meat. In swine, a moderate case of PSE corresponds to a rate of pH decline of .02 units/min, while in a severe case the pH drops at a rate of .10 units/min (Bendall, 1973; Bendall and Swatland, 1988; Offer 1991). These differences in early PM pH may have contributed to the differences observed in WHC and EM. Judge *et al*. (1989) indicated that lactic acid accumulation and the subsequent fall in pH early in the PM period results in a reduction of reactive groups on muscle proteins available for water binding. Furthermore, several studies have demonstrated that a low muscle pH resulting from rapid metabolism early PM combined with elevated temperatures results in protein denaturation leading to poor protein functionality and the development of PSE characteristics (Briskey, 1964; Warris and Brown, 1987; Offer, 1991). However, despite the observation that no differences in muscle temperature were observed, it is known that a low muscle pH causes more severe damage than a high muscle pH at the same temperature (Offer, 1991, McKee and Sams, 1998).

Studies relating changes in water holding properties with age at slaughter have been very well documented in other species; however, studies in poultry have been minimal. Northcutt *et al*. (1994) reported an age related change in the ability of broiler breast meat to hold water; breast meat from younger broilers (21 d) had higher rates and initial amounts of drip loss than breast meat from older broilers (28, 35 and 42 d). They indicated that these changes could be the result of alterations in muscle protein isoforms that occur

during maturation. Ngoka and Froning (1982) reported no significant differences in WHC and cooking losses between breast muscles of turkeys of 16 and 20 week of age. However, the 16 week old turkeys had a significantly higher thaw loss than the 20 week old turkeys.

Colour measured at dorsal and ventral surfaces1 of broilers processed at 56 d of age

The results obtained on table 6 showed that breast meat L* values in the present study were considerably higher than those generally reported in the literature. The overall mean L* value of breast parts in the present study at 24 h PM was 66.17 and ranged between 54.46 and 73.71.

Table 6. Pectoralis major muscle colour variables of lightness (L*), redness (a*), and yellowness (b*) measured at dorsal and ventral surfaces1 of broilers processed at 56 d of age

Variables	L*	a*	b*
		Dorsal surface$_1$	
Body$_2$	63.56±0.02b,x	0.334±0.07b,x	3.59±0.09b,x
Breast$_2$	66.17±0.06a,x	0.718±0.02a,x	4.59±0.04a,x
SEM	0.58	0.27	0.39
		Ventral Surface$_1$	
Age:			
6weeks	54.46±0.08b,y	2.53±0.11a,y	8.11±0.02a,y
8weeks	56.71±0.10a,y	2.48±0.09a,y	8.79±0.06a,y
SEM	0.67	0.21	0.42

$^{x, y}$: Means with no common superscripts within the same column and line (comparison of surfaces) are significantly different at the ($p \leq 0.05$); 1 Measured dorsal (skin side), ventral (bone side) surface of boneless, skinless breast parts; 2 Line of commercial broilers selected for growth rate (Body) or enhanced breast yield (Breast

Evaluation of colour on the dorsal surface of the part and the fact that this study was conducted during the hot period which may have contributed to the higher L* values observed. McCurdy *et al*. (1996) reported that the incidence of PSE in turkeys was highest during the summer and lowest during the winter and associated these changes to environmental temperatures. Santos *et al*. (1994) stated that the higher temperatures and humidity of the summer months doubled the percentage of pig carcasses exhibiting PSE characteristics. Therefore, in order to evaluate variation in colour due to location of measurement, colour assessment was performed on both surfaces of the breast at 8 week of age. Colour L*, a*, and b* values measured on the dorsal and ventral surfaces of the part at 8 weeks are presented in Table 6. Meat lightness was significantly higher on the dorsal than on the ventral surface of the part by an average of 7.54 L* units at week 8. Differences in redness and yellowness were also observed between surfaces. The a* and b* values were approximately 2 and 1.8 times higher on the ventral than on the dorsal surface of the parts, respectively. However, despite the fact that lower L* values were observed on the ventral side, breast parts of the Breast line broilers were still significantly paler than those of the Body line and the values are still higher than those reported by other researchers. Barbut (1997) reported that breast parts of 7 week old broilers had an average L* of 46.3 and ranged between 41 and 56 L* units. In the present study the mean L* value for breast was 63.95 and ranged. However, in contrast to Barbut's study and similar to the present study, Wilkins *et al*. (2000) reported an overall mean L* value of 55.2 with a range of 45 .0 to 67.3 in a study conducted in the United Kingdom and indicated that broiler breast meat was considerably paler in the United Kingdom than in North America Barbut (1997) suggested that an L* > 49 / 50 can be used as a predictor of the incidence of PSE in broilers. If such a reference value were to be applied to the present study, approximately 90% of breast parts would be categorized as PSE. However, if a limiting value of L* > 56 is used as proposed by Boulianne and King (1995), the occurrence of PSE in the breast fillets would be approximately 40%. These results are similar to those of Wilkins *et al*. (2000) who concluded that if an L* > 50 was used as a cut-off point to characterize PSE in their study; the incidence would be higher than 90%. The results of Wilkins *et al*. (2000) and this study indicate that the incidence of pale fillets could be higher than previously reported and suggests that categorizing meat based solely on L* values may not be the most appropriate method for assessing the incidence of PSE in broilers.

