International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(5): 393-397

Received: 01-06-2020
Accepted: 02-07-2020

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Meat quality characteristics of Beltsville Small White broiler and spent hen turkeys (*Meleagris gallopavo*)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i5f.10324

Abstract
A study was conducted to assess the physico - chemical, proximate and sensory characteristics of meat from Beltsville Small White turkey *(Meleagris gallopavo)* broilers and turkey spent hens. Significantly ($P< 0.05$) higher pH, water holding capacity and moisture content values were observed in Beltsville Small White turkey broiler meat as compared to Beltsville Small White turkey spent hen meat. However, cooking loss, drip loss, shear force value, fragmentation index and collagen, protein and fat content values were significantly ($P< 0.05$) lower in Beltsville Small White turkey broiler meat then Beltsville Small White turkey spent hen meat. Sensory attributes scores for appearance and colour, flavour, juiciness, tenderness, oiliness and overall acceptability scores were significantly ($P<0.05$) higher in Beltsville Small White turkey broiler meat as compared to Beltsville Small White turkey spent hen meat. Turkey meat from Beltsville Small White turkey broiler had highly favourable physico – chemical characteristics and highly acceptable sensory characteristics then Beltsville Small White turkey spent hen meat.

Keywords: Turkey, broiler, spent hen, meat, quality, acceptability

Introduction
Turkey *(Meleagris gallopavo)* farming in India has now shifted from backyard farming to scientific intensive farming due to change in market priorities and consumer preference (Ramakrishna *et al.*, 2012) [28]. The production and consumption of turkey meat have increased rapidly in India. A significant number of spent turkey hens are also marketed for meat production along with commercial turkey broilers. However, no qualitative or quantitative data on meat quality attributes of turkey broiler and turkey spent hen is available. Several factors such as genetics, age, live weight and sex have been shown to affect poultry meat yield, its composition and overall quality (Young *et al.*, 2001) [31]. The most important factors affecting the meat quality characteristics of poultry meat are origin and slaughter age and they are mainly determine the organoleptic attributes of meat, but also have an effect on its technological properties (Poltowicz and Doktor, 2012) [27]. Many studies indicate that the slaughter age of farm animals determines the physico - chemical characteristics of their meat. Meat quality traits including physico – chemical characteristics like pH, drip loss, water holding capacity, muscle fibre diameter, shear force value, myoglobin content, collagen content, extractable proteins, proximate composition and sensory attributes (Bhaskar Reddy *et al.* 2016) [3]. Since scanty published literature is available on meat quality traits, proximate and sensory characteristics of turkey broiler and turkey spent hen, the present study was conducted to determine meat quality characteristics of Beltsville Small White turkey broiler and spent hen.

Material and Methods
Experimental design
The study was conducted at Turkey Research Unit of Tamil Nadu Veterinary and Animal Sciences University - Regional Research Centre, Pudukkottai, Tamil Nadu, India. Forty numbers of Beltsville Small White turkeys, each from turkey broiler (5 months old) and turkey spent hens (12 months old) were selected for the study.

The birds from each group were divided into four replicates, each comprising five birds. The birds were slaughtered following standard procedure, dressed hygienically and manually deboned.

The deboned turkey meat was cut into small pieces and was used for analysis of various physico – chemical, proximate and sensory characteristics. The time lag between the slaughter of the turkey birds and the commencement of the experiment was about 3 hrs.

Physico – chemical analysis

pH

The pH of the raw turkey broiler and turkey spent hen meat samples were determined by homogenizing 10 gm of sample with 50 ml distilled water with the help of tissue homogenizer for 1 min. The pH of the suspension was recorded by immersing the combined glass electrode of digital pH meter.

Water holding capacity

Twenty gm of minced raw turkey broiler / turkey spent hen meat sample was placed in centrifuge tube. 30 ml of 0.6M NaCl was added to the tube and the mixture was stirred for 1 min with a glass rod.

The tube was then kept in refrigerator temperature (4±2°C) for 15 min., stirred for 1 min and then centrifuged at 5000 rpm for 15 min. The supernatant was measured and water holding capacity (as ml of 0.6M NaCl retained by 100 gm of meat) was expressed in percentage as described by Wardlaw *et al*. (1973) [30].

Cooking loss

Twenty gm small pieces of raw turkey broiler / turkey spent hen meat samples were rolled into balls and placed in polyethylene bags. The samples were cooked at 80°C in a thermostatically controlled water bath for 20 min. After draining out of the exudates, the cooked mass was cooled and weighed again. The cooking loss was calculated as percentage weight loss as described by Baliga and Madaiah (1971) [2] with slight modifications.

