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Evaluation of Physical and Chemical Characteristics of Male and Female Ducks Carcasses at Different Ages

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Abstract: This study was conducted at Agricultural Research Station, College of Animal Sciences, Agriculture University of Huazhong, China, for the period of 27/3/2009 to 27/6/2009. The aim was to determine the effect of strain, sex and age at slaughtering on quality traits of meat of two breeds of ducks (Cherry Valley and Chinese local duck). A total of 120 chicks (60 from each breed) one day old were used. A sample of birds was slaughtered at 6, 8, 10 and 12 weeks of age. Muscle pH at 0.25, 6 and 24 h, meat color at 24 h of breast and leg muscles, water holding capacity and proportion of losing fluids were measured. Breeds had no significant effect on breast or legs muscle PH, however, Leg muscle showed higher ($p<0.05$) pH at the storing period of 0.25 and 24 h than breast. Breast muscle of local Chinese ducks showed higher ($p<0.05$) redness (a) and less transparency (L) in comparison with Cherry Valley ducks. Males breast muscle were more ($p<0.05$) yellowness (b) in comparison with that of female for both breeds. Viscous of Cherry Valley ducks were higher ($p<0.05$) than that of Chinese local ducks. Both breeds did not exhibit significant differences. Local Chinese ducks breast muscle males showed significantly ($p<0.05$) higher water holding capacity than that of Cherry Valley breed for both sexes. Muscle extensibility and muscle shearing value and drip loss percentage of Cherry Valley carcass were higher ($p<0.05$) than that of local Chinese ducks in preceding ages.

Key words: Cherry valley duck, Chinese local duck, breast muscle

INTRODUCTION

Despite their importance, the poultry grading system based on conformation, presence or absence of carcass defects, bruises, missing parts and skin tears without taking into account the functional properties of meat (Barbut, 1997). Meat final quality depends on appearance, texture, juiciness, wateriness; firmness, tenderness, odor and flavor (Cross *et al*., 1986). Water holding capacity, shear force, drip loss, cook loss, pH, shelf life, collagen content, protein solubility, cohesiveness and fat binding capacity are among valuable quantifiable properties of meat (Allen *et al*., 1998). Meat characteristics including its physical, chemical, morphological, biochemical, microbial, sensory, technological, hygienic, nutritional and culinary properties are components of meat quality (Ingr, 1989). Postmortem temperature and pH determine the degree of protein denaturation and physical appearance of meat, influencing the amount of light that is reflected from the interior and exterior of the meat surface (Lawrie, 1991). At a pH $\geq$ 6.0, protein denaturation is minimal, light scattering is low and the muscle remains translucent. However, at pH $\leq$ 6.0 protein denaturation is high, light scattering increases and the muscle becomes very opaque. Changes in light scattering affect meat lightness (L*) in a fashion inverse to that caused by heme pigment concentration, having a minimal effect on meat redness (a*) and yellowness (b*). Genetics role in broilers meat quality has been reported (Le Bihan-Duval *et al*., 1999; Gardzielewska *et al*., 1995; Berri *et al*., 2001). Gardzielewska *et al*. (1995) showed differences in the rate of postmortem pH decline between five commercial broiler lines. Intense selection for growth and body composition traits in broilers had altered breast muscle metabolism in studies conducted using experimental and commercial lines (Berri *et al*., 2001). The purpose of the present study was to investigate the effects of duck genotype, age at slaughter and sex on certain physical, chemical and quality characteristics of duck muscles.