Correlation Response

In that study, pH at 0.30 h was significantly correlated with pH at 6 h (0.83) but was not correlated with pH at 24 h. In addition, the correlation between pH at 6 h and pH at 24 h was significant but small (0.22) (Table 7). These correlations agree with those reported by Berri *et al*. (2001) who observed a very low genetic correlation between pH at 15 min and ultimate pH and indicated that the rate and extent of pH decline appeared to be controlled by different genes. These reports agree with results in the present study and suggest that ultimate pH may not be influenced by early PM pH values.

Table 7. Correlation coefficients of pH at 0.30 h PM (pH0.30), pH at 6 h PM (pH6), pH at 24 h PM (pH24), lightness (L*), redness (a*), yellowness (b*), body weight (BW), breast muscle weight (BMW), water holding capacity (WHC), and expressible moisture (EM)

	pH4	ph24	L*	a*	b*	BW	BMW	EM	WHC
pH.30	0.83	0.09	0.09	0.38	-0.46	0.57	0.59	-0.29	0.08
pH6		0.22	-0.02	0.24	-0.37	0.40	0.40	-0.18	0.09
pH24			-0.49	-0.18	-0.37	0.06	-0.08	-0.06	0.48
L*				0.21	0.27	0.11	0.26	0.12	-0.45
a*					-0.37	0.69	0.65	-0.19	-0.05
b*						-0.68	-0.51	0.39	-0.34
BW							0.89	-0.41	0.17
BMW								-0.26	0.04
EM									-0.28

The study, of the correlations were also significant with pH at 24 h being negatively correlated with meat lightness (L*) and yellowness (b*) by –0.49 and –0.37, respectively (Table 7). However, the observation that a* values were higher in parts exhibiting higher L* values and lower ultimate pH differ from results of Allen et al. (1998) and Qiao *et al*. (2001) who reported a significant positive correlation between ultimate pH and a* values (r = .55 and r = .94, respectively). However, in these studies colour attributes were evaluated in breast fillets obtained from a commercial processing plant and after separating the parts into groups according to colour intensity. In both studies, neither the strain nor the age of the birds was reported. In the studies of Le Bihan-Duval *et al*. (1999), a* and b* values were reported to be poorly correlated with ultimate pH (r = 0.11 and r = -0.11, respectively). In the same study, L* values were significantly correlated with a* values (r = -0.45) but not correlated with b* values (r = 0.06).

In the present study, a* and b* values were found to be positively correlated with meat lightness* (0.21 and 0.27) and negatively correlated with pH at 24 h (-0.18 and –0.37) (Table 7). Breast parts of the Breast birds had significantly lower WHC (percentage of held water) and higher EM when compared to those of the Body line. These results are consistent with the lower pH and higher L* values of breast fillets from the Breast line birds. Barbut (1993, 1997) also found that higher L* values and lower ultimate pH values corresponded to breast meat with lower WHC.

These correlations were also significant in the present study, with a correlation of -0.49 between L* and WHC and 0.48 between pH at 24 h and WHC (Table 7). Xiong *et al*. (1993) reported significant differences in breast meat ultimate pH among different commercial lines of broilers and indicated that small differences in pH can result in considerable variation in water binding properties of poultry.

