

Meat quality and sensory attributes of *Pectoralis major* muscle in spent chicken subjected to different marination methods

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Abstract

The effects of four marination methods (water, papaya leaves juice, papaya leaves powder, and commercial meat tenderizer) on the meat quality and sensory attributes of cooked (moist and/or grill) *Pectoralis major* muscle of spent chicken were examined. *Pectoralis major* muscles from 40 spent chickens were assigned to four marination methods: marinating with 100 mL distilled water, Control (T1) ($n = 10$); marinating with papaya leaves juice (50 g PLP + 100 mL distilled water), T2 ($n = 10$); marinating with 50 g papaya leaves powder, T3 ($n = 10$); and marinating with 50 g commercial meat tenderizer, T4 ($n = 10$). Results of meat quality revealed the lowest drip loss, cooking loss, and shear force values of samples from T3 as compared to the other treatments. Additionally, myofibril fragmentation index of marinated *Pectoralis major* muscle from T3 was significantly higher than the other treatments. Among the treatments within the moist cooking method, T3 presented significantly higher scores for tenderness and juiciness and significantly lower score for flavour as compared to T1 and T2. In the grill cooking method, the highest scores for tenderness and juiciness were significantly demonstrated by samples of T2 and T3. Furthermore, samples from T2 had significantly higher score for flavour. Results of the present work demonstrated that marinating spent chicken meat with 50 g papaya leaves powder improved its tenderness and water holding capacity. Furthermore, greater improvement in tenderness and juiciness were observed when meat samples marinated with papaya leaves powder (T3) were further subjected to moist cooking method.

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Keywords

Papaya leaves juice

Papaya leaves powder

Tenderness

Moist cooking

Grill cooking

Introduction

The poultry industry is one of the most important industries in Malaysia. The increasing egg production in Malaysia caused a plentiful availability of spent chickens. Globally, this sector involves about 2.6 billion spent chickens which are commonly associated with pet food industry and not much for human consumption (Kalaikannan *et al.*, 2007). Spent chicken has a disadvantage of having tough meat while meat tenderness is a major determinant for consumer perception on meat

eating quality (Cunningham, 1998). It has been well documented that spent chickens are commonly sold at a lower market price than the commercial broiler chickens (Sams, 1990), and this could be partly due to its less favourable tougher meat characteristics (Chueachuychoo *et al.*, 2011) as compared to the commercial broiler. Spent chicken meat has been traditionally used in less profitable, comminuted or retorted products in which small particle size or thermal processing is used to reduce the toughness. The toughness of spent chicken meat is primarily due to the increased cross-linking of collagen (Archile-

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Contreras *et al.*, 2011), a natural process occurring in egg-laying chickens that have completed few laying cycles.

Papaya (*Carica papaya* L.) is a tropical fruit that contains an enzyme known as papain which is present in the bark, leaves and fruit (Aravind *et al.*, 2013). Papain is a primary ingredient in meat tenderization because it breaks down the proteins in meat (Ha *et al.*, 2012). Papaya leaves have numerous benefits such as high content of alkaloids, carpinine, carpaine, and vitamins C and E. The leaves also help in the digestion of proteins due to their rich source of proteolytic enzymes (Aravind *et al.*, 2013). Marinating is a traditional culinary technique that is used to tenderize and to improve flavour and juiciness of originally tough poultry meat (Lemos *et al.*, 1999). Marinating of poultry meat and meat product in herbs and spices are commonly adopted by meat processors and retailers as a practical approach in improving the tenderness apart from extending the stability and shelf life of the meat and meat products. Nowadays, unlike the natural enzymatic tenderization through marination, the commercially available meat tenderizers usually contain ingredients such as dextrose, salt, monosodium glutamate and garlic powder that serve as fillers, and relatively small amount of the active ingredient papain, which on a weight basis is the most expensive component of the entire formulation (Alarcón-Rojo, 2010).

The appearance of raw meat is one of the main sensory traits followed by the cooked characteristics such as tenderness, juiciness and flavour on which an ultimate decision would be made by the consumers to purchase the meat. Dransfield *et al.* (1984) reported that meat tenderness is a main evaluative determining factor of overall acceptability of the consumer's perception. Sensory evaluation can be conducted either by consumers or trained panellists to assess meat quality characteristics and their acceptability (Muchenje *et al.*, 2008).