MATERIALS AND METHODS

Two genotypes of commercial duck were used. The duck genotype included a breed selected for overall rapid growth (Cherry Valley) and Local Chinese duck. Birds were housed in floor pens with wood shavings in groups of 60 birds/pen providing a stocking density of 0.08 M2 per bird. Each pen was equipped with one automatic bell drinker and one tube feeder. Every pen was considered an experimental replicate. Ducks were provided free access to feed and water for *ad-libitum* consumption and a lighting program of 23 h of light and

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1 h of dark per day during the entire growing period. Bird were fed starter diet contained 18% cp and 2900 kcal/kg metabolizable energy for 4 weeks. Final (growth) diet consisted of 16% cp and 2950 kcal/kg ME (NRC, 1998). One hundred and twenty ducks were processed at 84 day of age to evaluate meat quality characteristics. The day before processing, 6 birds per replicate (pen) for total of 24 birds per treatment combination were randomly chosen, wing banded, weighed and placed in coops 12 h prior to slaughter. During this 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 six birds at 15 min intervals to allow for Postmortem (PM) sampling. Birds were weighed before slaughter, stunned and slaughtered according to commercial practices. Stunning was accomplished by placing a charged knife stunner 1 (120 volts, 10 Amp) in contact with the neck of the bird at the base of the beak for 5 s and allowing the current to pass through the body to the feet. Following stunning, all birds were exanguinated within 15 s by severing both the carotid artery and jugular vein on one side of the neck and were allowed to bleed for 150 s. After bleeding, birds were subscalded at 54°C for 120 s in a rotary scalder 2, defeathered in a rotary drum picker 3 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 clamped 4 to avoid direct water contact with the muscle. Tissue samples were cut parallel to the muscle fibers from the cranial portion of the left fillet of each carcass at 0.25, 6 and 24 h PM. Immediately after sampling, muscle tissues were wrapped in wax paper and aluminum foil, frozen in liquid nitrogen, placed in labeled plastic bags and stored in dry ice until transported to the laboratory. 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.

Color measurements were made on the cranial portion of the dorsal and ventral surfaces of the right fillet. Color measurements of the skinless muscle surfaces were determined using a portable Minolta colorimeter and reported according to the CIELAB Color System values of (L*) lightness, (a*) redness and (b*) yellowness. The spectrocolorimeter was programmed to calculate the average of three separate color readings and was calibrated every 50 measurements against a standard calibration (L* = 97.91, a* = -0.68, b* = 2.45). Immediately after color evaluation, the right fillet was placed in zip-loc plastic bags and kept frozen at -20°C until used.

Measurement of pH: Tissue samples collected from the *Pectoralis major* muscle at 0.25, 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 homogenizing 3 g of tissue in 30 ml of a 0.005 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 meter equipped with a Fisher pH electrode.

Determination of water holding capacity: Water Holding Capacity (WHC) was determined according to the procedure described by Wardlaw *et al.* (1973). The frozen right fillets were thawed at 4°C for 8 h in a refrigerator. The cranial ends were cut and ground for 1 min in a food processor 12 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 centrifuged 13 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 drip loss: Drip Loss (DL) was determined according to the procedure described by Earl *et al.* (1996). The ground cranial portion of the right breast fillet used for determination of WHC was used for this analysis. Three pieces of Whatman 14 # 3 paper (5.5 cm) and one piece of Whatman # 50 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 # 50 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 cm^2 piece of 0.1 mm mesh white tulle netting was placed inside the thimble. 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:

DL = ((raw meat sample weight - sample weight after filtering)/raw meat sample weight) x 100

Meat tenderness measurements: Tenderness was measured by using Texture Analysis (TA, XT, Plus). A sample of known weight meat from breast and leg was put individually in a specific place. A power of 35 kg or 50 kg depended on time (second) and area (cm^2). The whole apparatus connected to a computer to get the following data:

- Muscle Extensibility (ME)
- Muscle shear value
- Muscle viscous

Statistical analysis: The data were analyzed as a 2 x 2 x 5 factorial design using the statistical analyses and the General Linear Model procedures of SAS (SAS Institute, 1988). Data were analyzed by analysis of variance with broiler line, plane of nutrition and age at slaughter as main effects. The Turkey's test option of SAS was used to compare and separate means when main effects were significant. Correlation coefficients for meat quality and broiler performance traits were generated using the Pearson's Correlation Coefficient option of SAS. Differences were considered significant at the $p \leq 0.05$. The data were analyzed according to the following statistical model:

$$Yijkl = \mu + Ai + Sj + Ck + (AS)ij + (AC)ik + (SC)jk + (ASC)ijk + Eijkl$$

Where, μ = Population mean; Ai = Effect of the duck line (i = 1: Cherry Valley; I = 2: Local); Sj = Effect of duck sex; Ck = Effect of the age at slaughter (k = 1: 42 days; k = 2: 53 days); (AB)ij, (AC)ik, (BC)jk, (ABC)ijk = Interactions of the main effects and Eijkl = Overall error term.