Conclusion

In conclusion, the present study demonstrated that the growth period of broiler chickens could be extended up to 8 weeks. It was ascertained that for profitability at 6 weeks of age, the body and breast weight muscle also increased to market weight good quality broiler meat obtained for marketing and consumption.

References

Allen, C. D., D. L. Fletcher, J. K. Northcutt, and S. M. Rusell (1998). The relationship of broiler breast colour to meat quality and shelf life. Poultry Sci. 77:361-366.

Baéza, E., C. Arnould, M. Jlali, P. Chartrin, V. Gigaud, F. Mercerand, C. Durand, K. Meteau, E. Le Bihan-Duval, and C. Berri, (2012): Influence of increasing slaughter age of chickens on meat quality, welfare, and technical and economic results. J. Anim. Sci. **90**, 2003- 2013.

Barbut, S. (1993). Colour measurements for evaluating the pale soft exudative (PSE) occurrence in turkey meat. Food Res. Intern. 26:39-43.

Barbut, S. (1997). Problem of pale soft exudative meat in broiler chickens. Br. Poultry Sci. 38:355-358.

Bendall, J.R. (1973). Post-mortem changes in muscle. Pages 227-274 In: G.H. Bourne (Ed.) The Structure and Function of Muscle. Academic Press. New York, NY.

Bendall, J. R., and H. J. Swatland, (1988). A review of the relationships of pH with physical aspects of pork quality. Meat Sci. 24:85-126.

Berri, C., N. Wacrenier, N. Millet, and Le Bihan-Duval, (2001). Effect of selection for improved body composition on muscle and meat characteristics of broilers from experimental and commercial lines. Submitted for publication at Poultry Science.

Bihan-Duval, E., Millet, N., and Remignon, H. (1999). Broiler meat quality: Effect of selection for increased carcass quality and estimates of genetic parameters. *Poultry Science*, 78(6), 822-826.

Bouton, P.E., P.V. Harris, W.R. Shorthose, (1975): Possible relationships between shear, tensile, and adhesion properties of meat and meat structure. J. Texture Stud. **6**, 297-314.

Boulianne, M., and A. J. King, (1995). Biochemical and colour characteristics of skinless boneless pale chicken breast. Poultry Sci. 74:1693-1698.

Briskey, E. J., (1964). Etiological status and associated studies of pale, soft, exudative porcine musculature. Adv. Food. Res. 13:89-178.

Calkins, C. R., T. R. Dutson, G. C. Smith, and Z. L. Carpenter, (1982). Concentration of creatine phosphate, adenine nucleotides, and their derivatives in electrically stimulated and non-stimulated beef muscle. J. Food Technol. 8:163-166.

Earl, L. A., A. J. King, D. P. Fitzpatrick, and J. E. Cooper, (1996). A modification of a method to determine expressible moisture in ground, dark poultry meat. Poultry Sci. 75:1433-1436.

Fleming, B. K., G. W. Froning, and T. S. Yang, (1991). Haem pigment levels in chicken broilers chilled in ice slush and air. Poultry Sci. 57:630-633.

Froning, G. W., J. Daddario, and T. E. Hartung, (1968). Colour and myoglobin concentration in turkey meat as affected by age, sex, and strain. Poultry Sci. 48:668-674.

Jeacocke, R. E., (1977). Continuous measurement of the pH of beef muscle in intact beef carcasses. J. Food Technol. 12:375-386.

Joo, S.T., G.D. Kim, Y.H. Hwang, Y.C. Ryu, (2013): Control of fresh meat quality through manipulation of muscle fibre characteristics. Meat Sci. **95**, 828-836.

Judge, M. D., E. D. Aberle, J. C. Forrest, H. B. Hedrick, and R. A. Merkel,(1989). Page127 in: Principles of Meat Science. Kendall E.D. Hunt Publishing, Dubuque, IA.

Le Bihan-Duval, E., N. Millet, and H. Remignon, (1999). Broiler meat quality: Effect of selection for increased carcass quality and estimates of genetic parameters. Poultry Sci. 78: 822-826.