Previous report of Abdalla *et al.* (2013) showed that marinating meat with papaya leaves could improve the tenderness; thus, continuous attempt for improving meat tenderness via marination with papaya leaves is still necessary and scientifically valid. Furthermore, research on the influence of papaya leaf extract as a marinade on spent chicken meat tenderization and other eating quality traits is still scarce. The present work was therefore conducted to examine the effects of marinating spent chicken meat with powdered and juice extract of papaya leaves on tenderness and other meat-eating qualities.

Materials and methods

Preparation of papaya leaves

Fresh papaya leaves (FPL) were picked from papaya trees located in Field 2, Universiti Putra Malaysia. The harvested FPL's were then divided into two parts. The first part was washed with water and blotted with tissue paper to remove excess water. Then, the leaves were cut into small pieces and placed in a paper bag and oven dried at 60°C for 48 h, following which, the resulted oven dried papaya leaves were ground into papaya leaves powder (PLP). The PLP was weighed to approximately 50 g for marinating the spent chicken meat. The remaining fresh papaya leaves were cut into small pieces and weighed to approximately 50 g, before mixing with 100 mL distilled water, and subjected to aqueous extraction. The homogenate was filtered through a piece of cheese cloth, and the resulted filtrate was pooled and stored in -20°C as papaya leaves juice (PLJ) for subsequent meat marination procedure.

Experimental animals, slaughtering and sampling

A total of 40 spent chickens (Leghorns, 80 w old) were assigned to four treatments consisting of 10 birds in each treatment group. The chickens were humanely slaughtered according to the halal slaughter procedure as outlined in the MS 1500:2009 (Standards Malaysia, 2009). After evisceration, the *Pectoralis major* muscles were collected from the carcasses, trimmed off from any visible fat and connective tissue, and divided into two parts. Samples of the right *Pectoralis major* muscles were assigned for meat quality analysis, while the left side of the muscle was assigned for sensory evaluation.

Marinating procedure

Firstly, 50 g *Pectoralis major* muscles were subjected to one of the following treatments: [1] marinating with 100 mL distilled water, Control (T1) ($n = 10$); [2] marinating with PLJ (50 g PLP + 100 mL distilled water), T2 ($n = 10$); [3] marinating with 50 g PLP, T3 ($n = 10$); and [4] marinating with 50 g commercial meat tenderizer (McCormick® bromelain), T4 ($n = 10$). The commercial bromelain was used as it is more commercially available as compared to papain, while their proteolytic actions are similar (Arshad *et al.*, 2014). Furthermore, the sensory evaluation on bromelain-treated meat was improved as compared to the other enzymes (Sullivan and Calkins, 2010). Therefore, the commercial bromelain was a good candidate as positive control

in the present work. For T3 and T4, the powders were sprinkled on the meat. All marinations were conducted at room temperature (approximately 16°C) for 120 min.

Drip loss

Approximately 20 g marinating *Pectoralis major* samples were individually weighed and recorded as W1 before placed in a polyethylene bag, vacuum packed, sealed and stored at 4°C for 7 d. At d 7, samples were removed from the polyethylene bag, gently blotted dry, weighed and recorded as W2. The following equation of Honikel (1998) was used to calculate the percentage of drip loss:

$$\text{Drip loss (\%)} = [(W1 - W2)/W1] \times 100 \quad (\text{Eq. 1})$$

where, W1 = sample weight at d 0, and W2 = sample weight at d 7.

Cooking loss

Marinated samples from the right *Pectoralis major* muscle were weighed and recorded as W1. The samples were placed in polyethylene bags and cooked in a water bath at 80°C for 30 min. The cooked samples were removed from the polyethylene bags, cooled to room temperature, gently blotted dry, weighed and recorded as W2. Cooking loss percentage was calculated following the equation of Honikel (1998):

$$\text{Cooking loss (\%)} = [(W1 - W2)/W1] \times 100 \quad (\text{Eq. 2})$$

where, W1 = sample weight at d 0, and W2 = sample weight at d 7.