RESULTS

pH of breast muscle: Values of pH measured at 0.25, 6 and 24 h postmortem of breast muscle of Cherry Valley and local duck males and females were shown in Table 1. pH values were almost stable as time postmortem increased especially at older slaughter age (5.7-6.2 at the age of 12 weeks). Overall range of pH was 5.7-7.7, which indicated that their values more neutral to somehow acidity. Duck strain did not show significant effect on pH at all slaughter ages and time postmortem.

Leg muscle pH: Leg muscle pH values were not decrease less than 6.0 due to change in strain, slaughter age, gender or time postmortem (Table 2). Both strain and gender showed their significant ($p<0.05$)on leg muscle pH at 0.25 and 24 h postmortem of the age of 6 weeks, since local duck obtained higher values (>6.5) than Cherry Valley duck (<6.5). Lack of significance was exhibited due to strains, gender and time postmortem at the rest of slaughter age (except 6 weeks).

Table 1: Influence of strain, gender and age at slaughter on postmortem pH of breast muscle of ducks measured at 0.25, 6 and 24 h postmortem

		Age											
		6			8			10			12		
Strain	Sex	0.25	6	24	0.25	6	24	0.25	6	24	0.25	6	24
Cherry	M	5.9^{a}	6.0^{a}	5.7^{a}	6.1^{a}	6.1^{a}	6.2^{a}	6.0^{a}	6.0^{a}	6.0^{a}	5.8^{a}	5.8^{a}	5.7^{a}
vally		±0.26	±0.228	±0.17	±0.23	±0.16	±0.22	±0.25	±0.36	±0.39	±0.23	±0.12	±0.07
	F	6.2^{a}	6.3^{a}	5.9	5.9^{a}	6.0^{a}	6.0^{a}	6.2^{a}	5.8^{a}	5.7^{a}	5.9^{a}	5.9^{a}	6.0^{a}
		±0.44	±0.40	±0.40	±0.19	±0.27	±0.25	±0.47	±0.11	±0.10	±0.18	±0.09	±0.08
Local	M	6.3^{a}	6.0^{a}	6.0^{a}	6.27^{a}	6.1^{a}	6.1^{a}	6.5^{a}	6.18^{a}	6.1^{a}	6.0^{a}	6.2^{a}	5.9^{a}
duck		±0.012	±0.01	±0.02	±0.354	±0.32	±0.22	±0.23^{a}	±0.26^{a}	±0.26	±0.18	±0.23	±0.22
	F	6.3^{a}	6.0^{a}	6.0^{a}	6.16^{a}	6.1^{a}	6.0^{a}	6.3^{a}	6.2^{a}	6.2^{a}	6.2^{a}	5.9^{a}	5.9^{a}
		±0.014	±0.01	±0.012	±0.13	±0.17	± 0.1	±0.04	±0.03	±0.08	±0.17	±0.26	±0.23

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 2: Influence of strain, gender and age at slaughter on postmortem pH of leg muscle of ducks measured at 0.25, 6 and 24 h postmortem