McKee, S. R. and A. R. Sams, (1998). Rigor mortis development at elevated temperatures induces pale exudative turkey meat characteristics. Poultry Sci. 77:169-174.

McCurdy, R. D., S. Barbut, and M. Quinton, (1996). Seasonal effect on pale soft exudative (PSE) occurrence in young turkey breast meat. Food Res. Intern. 29:363-366.

Ngoka, D. A. and G. W. Froning, (1982). Effect of free struggle and preslaughter excitement on colour of turkey breast muscles. Poultry Sci. 61:2291-2293.

Northcutt, J. K., E. A. Foegeding, and F. W. Edens, (1994). Water-holding properties of thermally preconditioned chicken breast and leg meat. Poultry Sci. 73:308-316.

Offer, G., (1991). Modelling of the formation of pale, soft and exudative meat: Effects of chilling regime and rate and extent of *glycolysis*. Meat Sci. 30:157-184.

Onimisi, Alao *(2014). "Plateau* communities *make commitment to peace"*. Daily *Trust*. *Retrieved 2015-11-05*

Owens, C. M., E. M. Hirschler, S. R. McKee, R. Martinez-Dawson, and A. R. Sams, (2000). The characterization and incidence of pale, soft, exudative turkey meat in a commercial plant. Poultry Sci. 79:553-558.

Owens, C. M., S. R. McKee, N. S. Mathews, and A. R. Sams, (2000). The development of pale, exudative meat in two genetic lines of turkeys subjected to heat stress and its prediction by halothane screening. Poultry Sci. 79:430-435.

Pietrzak, M., M. L. Greaser, and A. A. Sosnicki, (1997). Effect of rapid rigor mortis processes on protein functionality in pectoralis major muscle of domestic turkeys. J. Anim. Sci. 75:2106-2116.

Qiao, M., D. L. Fletcher, D. P. Smith, and J. K. Northcutt, (2001). The effect of broiler breast meat colour on pH, moisture, water-holding capacity, and emulsification capacity. Poultry Sci. 80:676-680.

Rathgeber, B. M, J. A. Boles, and P. J. Shand, (1999). Rapid post-mortem pH decline and delayed chilling reduce quality of turkey breast meat. Poultry Sci. 78:477-484.

Sams, A. R., and D. M. Janky, (1986). The influence of brine chilling on tenderness of hot boned chill-boned and age-boned broiler fillets. Poultry Sci. 65:1316-1321.

Santos C., L. C. Roserio, H. Goncalves, and R. S. Melo, (1994). Incidence of different pork quality categories in a Portuguese slaughterhouse: A survey. Meat Sci. 38:279-287.

SAS. (2001). SAS/STAT User's Guide. Vol. 2, Version 6, SAS Inc., Cary, NC., USA

Thompson, L. D., D. M. Janky, and S. A. Woodward, (1987). Tenderness and physical characteristics of broiler breast fillets harvested at various times from post-mortem electrically stimulated carcasses. Poultry Sci. 66:1158-1167.

Wardlaw, F. B., L. H. McCaskill, and J. C. Acton, (1973). Effects of post-mortem muscle changes on poultry meat loaf properties. J. Food Sci. 38:421-423.

Warris, P. D., and S. A. Brown, (1987). The relationship between initial pH, reflectance, and exudation of in pig muscle. Meat Sci. 20:65-74.

Wheeler, B. R., S. R. McKee, N. S. Mathews, R. K. Miller, and A. R. Sams, (1999). A halothane test to detect turkeys prone to developing pale, soft, and exudative meat. Poultry Sci. 78:1634-1638.

Wilkins, I. J., S. N. Brown, A. J. Phillips, and P. D. Warris, (2000). Variation in the colour of broiler breast fillets in the UK. Br. Poultry. Sci. 41:308-312.

Woelfel, R. L., C. M. Owens, E. M. Hirschler, and A. R. Sams, (1998). The incidence and characterization of pale, soft, and exudative chicken meat in a commercial plant. Poultry Sci. 77 (Suppl. 1):62.

Xiong, X. L., A. H. Cantor, A. J. Pescatore, S. P. Blanchard, and M. L. Straw, (1993). Variations in muscle chemical composition, pH, and protein extractability among different broiler crosses. Poultry Sci. 72:583-588.