Shear force values

Samples used for cooking loss determination were also used for shear force values determination. Each sample was divided into three sub-samples, with each having a dimension of 1 cm × 1 cm × 2 cm. Each sample was perpendicularly sheared once to the fibres at a speed of 1.0 mm/sec with a Volodkovitch bite jaw attached to a texture analyser (HD double arm Stable Micro System, Surrey, UK) fitted with a 5 kg load cell.

Myofibrillar fragmentation index measurement

Myofibril fragmentation index (MFI) was measured according to Culler *et al.* (1978) with some modifications by Lametsch *et al.* (2007).

Approximately 2.5 g pulverised *Pectoralis major* muscles were homogenised with 30 mL 20 mM ice-cold potassium phosphate buffer (pH 7.0) for 60 sec. The homogenates were then centrifuged at 1,000 g for 15 min at 2°C. The resulted supernatant was discarded and the pellet was re-suspended in 25 mL buffer and stirred using a glass rod. The centrifugation was repeated. Then, the supernatant was discarded and the pellet was suspended in 15 mL buffer and stirred again using a glass rod, followed by vortexing. The myofibril suspensions were filtered into 50 mL centrifuge tubes through a 1.0 mm polyethylene strainer to remove any remaining connective tissue. The protein concentration of final suspension was determined using the Bio-Rad Protein Assay Kit II 500-0002 from Bio-Rad. The myofibril suspension was diluted with potassium phosphate buffer to a final protein concentration of 0.5 ± 0.05 mg/mL, and the absorbance of the diluted myofibril suspensions was measured at 540 nm with a spectronic VR 20 GENESYSTEM spectrophotometer (Spectronic Instruments, USA). Triplicate absorbance readings were averaged and multiplied by 150 (Hopkins *et al.*, 2000) to obtain the index values for myofibrillar fragmentation.

Sensory evaluation

The left *Pectoralis major* muscle samples were used for the sensory evaluation, which involved 100 untrained panellists from UPM. The panellists consisted of students aged between 21 and 25. Briefly, 50 panellists were assigned for the evaluation of moist cooked samples while the remaining 50 panellists were assigned for the evaluation of grill cooked samples. These two cooking methods were assessed to determine the suitable method to cook spent chicken in term of tenderness. To cook the meat, the meat samples were taken from the -20°C freezer and thawed overnight in a chiller at 4°C. The meat samples were then cooked using the two methods (i.e., grilled at 275°C for 20 min, or moist cooked in a water bath at 80°C for 20 min). The panellists were initially briefed on how to complete the score sheet. A questionnaire form was distributed to each panellist for the evaluation on flavour, tenderness, and juiciness of the cooked meat samples. A 5-point hedonic scale was employed where 1 = very poor, 2 = poor, 3 = moderately good, 4 = very good, and 5 = best desirable attribute. The cooked meat samples for each treatment group were cut into (1.5 × 1.5 × 1.5 cm) cubes before being served warm to the panellists. The panellists initially cleansed their oral cavity with cream cracker, and rinsed with mineral water between each individual sample (Bosman *et al.*, 1997).

Statistical analysis

The experiment was of a completely randomized design (CRD). Data analysis was performed using the GLM procedure of Statistical Analysis System package (SAS, 2007) version 9.2. Statistical significance was set at $p < 0.05$. Duncan multiple range test was used to determine the differences between the means.

Results and discussion

Meat quality parameters

Marination of meat has been a vigorous area of investigation because it brings about changes in the structure of meat and can have an effect on several characteristics, such as texture, juiciness, flavour, and storage properties (Young and Buhr, 2000). In the present work, marinating time for *Pectoralis major* muscle for all treatments was of 120 min. It has been reported that marinating time of 120 min was found to yield more acceptable end products with better scores for sensory characteristics (Yusop *et al.*, 2010).

In the present work, drip loss was calculated to get an overall estimation of the water binding attributes of muscle. The drip loss values for *Pectoralis major* muscle from spent chicken subjected to marination in water, papaya leaves juices (PLJ), papaya leaves powder (PLP), and commercial meat tenderizer are shown in Table 1. The results showed that marination of *Pectoralis major* muscle in T1 had the highest drip loss ($p < 0.05$) as compared to T2, T3 and T4 after 7 d of aging. This could be due to the disruption of collagen and myofibrillar proteins during the process of aging which in turn could cause myofibrillar proteins to lose their ability to hold water molecules (Pearce *et al.*, 2011). T3 significantly showed the lowest ($p < 0.05$) drip loss as compared to T1 and T4 (Table 1). It has been documented that papain prevents acto-myosin formation which increases the meat water holding capacity. Furthermore, Alarcón-Rojo (2010) documented that effective marinating technique includes adding components that improve the ability of muscle to bind water. The present

results are in line with those of Chueachuaychoo *et al.* (2011) that marinated spent chicken meat samples had significantly lower ($p < 0.05$) drip loss than the non-marinated meat samples.