		Age											
		6			8			10			12		
Strain	Sex	0.25	6	24	0.25	6	24	0.25	6	24	0.25	6	24
Cherry	M	6.1^{b}	6.4^{a}	6.0^{a}	6.4^{a}	6.5^{a}	6.5^{a}	6.4^{a}	6.4^{a}	6.3^{a}	6.6^{a}	6.5^{a}	6.4^{a}
vally		±0.19	±0.27	±0.34	±0.39	±0.39	±0.3	±0.44	±0.36	±0.38	± 0.2	±0.20	±0.22
	F	6.4^{ab}	6.6^{a}	6.3^{ab}	6.5^{a}	6.6^{a}	6.6^{a}	6.1^{a}	6.2^{a}	6.1^{a}	6.7^{a}	6.6^{a}	6.3^{a}
		±0.26	±0.30^{a}	±0.44	±0.32	±0.24	±0.25	±0.32	±0.28	±0.32	±0.21	±0.19	±0.27
Local	M	6.7^{a}	6.8^{a}	6.7^{b}	6.6^{a}	6.5^{a}	6.6^{a}	6.6^{a}	6.5^{a}	6.7^{a}	6.7^{a}	6.7^{a}	6.4^{a}
duck		±0.15	±0.15	±0.24	±0.21	±0.21	±0.20	±0.2	±0.17	±0.16	±0.29	±0.10	±0.51
	F	6.5^{ab}	6.6^{a}	6.7^{b}	6.7^{a}	6.5^{a}	6.5^{a}	6.5^{a}	6.5^{a}	6.5^{a}	6.8^{a}	6.8^{a}	6.6^{a}
		±0.40	±0.40	±0.29	±0.07	±0.16	±0.09	±0.14	±0.11	±0.13	±0.26	±0.20	±0.10

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 3: Influence of strain, gender and age at slaughter on color attributes of lightness (L*), redness (a*) and yellowness (b*) of breast (24) h of ducks

		Age											
		6			8			10			12		
Strain	Sex	0.25	6	24	0.25	6	24	0.25	6	24	0.25	6	24
Cherry vally	M	120.68^{a} ±7.6	7.81^{a} ±3.7	7.96^{a} ±1.3	44.58^{a} ±5.9	12.42^{a} ±1.3	11.59^{b} ±1.4	43.92^{a} ±9.3	14.4^{a} ±1.6	15.29^{ab} ±2.2	38.60^{a} ±5.2	9.31^{a} ±2.0	5.80^{a} ±1.8
	F	95.10^{b} ±29.5	7.02^{a} ±5.6	8.97^{a} ±4.4	44.04^{a} ±3.0	11.23^{a} ±1.5	10.79^{b} ±2.4	36.94^{a} ±2.8	14.83^{a} ±1.1	13.92^{ab} ±1.4	37.07^{a} ±3.2	10.63^{a} ±2.2	6.96^{a} ±1.6
Local duck	M	41.3^{c} ±3.7	13.36^{b} ±3.7	9.2^{a} ±1.6	48.16^{a} ±8.7	12.10^{a} ±3.4	16.49^{a} ±2.8	39.46^{a} ±7.7	12.10^{a} ±3.2	15.99^{a} ±4.2	43.4^{a} ±3.7	9.9^{a} ±1.1	12.63^{b} ±1.3
	F	40.0^{c} ±4.4	12.5^{a} ±4.1	8.6^{b} ±2.9	42.1^{a} ±4.3	16.5^{a} ±2.3	13.7^{b} ±2.1	40.4^{a} ±3.7	12.9^{a} ±5.9	10.8^{b} ±5.9	37.0^{a} ±4.6	10.1^{a} ±0.9	19.1^{b} ±1.3

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 4: Influence of strain, gender and age at slaughter on color attributes of lightness (L*), redness (a*) and yellowness (b*) of leg (24) h of ducks