Shear force value

Core of 1 cm^3 were taken from turkey broiler and turkey spent hen meat samples after cooling at 4±2°C for overnight and sheared using shear press apparatus with the fibres parallel to the longitudinal axis. The force required to shear the samples was observed and recorded (kg / cm^3).

Drip loss

Drip loss was determined by reweighing blotted pieces slices of raw turkey broiler and turkey spent hen meat samples following one week storage at 4±2ºC (drip loss = weight loss / initial weight × 100).

Fragmentation index

Ten gm of 7 mm cubes of cooked turkey broiler and turkey spent hen meat samples were added to 50 ml of 0.24M cold sucrose and 0.02M potassium chloride solution in a 100 ml centrifuge tube. After 5 min, sample was blended for one min at full speed in tissue homogenizer.

The resulting homogenate was filtered through a preweighted muslin cloth. The residue and muslin cloth were blotted twice on Whatman No. 1 filter paper and the residue was allowed to air dry at 50°C for 5 hr. The fragmentation index was reported as weight in gm x 100 as described by the procedure outlined by Davis *et al*. (1980) [10].

Collagen content

Hydroxyproline content of the raw turkey broiler / turkey spent hen meat sample was determined based on the procedure of Neuman and Logan (1950) [24] with some modifications. 2 gm meat sample was hydrolyzed with 40 ml of 6N HCl at 105°C temperature for 18 hrs. The hydrolyzed sample was filtered and the volume was adjusted to 50 ml with distilled water. Suitable aliquot (25 ml) was taken, pH was adjusted to 7 (with 40% NaOH) and the volume was made to 50 ml. From this, 1 ml aliquot was taken in a test tube to which 1 ml each of 0.01N copper sulphate, 2.5N NaOH and 6% H_2O_2 were added. In the blank, instead of 1 ml aliquot, 1 ml distilled water was taken. After mixing, the test tubes were kept at room temperature for 5 min and occasional shaking. Then, tubes were placed in water bath at 80°C for 5 min with frequent rigorous shaking. Then test tubes were taken out and chilled in ice. Four ml of 3N H_2SO_4 and 2 ml of 5% DMEB (4-dimethylaminobenzaldehyde) in n-proponal were added to each tube. After thorough mixing, the tubes were placed in water bath at 70°C for 16 min. Tubes were taken out and the absorbance was measured at 540 nm wavelength in spectrophotometer. Hydroxyproline content was expressed as % Hydroxyproline /100 gm of tissue, by referring to a standard graph. Collagen content was calculated by multiplying by 7.14 and was expressed in mg / gm tissue.

Proximate composition

The moisture, protein and fat contents of raw turkey broiler and turkey spent hen meat samples were determined by standard methods using hot air oven, kjeldahl's assembly and soxhlet extraction apparatus, respectively (AOAC, 1995) [1].

Sensory evaluation

Cooked turkey broiler and turkey spent hen meat samples served to to an experienced panel consisting of faculty and students to determine sensory characteristics. Samples were evaluated for appearance and colour, flavour, juiciness, tenderness, oiliness and overall acceptability using 9-point descriptive scale (where in 9 = extremely desirable, 1= extremely undesirable) as described by Keeton (1983) [17].

Statistical analysis: The data generated from each experimental group were analyzed statistically by following standard procedures (Snedecor and Cochran, 1989) [29] for comparing the means and to determine the effect by using SPSS-16 (SPSS Inc., Chicago, IL., USA).

Results and Discussion

Meat physico – chemical characteristics

Meat physico – chemical characteristics of Beltsville Small White turkey broiler and turkey spent hen are presented in Table 1. The mean ± SE pH, water holding capacity, cooking loss and drip loss values of Beltsville Small White turkey broiler and turkey spent hen were found to be 6.33 ± 0.20 and 6.16 ± 0.28, 32.60 ± 0.26 and 28.20 ± 0.35, 24.45 ± 0.22 and 30.26 ± 0.28 and 1.45 ± 0.42 and 2.12 ± 0.37, respectively. The results showed that Beltsville Small White turkey broiler meat had significantly (P>0.05) higher pH and water holding capacity values then Beltsville Small White turkey spent hen meat. However, significantly lower cooking loss and drip loss values were observed in Beltsville Small White turkey broiler meat. These pH differences of turkey broiler meat and turkey spent hen meat are probably due to the differences in muscle type and glycogen content, which change according to the proportion of the muscle fibers that are responsible for different patterns of muscle metabolism (Khan *et al*., 2019)