Cooking loss is another parameter in the evaluation of meat water holding capacity (WHC). Similar to drip loss, cooking loss of the samples in T1 was significantly higher ($p < 0.05$) than the other treatments (Table 1). Modzelewska-Kapituła *et al.* (2012) noted that the percentage of drip loss in raw meat was negatively correlated to moisture after cooking. Likewise, the marination of samples in T3 had also resulted in the lowest cooking loss ($p < 0.05$) as compared to T1, T2 and T4 (Table 1). Alarcón-Rojo (2010) reported that water loss of meat marinated with papaya leaves declined during cooking. Additionally, Murphy and Marks (2000) stated that WHC of muscle tissue is related to the extent of heat denaturation of myofibrillar proteins during thermal processing that leads to structural changes and release of the sarcoplasmic fluid from the muscle fibres, resulting in water loss from meat tissue.

Shear force analysis is a method to objectively measure the tenderness of the meat (Table 1). The samples in T1 showed a significantly ($p < 0.05$) higher shear force values as compared to the other treatments. This could possibly be explained by the high content of stromal proteins in the spent chicken meat which might have slowed down the infiltration of the marinade into the muscle (Chueachuaychoo *et al.*, 2011). The lowest ($p < 0.05$) shear force values were indicated by T3. In the present study, the shear force results indicated improved tenderness ($p < 0.05$) following T2, T3 and T4 marinations. However, T3 samples showed better tenderness as compared to T2 and T4. It has been documented that marination of meat with PLP could improve palatability by reducing toughness (Alarcón-Rojo, 2010). Generally, the present results demonstrate the effectiveness of papaya leaves powder (PLP) in improving the tenderness of spent chicken meat through marination.

The measurement of MFI is one of the most

Table 1. Effect of marinating methods on quality of *Pectoralis major* muscle of spent chicken.

Quality attributes	Treatments			
	T1	T2	T3	T4
Drip loss (%)	9.58 ± 0.97 ^a	3.31 ± 0.34 ^{bc}	2.64 ± 0.49 ^c	4.71 ± 0.73 ^b
Cooking loss (%)	44.35 ± 2.71 ^a	29.57 ± 1.31 ^b	19.95 ± 1.42 ^c	35.33 ± 3.12 ^b
Shear force (kg)	1.29 ± 0.05 ^a	0.69 ± 0.05 ^c	0.41 ± 0.03 ^d	0.89 ± 0.02 ^b
MFI	69.21 ± 6.37 ^c	108.28 ± 6.95 ^b	158.73 ± 12.34 ^a	102.87 ± 9.21 ^b

T1: Control (marinated with distilled water); T2: marinated with papaya leaves juice; T3: marinated with papaya leaves powder; T4: marinated with commercial meat tenderizer (McCormick®). MFI: Myofibril fragmentation index. Means ± SE within a row with different superscripts are significantly different ($p < 0.05$).

commonly used methods to determine post-mortem proteolysis in meat (Taylor *et al.*, 1995). The MFI has been negatively associated with shear force values or toughness. In the present work, there were significant differences in MFI among the treatment groups (Table 1). T3 samples significantly showed the highest MFI ($p < 0.05$) as compared to the other treatments. Apart from presenting higher MFI, T3 also presented the lowest shear force values and highest water holding capacity as compared to the other treatments. Marino *et al.* (2013) reported a strong negative correlation ($r^2 = -0.98$, $p < 0.001$) between MFI and shear force values of Longissimus dorsi muscle in young bulls from Romagnola \times Podolian crossbred, Podolian and Friesian breeds.