		Age											
		6			8			10			12		
Strain	Sex	0.25	6	24	0.25	6	24	0.25	6	24	0.25	6	24
Cherry vally	M	102.1^{a} ±40.0	10.2^{a} ±5.6	9.1^{a} ±3.5	52.1^{a} ±4.0	11.2^{a} ±1.3	12.74^{a} ±0.7	41.9^{a} ±2.8	12.4^{a} ±0.4	13.8 ±1.4	42.0^{a} ±4.9	9.24^{ab} ±2.1	6.7^{a} ±1.4
	F	91.6^{a} ±43.3	10.9^{a} ±3.2	11.2^{a} ±4.1	41.6^{a} ±2.6	12.4^{a} ±3.4	11.2^{a} ±1.7	37.9^{a} ±4.6	13.1^{a} ±1.4	12.0^{ab} ±1.9	43.5^{a} ±1.8	11.9^{b} ±1.3	3.6^{a} ±1.2
Local duck	M	43.2^{b} ±2.3	12.5^{a} ±2.0	9.3^{a} ±1.8	33.6^{a} ±4.7	17.6^{b} ±0.4	14.09^{a} ±2.2	30.2^{a} ±3.4	10.8^{a} ±1.8	9.36^{b} ±3.5	30.9^{a} ±3.9	10.7^{ab} ±3.4	15.27^{b} ±3.8
	F	42.0^{b} ±5.3	11.8^{a} ±0.7	9.9^{a} ±2.0	40.3^{a} ±4.9	14.1^{ab} ±2.7	11.64^{b} ±1.3^{a}	35.5^{a} ±6.5	10.7^{a} ±1.9	11.8^{ab} ±1.9	29.1^{a} ±3.4	15.1^{ac} ±1.6	16.9^{b} ±2.7^{b}

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Breast color at 24 h postmortem: Lightness and redness of breast at 24 h postmortem had not been influenced by different strain all over slaughtering age (Table 3). Whereas, yellowness was significantly ($p<0.05$) influenced by strain at the age of 8, 10 and 12 weeks, as local ducks breast being more yellowness than that of Cherry Valley (the lowest at 12 weeks, average of both gender was around 6). Male of Cherry Valley exceeded ($p<0.05$) female in their lightness only at 6 weeks (120.6 vs. 95.1). Redness was similar for both genders at all ages. Yellowness of local duck males breasts (16.49 and 15.9) were higher ($p<0.05$) in comparison to those of females at the age of 8 and 10 weeks (13.7 and 10.8 respectively).

Leg color at 24 h postmortem: Color attributes of lightness, redness and yellowness of leg at 24 h postmortem of Cherry Valley and local duck were shown at Table 4. Lightness of leg meat was influenced significantly ($p<0.05$) when slaughter was done at 6 weeks of age. Cherry Valley leg meat exhibited higher lightness (102.1, male and 91.6, female) than that of local duck (43.2, male and 42.0, female). Lightness of duck strains slaughter at other ages (8, 10 and 12) was similar. Furthermore, redness of leg meat was significantly ($p<0.05$) influenced by strain when they were slaughtered at 8 and 12 weeks (Table 4), as local duck leg meat showed more redness at 24 h postmortem for both time of slaughter. Although Cherry Valley leg meat got higher ($p<0.05$) yellowness at 10 weeks, but it showed less ($p<0.05$) yellowness at 12 weeks. Gender of duck showed significant ($p<0.05$) effect on redness at 12 weeks only. Females leg meat of both strains were more redness than males (9.24, 11.9, 10.7 and 15.1 redness values for Cherry Valley male and female and Local duck male and female respectively). Lightness of leg meat showed negative slope with progressing age. It recorded highest values when slaughter was done at 6 weeks and lowest values at 12 weeks. The action was most pronounced in the case of Cherry Valley strain (42.0-43.5 at 12 weeks). Redness was more stable as age at slaughter increased. Yellowness of Cherry Valley leg meat decreased with increasing age at slaughter, especially in the case of females (to 3.6 at 12 weeks). On the contrary, yellowness of local duck increased as age of slaughter increase (to >15 at 12 weeks).

Breast and leg muscle shear value (LMSV): Shear value of breast muscle was indicated at Table 5. It was shown that neither strain nor gender of duck slaughtered at different ages influence breast shear values. Work shear was nearly doubled when slaughter took place at 8-12 weeks in comparison to their values at 6 weeks, especially for Cherry Valley ducks. Values of leg muscle shear of duck of different strain and gender were similar work shear increased with progressing of slaughter age of both strain and genders.