[18]. Chuaynukool *et al.* (2007) [8] reported that breast meat of commercial broiler chicken showed a higher pH value then that of spent hen meat. Mussah and Phoya (2017) [23] also observed a tendency towards a decrease in muscle pH with the advancement of age. The pH values of meat can influence physico - chemical characteristics including color, water holding capacity and tenderness (Honikel, 1987) [15]. Fakolade (2015) [13] reported that water holding capacity of meat decreased with increase in age of birds. Water holding capacity of meat related to pH (Bowker and Zhuang, 2015) [6] and lower pH of meat lower the water holding capacity of meat (Oblakova *et al.*, 2016) [26]. Studies on beef by Bouton *et al.* (1973) [5] reported a linear increase in water holding capacity with increasing pH. Lyon *et al.* (1983) [22] reported that meat cooking loss decreased significantly as the age of the bird increased. Further they confirmed that with an increased age of birds, muscle fat content increased which in turn decrease in cooking loss of broiler breast. Chuaynukool *et al.* (2007) [8] reported a higher cooking loss value in breast meat of spent hens compared with commercial broiler chickens. Lower pH is associated with lower water holding capacity, which results in increased cooking loss and drip loss (Lakshani *et al.*, 2016) [20]. Water holding capacity of meat causing more moisture loss during cooking (Bhaskar Reddy *et al.*, 2016) [3] and it might be due to due to higher proportion of oxidative fibre. Drip loss values of in Beltsville Small White turkey broiler and turkey spent hen meat differ significantly (P<0.05) between them and significantly higher drip loss value was observed in Beltsville Small White turkey spent hen meat. The higher drip loss was attributed to the lower pH values were associated with lower meat water holding capacity (Oblakova *et al.*, 2016; Lakshani *et al.*, 2016) [26, 20]. The findings of the present study were also in conformity with the above reports.

Table 1: Meat physico – chemical characteristics of Beltsville Small White turkey broiler and turkey spent hen meat (Mean ± SE)

Meat physico – chemical characteristics*	Turkey broiler	Turkey spent hen
pH	6.33±0.20^a	6.16±0.28^b
Water holding capacity (%)	32.60±0.26^a	28.20±0.35^b
Cooking loss (%)	24.45±0.22^a	30.26±0.28^b
Drip loss (%)	1.45±0.42^a	2.12±0.37^b
Shear force value (kg / cm^3)	1.72±0.18^a	4.85±0.22^b
Fragmentation index	450±0.31^a	680±0.40^b
Collagen content (mg/gm)	10.35±0.28	12.50±0.25^b

*Number of observations: 4
Means bearing same superscripts row-wise do not differ significantly (p<0.05).

The mean ± SE shear force value, fragmentation index and collagen content values in Beltsville Small White turkey broiler and turkey spent hen were found to be 1.72 ± 0.18 and 4.85 ± 0.22, 450 ± 0.31 and 680 ± 0.40 and 10.35 ± 0.28 and 12.50 ± 0.25, respectively. Significantly (P>0.05) lower shear force value, fragmentation index and collagen contents were observed in Beltsville Small White turkey broiler meat as compared to Beltsville Small White turkey spent hen meat. The present findings of shear force value are in conformity with Ngoka *et al.* (1982) [25] who reported that shear force value in turkey breast meat decreased significantly with increased birds age. The Higher shear force value in turkey spent hen meat might be due to hardness of the connective tissue which is increase in advancement of age of poultry (Díaz *et al.*, 2010) [11]. Fletcher (2002) [14] reported that increased shear force values might be due to increase in collagen cross linking with advancement of age. The present findings are probably due to the difference in total and soluble collagen contents between the meat of turkey broiler and turkey spent hen. Lee *et al.* (1976) [21] reported low water holding capacity and higher shear values in muscles are due to low final pH. Fragmentation index provides a potential method for identifying tough and tender meat and mechanical breaking of myofibrils upon homogenization was an indication of the structural weakening that occurs with increase in tenderness (Culler *et al.*, 1978) [9]. The reports of the present study were also in conformity with the above findings.