Sensory characteristics

Marination is commonly practiced to tenderize and enhance the juiciness and flavour of meat (Lemos *et al.*, 1999). The mean values of sensory characteristics of *Pectoralis major* muscle from spent chicken as affected by different marinating procedures (water, PLJ, PLP, and commercial meat tenderizer) and two cooking methods (moist and grill) are shown in Tables 2 and 3, respectively. Among the treatments within the moist cooking method, T3 presented significantly higher ($p < 0.05$) scores for tenderness and juiciness (Table 2). However, significantly lower ($p < 0.05$) scores for flavour was also noticed in T3 as compared to T1 and T2. The lowest scores ($p < 0.05$) for tenderness and juiciness were found in T1. In comparison with the

other groups, the highest score for flavour ($p < 0.05$) was observed in T2. The grill (oven) cooking method did not affect tenderness and juiciness of the samples in T2 and T3 (Table 3). However, T2 samples had significantly higher ($p < 0.05$) score for flavour. The lowest scores for tenderness and juiciness ($p < 0.05$) were exhibited by T1.

Regardless of the cooking methods employed, the present work suggested that the improved tenderness (as perceived by the sensory panellists) of spent chicken resulted from T3 marination. Mendiratta *et al.* (2002) reported that sensory evaluation of papain marinade spent chicken revealed significantly higher scores for juiciness and tenderness. Additionally, higher scores of tenderness and juiciness were noticed when samples were subjected to moist cooking as compared to the grill (oven) cooking method. Modzelewska-Kapituła *et al.* (2012) reported that cooking procedure and final temperature influence tenderness and juiciness. Cooking to high internal temperature in dry air reduces the juiciness of the roast and produces roasts with undesirable palatability. The results further support the earlier report by Abdalla *et al.* (2013) that moist cooking has greater influence on tenderness than the oven cooking method. This might be due to the fact that moist cooking affects the structural proteins and it results in less cooking loss than other cooking methods (Navid *et al.*, 2011). Furthermore, the dry hot temperature of the oven may also lead to denaturation of proteins, thereby reducing the tenderness of the meat.

Table 2. Sensory attributes of spent chicken meat subjected to moist cooking and different marinating procedures.

Quality attributes	Treatments			
	T1	T2	T3	T4
Tenderness	2.26 \pm 0.09 ^d	4.04 \pm 0.05 ^b	4.88 \pm 0.06 ^a	3.24 \pm 0.07 ^c
Juiciness	1.90 \pm 0.07 ^d	3.88 \pm 0.06 ^b	4.18 \pm 0.05 ^a	2.82 \pm 0.07 ^c
Flavour	3.94 \pm 0.03 ^b	4.520 \pm 0.09 ^a	1.50 \pm 0.11 ^c	1.10 \pm 0.04 ^e

T1: Control (marinated with distilled water); T2: marinated with papaya leaves juice; T3: marinated with papaya leaves powder; T4: marinated with commercial meat tenderizer (McCormick®). Means \pm SE within a row with different superscripts are significantly different ($p < 0.05$).

Table 3. Sensory attributes of spent chicken meat subjected to oven cooking (grill) and different marinating procedures.

Sensory attributes	Treatments			
	T1	T2	T3	T4
Tenderness	2.46 \pm 0.09 ^c	4.200 \pm 0.06 ^a	3.760 \pm 0.11 ^a	2.900 \pm 0.09 ^b
Juiciness	2.18 \pm 0.07 ^c	3.400 \pm 0.06 ^a	3.920 \pm 0.04 ^a	2.700 \pm 0.08 ^b
Flavour	4.28 \pm 0.08 ^b	4.680 \pm 0.07 ^a	1.280 \pm 0.07 ^c	1.200 \pm 0.07 ^c

T1: Control (marinated with distilled water); T2: marinated with papaya leaves juice; T3: marinated with papaya leaves powder; T4: marinated with commercial meat tenderizer (McCormick®). Means \pm SE within a row with different superscripts are significantly different ($p < 0.05$).

Conclusion

The present work demonstrated that marinating spent chicken meat with 50 g papaya leaves powder for 2 h before cooking improved its tenderness and water holding capacity. Furthermore, a comparison between moist and grill (oven) cooking showed that the moist cooking had higher scores for tenderness and juiciness as compared to the grill cooking method. Moreover, greater improvement in tenderness and juiciness were observed when meat samples marinated with papaya leaves powder (T3) were further subjected to moist cooking method.

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