Table 5: Influence of strain, gender and age at slaughter on breast and muscle shear value (LMSV) kg/cm^2 of ducks

		Age							
		6		8		10		12	
Strain	Sex	Breast	Leg	Breast	Leg	Breast	Leg	Breast	Leg
Cherry vally	M	2.80^a±0.94	2.03^a±1.65	1.86^a±1.07	2.0^a±1.2	2.79^a±0.43	2.91^a±2.70	2.72^a±0.90	3.3^a±1.2
	F	2.46^a±1.25	2.25^a±1.14	3.25^a±0.87	3.11^a±2.10	2.54^a±0.298	2.3^a±1.22	2.90^a±0.88	2.52^a±1.34
Local duck	M	3.18^a±0.92	1.72^a±0.56	3.24^a±1.61	1.84^a±0.66	3.61^a±1.5	2.38^a±0.79	4.41^a±0.586	3.84^a±1.16
	F	2.24^a±0.69	1.9^a±0.8	1.95^a±1.11	1.74^a±0.98	3.29^a±2.03	2.62^a±1.30	4.05^a±1.0	2.96^a±1.0

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 6: Influence of strain, gender and age at slaughter on Breast Muscle Extensibility (BME) kg/cm^2 of ducks

		Age							
		6		8		10		12	
Strain	Sex	Breast	Leg	Breast	Leg	Breast	Leg	Breast	Leg
Cherry vally	M	0.74^a±0.39	0.40^a±0.15	0.44^a±0.16	0.28^a±0.08	0.46^a±0.11	0.49^a±0.25	0.37^a±0.15	0.636^a±0.456
	F	0.61^a±0.28	0.51^a±0.22	0.40^a±0.34	0.50^a±0.27	1.05^a±1.127	0.97^a±0.73	0.62^a±0.12	0.567^a±0.42
Local duck	M	0.38^a±0.22	0.33^a±0.17	0.48^a±0.26	0.63^a±0.41	0.66^a±0.28	0.95^a±0.43	1.12^a±0.31	0.92^a±0.56
	F	0.34^a±0.24	0.35^a±0.24	0.53^a±0.38	0.34^a±0.15	0.573^a±0.241	0.86^a±0.73	0.61^a±0.28	0.45^a±0.08

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 7: Influence of strain, gender and age at slaughter on Breast and Leg Muscle Viscous (BMV, LMV)

		Age							
		6		8		10		12	
Strain	Sex	Breast	Leg	Breast	Leg	Breast	Leg	Breast	Leg
Cherry vally	M	7.74^a±0.01	7.75^a±0.03	7.72^a±0.013	7.74^a±0.017	7.72^a±0.022	7.71^a±0.021	7.7^a±0.04	7.75^{ab}±0.03
	F	7.7^a±0.03	7.75^a±0.03^a	7.7^a±0.034	7.72^a±0.01	7.704^a±0.006	7.69^b±0.01	7.7^a±0.015	7.7^b±0.021
Local duck	M	7.72^a±0.03	7.88^b±0.03	7.84^b±0.05	7.77^a±0.03	7.78^b±0.037	7.75^b±0.03	7.73^a±0.04	7.78^a±0.04
	F	7.70^a±0.02	7.89^b±0.02	7.78^c±0.03	7.76^a±0.04	7.28^c±0.01	7.22^{ac}±0.01	7.7^a±0.03	7.76^a±0.03

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Breast and leg muscle extensibility (LME): Extensibility of duck breast muscle was shown in Table 6. Extensibility (kg/cm^2) was not influenced by strain or gender at all age of slaughter. However, extensibility of leg muscle was significantly ($p<0.05$) higher that of male of the same strain and both gender local duck slaughtered at 12 weeks.

Breast and leg muscle viscous (BMV, LMV): Duck of different strains and gender breast muscle viscous was shown in Table 7. Viscous (F.1 kg) was influenced ($p<0.05$) by strain of duck slaughtered at 8 and 10 weeks, local duck obtained higher values. Viscous of duck slaughtered at 8 and 12 weeks were influenced ($p<0.05$) by gender. Strain affected leg muscle viscous (kg) of duck slaughtered at 6, 10 and 12 weeks significantly ($p<0.05$; Table 7), as local duck got higher values than Cherry Valley strain. Gender significant ($p<0.05$) effect viscous (F.1 kg) appeared at slaughter age at 10 weeks. However, higher values did not associated with one gender (fluctuated between male and female). Values of viscous of leg muscle were stable at all ages of slaughters.