Meat proximate characteristics

Proximate characteristics of Beltsville Small White turkey broiler and turkey spent hen are presented in Table 2. The mean ± SE moisture, protein and fat contents values Beltsville Small White turkey broiler and turkey spent hen were found to be 75.31 ± 0.42 and 73.27 ± 0.51, 20.15 ± 0.38 and 22.70 ± 0.41 and 2.58 ± 0.21 and 4.72 ± 0.25, respectively. Significantly (P>0.05) higher moisture contents were observed in Beltsville Small White turkey broiler meat then turkey spent hen meat. However, significantly (P>0.05) higher protein and fat contents were observed in Beltsville Small White turkey spent hen meat as compared to Beltsville Small White turkey broiler meat. The significant effect of age on carcass composition had also been reported (El-Full, 2000) [12]. The level of moisture in meat decreased and that of lipid contents increased as increase with age (Ngoka *et al.* 1982) [25]. Chuaynukool *et al.* (2007) [8] also reported higher moisture content in commercial broiler breast meat as opposed to spent hen breast meat. Ji *et al.* (2007) [16] observed that older birds had more fat in their meat than the younger birds. Boni *et al.*, (2010) [4] reported that moisture content decreases as the age increased and this could be attributed to growth and maturity of muscle of the birds. El-Full (2000) [12] also reported that moisture content of quail carcass tends to decrease, while fat content increased with advancing age. The findings of the present study were also in conformity with the above reports.

Table 2: Meat proximate characteristics of Beltsville Small White turkey broiler and turkey spent hen meat (Mean ± SE)

Meat proximate characteristics**	Turkey broiler	Turkey spent hen
Moisture (%)	75.31±0.42^a	73.27±0.51^b
Protein (%)	20.15±0.38^a	22.70±0.41^b
Fat (%)	2.58±0.21^a	4.72±0.25^b

**Number of observations: 4
Means bearing same superscripts row-wise do not differ significantly (p<0.05).

Meat sensory characteristics

The results of sensory characteristics of Beltsville Small White turkey broiler and turkey spent hen are presented in Table 3. The sensory attributes scores for appearance and colour, flavour, juiciness, tenderness, oiliness and overall acceptability were significantly (P<0.05) higher for of Beltsville Small White turkey broiler meat then turkey spent hen meat. Meat from Beltsville Small White turkey broiler meat was highly acceptable, whereas the meat from Beltsville Small White turkey spent hen meat only moderately acceptable. The lower sensory scores for Beltsville Small White turkey spent hen meat compared to Beltsville Small White turkey broiler meat are due to lower sensory scores for

appearance and colour, flavor, juiciness, tenderness, oiliness and overall acceptability. These results of sensory scores are coincide with various physico - chemical characteristics like water holding capacity, shear force value, drip loss, pH, fat and muscle fibre diameter which cumulatively influence the sensory characteristics of cooked meat samples. For chicken meat, colour, tenderness and flavour are the main factors contributing the overall palatability of meat (Bhaskar Reddy *et al*. 2016) [3]. The lower appearance and colour scores for turkey spent hen meat might be due to change in meat color as the birds are growing could be due to structural changes in the muscles of the birds. i.e. more myoglobin as well as collagen and fat which become prominent. Our present results are also conformity of Castellini, *et al.*, (2008) [7] who reported that age of birds mainly affects the tenderness and juiciness of the meat, which generally decreases as chickens become older and it might be due to density of the collagen network increases with age, which in turn reduces the tenderness of meat. Komiyama *et al.* (2010) [19] also found higher toughness and lower juiciness of breast fillets in broiler breeder meat than in broiler chicken meat. The reports of the present study were also in conformity with the above findings.

Table 3: Meat sensory characteristics of Beltsville Small White turkey broiler and turkey spent hen meat (Mean ± SE)

Meat sensory attributes***	Turkey broiler	Turkey spent hen
Appearance and colour	8.5± 0.18^{a}	7.5± 0.20^{b}
Flavor	8.5± 0.22^{a}	7.0± 0.31^{b}
Juiciness	8.5± 0.40^{a}	7.0± 0.37^{b}
Tenderness	8.5± 0.53^{a}	7.0± 0.42^{b}
Oiliness	8.0± 0.33^{a}	7.0± 0.54^{b}
Overall acceptability	8.4 ± 0.33^{a}	7.1± 0.37^{b}

***Number of observations = 28.

Sensory attributes were evaluated on a 9-point descriptive scale (wherein, 1 = extremely undesirable; 9 = extremely desirable).

Means bearing same superscripts (lowercase letters) row-wise do not differ significantly ($p< 0.05$).

Conclusion

The turkey meat from Beltsville Small White turkey broiler meat had significantly favourable physico - chemical characteristics as compared to Beltsville Small White turkey spent hen meat. Beltsville Small White turkey broiler meat had significantly and highly acceptable sensory characteristics then Beltsville Small White turkey spent hen meat.

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