Water holding capacity of breast and leg muscles: Water holding capacity of breast and leg muscles of Cherry Valley strain decreased dramatically with increasing in slaughter age (Table 8). Their values were around 0.15-0.20 at 6 weeks slaughter age; however, they dropped down to 0.08-0.10 at 12 weeks slaughter age. As well as, holding capacity of breast muscle influenced ($p<0.05$) by strain and gender at 12 weeks slaughter age and that of leg muscle at 6 and 12 weeks. Breast water holding capacity of local duck male at 12 weeks (0.175) was higher than that of female of the same strain and both gender of Cherry Valley ducks (0.11, 0.09 and 0.07 respectively). Leg muscle water holding capacity of Cherry Valley ducks slaughtered at 6 weeks was higher (0.27) than the rest groups. While, that of local duck female (0.20) was higher than others at 10 weeks.

Breast and leg muscles drip loss (BWDL and LWDL): BWDL was influenced ($p<0.05$) by strain and gender at 8-12 weeks slaughter ages, but LWDL influenced only at 10 and 12 weeks (Table 9). Local duck breast and leg muscle drop loss were mostly greater than that of cherry Valley ducks. Drop loss of breast muscle slightly decreased with preceding slaughter age. On the other hand, drop loss in leg muscle was almost stable at all slaughter ages.

Table 8: Influence of strain, gender and age at slaughter on Water Holding Capacity of Breast (BWHC) and Leg (LWHC) of ducks

		Breast (BWHC)				Leg (LWHC)			
Strain	Sex	6	8	10	12	6	8	10	12
Cherry vally	M	0.15^{a}±0.06	0.17^{a}±0.03	0.18^{a}±0.11	0.09^{ab}±0.02	0.11^{a}±0.04	0.12^{a}±0.07	0.14^{ab}±0.128	0.08^{b}±0.041
	F	0.20^{a}±0.06	0.14^{a}±0.06	0.14^{a}±0.07	0.07^{b}±0.03	0.27^{b}±0.13	0.09^{a}±0.001	0.09^{b}±0.03	0.10^{b}±0.02
Local duck	M	0.18^{a}±0.01	0.16^{a}±0.07	0.20^{a}±0.07	0.175^{a}±0.07	0.08^{c}±0.02	0.13^{a}±0.03	0.15^{ab}±0.06	0.15^{ab}±0.06
	F	0.19^{a}±0.02	0.15^{a}±0.008	0.30^{b}±0.022	0.11^{ab}±0.02	0.08^{c}±0.04	0.15^{a}±0.05	0.20^{a}±0.07	0.10^{b}±0.05

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

Table 9: Influence of strain, gender and age at slaughter on; Breast Muscle Drop Loss (BWDL), Leg Muscle Drip Loss (LWDL) of ducks

		Breast (WDL)				Leg (WDL)			
Strain	Sex	6	8	10	12	6	8	10	12
Cherry vally	M	0.05^{a}±0.01	0.05^{b}±0.01	0.09^{b}±0.05	0.03^{b}±0.01	0.04^{a}±0.01	0.05^{a}±0.02	0.03^{b}±0.003	0.04^{ab}±0.021
	F	0.04^{b}±0.01	0.05^{ab}±0.01	0.05^{b}±0.01	0.03^{b}±0.01	0.03^{a}±0.01	0.05^{a}±0.01	0.04^{ab}±0.009	0.04^{ab}±0.02
Local duck	M	0.09^{a}±0.01	0.09^{b}±0.03	0.084^{ab}±0.02	0.08^{a}±0.014	0.04^{a}±0.008	0.05^{a}±0.01	0.06^{a}±0.008	0.05^{a}±0.01
	F	0.08^{a}±0.02	0.08^{ab}±0.02	0.11^{a}±0.03	0.05^{b}±0.01	0.04^{a}±0.006	0.05^{a}±0.02	0.02^{c}±0.01	0.05^{a}±0.001

Means in a column within an effect with no common superscript differ significantly ($p<0.05$)

DISCUSSION

Muscle tissue pH and R-value measurements were used as indicators of the development and state of rigor mortis, respectively (Calkins *et al*., 1982). Values of pH of both breast and leg muscle measured at 0.25, 6 and 24 h postmortem did not influence by different breeds, gender and age of slaughter. These results are not 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. These results are consistent with previous reports (Le Bihan-Duval *et al*., 1999), a* and b* values were reported to be poorly correlated with ultimate pH. Barbut (1993, 1997) also found that higher L* values and lower ultimate pH values corresponded to breast meat with lower WHC. Xiong *et al*. (1993) reported significant differences in breast meat ultimate pH among different commercial lines of broilers and 45 indicated that small differences in pH can result in considerable variation in water binding properties of poultry muscles. 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. In that study, pH at 0.25 h was significantly correlated with pH at 4 h (0.74) but was not correlated with pH at 24 h. These results 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. 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 (53d) 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 (42d). These differences were not expected considering that in the present study neither ultimate pH nor L* values differed due to age at processing. These results are similar to those observed by Pietrzak *et al*. (1997) indicating that a rate of pH decline of 0.06 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 0.02 units/min, while in a severe case the pH drops at a rate of 0.10 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. 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 (21d) had higher rates and initial amounts of drip loss than breast meat from older broilers (28, 35 and 42d). 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 wk of age. However, the 16 wk old turkeys had a significantly higher thaw loss than the 20 wk old turkeys. It is important to note 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 fillets in the present study at 24 h PM was 63.6 and ranged between 54.1 and 72.3. 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. Barbut (1997) reported that breast fillets of 49d 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 was 54.6 and ranged from 45.0 to 64.0. 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 fillets 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 cutoff 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.

REFERENCES

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

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. Poult. Sci., 38: 355-358.

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

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.

Boulianne, M. and A.J. King, 1995. Biochemical and color characteristics of skinless boneless pale chicken breast. Poult. Sci., 74: 1693-1698.

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 nonstimulated beef muscle. J. Food Technol., 8: 163-166.

Cross, H.R., P.R. Durland and S.C. Seideman, 1986. Sensory qualities of meat. In: Muscle As Food. P.J. Bechtel, Ed. Academic Press, New York, pp: 279-320.

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

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

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

Gardzielewska, J., J. Kortz and M. Jakubowska, 1995. Post-mortem kinetics of muscle pH fall in relation to strain crosses of chicken broilers. In: Proceedings of the 12th European Symposium on the Quality of Poultry Meat, Zaragoza, Spain, pp: 37-40.

Ingr, I., 1989. Meat quality: Defining the term by modern standards. Fleisch., 69: 1268.

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

Judge, M.D., E.D. Aberle, J.C. Forrest, H.B. Hedrick and R.A. Merkel, 1989. In: Principles of Meat Science. Kendall E.D. Hunt Publishing, Dubuque, IA., pp: 127.

Lawrie, R.A., 1991. Meat Science. 5th Edn., Pergamon Press, New York, pp: 56-60, 188, 206.

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. Poult. Sci., 78: 822-826.

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 color of turkey breast muscles. Poult. 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. Poult. Sci., 73: 308-316.

NRC, 1998. Nutrient Requirments of poultry. 9th Rev. Edn., Nati. Acad. Press, Washington, DC.

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

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. Poult. Sci., 79: 553-558.

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 color on pH, moisture, water-holding capacity and emulsification capacity. Poult. Sci., 80: 676-680.

Rathgeber, B.M., J.A. Boles and P.J. Shand, 1999. Rapid postmortem pH decline and delayed chilling reduce quality of turkey breast meat. Poult. 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. Poult. 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 Institute, 1988. SAS/STAT guide for personal computers. Version 6.03 edition. SAS Institute Inc. Cary, NC.

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

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. Poult. 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. Poult. Sci., 41: 308-312.

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. Poult. Sci., 72: 583-588.