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Effect of Slaughtering Methods on Meat Quality Indicators, Chemical Changes and Microbiological Quality of Broiler Chicken Meat during Refrigerated Storage

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Abstract : *Slaughtering is a process of bringing an animal to a quick painless death. It involves throat cutting for maximum blood drainage and the amount of blood retained is dependent on the method of slaughter. This study investigated the effect of slaughtering method (Halal and Chinese methods) on meat quality indicators and shelf life of broiler chicken breast meat. Quality indicators such as pH, drip loss and colour (L*, a*, b*) were significantly (P<0.05) higher for birds slaughtered with the Chinese method (pH= 6.17, L*= 56.42, a*= 8.36, b*= 19.2, drip loss= 0.58) than the halal method. There were no differences in cook loss, thaw loss and toughness obtained from both slaughtering methods. Iron (Fe) content for birds slaughtered using Chinese method was 13.77 mg/kg which was significantly higher than those slaughtered using the halal method (10.00 mg/kg). The haem iron content were 2.55 and 3.25 mg/100g sample respectively for birds slaughtered using both halal and Chinese methods and this decreased during storage at 4^0C for 9 days. Higher microbial count after 9 days of refrigerated storage (6.28 cfu/g) were recorded for birds slaughtered using Chinese method as compared with the halal method (5.05 cfu/g). Results from this study indicate that method of slaughter for poultry significantly affects the quality and shelf life of meat produced.*
Keywords -*broiler chicken, quality indicators, chemical changes, microbiological quality, slaughtering methods.*

I. Introduction

Poultry meat account for about 33% of the world meat consumption (FAOSTAT) and consumer demand for high quality poultry meat is ever increasing. According to the Food and Agriculture Organization statistics, the average per capita consumption of poultry meat has quadrupled since the 1960s (11kg in 2003 compared with 3kg in 1963). This increase can be adduced to the fact that poultry meat is cheaper with good nutritional profile, easy to prepare and it is well suited for quick menus. Consumers attribute a special importance to the quality of the meat before a purchase can be made and these attributes are usually on the spot assessment of the meat products such as colour, flavor, juiciness and texture [1]. Some factors such as genotype, diet, sex, rearing techniques, pre-slaughter handling and post-mortem handling of the carcass influence the meat quality [2] but reports on the effect of slaughtering method on the overall meat quality and keeping quality is still sketchy.

Slaughtering is a major way of bleeding an animal and the amount of blood bled is dependent on method of slaughter. Ali *et al.,* [3] reported a maximum blood drainage which had a positive effect on the keeping quality of chicken meat for birds slaughtered using the Halal method. Residual blood left in the carcass as a result of improper bleeding may decrease the shelf life and hence the quality of the meat product because haemoglobin which is an important component of blood is a powerful promoter of lipid oxidation [4]. Traditional halal method has been the most commonly method of slaughter used worldwide. The Chinese method involves the use of a very sharp pointed object to poke the throat of the bird thereby creating a small hole for drainage of blood.

Therefore, the aim of this study is to determine the effect of slaughtering methods on the meat quality indicators and shelf life of broiler chicken meat.

II. Materials And Method

2.1 Sample Collection and Slaughter Methods

A total of 60 broiler chickens of approximately the same weight (2kg), of the same marketable age were used for this experiment. The birds were grouped into two groups of thirty birds per group. Two methods of slaughter were used- (a) Halal Slaughter Method (HSM): the birds were slaughtered according to the Islamic traditions by severing the jugular veins, carotid arteries, trachea and the oesophagus. This method was performed without stunning. (b) Chinese Slaughter method (CSM): Birds in this group were slaughtered using by a sharp pointed object to poke the neck of the bird to create a small hole for blood drainage. After slaughter, birds were immediately processed.

2.2 Meat Quality Indicator Measurements

After slaughtering, the slaughtered birds were immersed in hot water 60°C for two minutes to help in feathers scalding. Afterwards the feathers were removed mechanically by using a feather picking machine. The birds were then eviscerated and internal organs removed. The carcasses were weighed and manually deboned at 6-8 h post-mortem. The breast meat (Pectoralis major) was removed for evaluation of the quality parameters as listed below:

2.2.1 Drip loss

Percentage drip loss was calculated as [sample weight after deboning minus sample weight after 24 hours refrigeration] x 100/ sample weight after deboning [5].

2.2.2 Colour Measurement

Meat colour was evaluated at 30 h post-mortem (following the end of the 24 h drip test) using a hunter labscan colorimeter. The CIE system colour profile of lightness (L*), redness (a*), and yellowness (b*) was measured by a reflectance colorimeter by using illuminant source C at 2º setting. The colorimeter was calibrated throughout the study using a standard white ceramic tile. Colour was evaluated on the breast meat, in an area free of obvious colour defects, bruises, and blood spots [6].

2.2.3 pH measurement

pH was measured at approximately 30 h post-mortem on the breast meat sample. The pH was determined using a slurry method in which 5 g of the meat sample was homogenized in 20 ml of deionised water using a homogenizer at 13,600 rpm for 30 sec and the pH of homogenate was measured using a pH meter calibrated at pH 4.0 and 7.0 equipped with a pH electrode.

2.2.4 Thaw loss

Percentage thaw loss was calculated as [weight of sample before freezing minus sample weight after thawing] x 100/ sample weight before freezing [6].

2.2.5 Cooking Loss

For the cooking loss breast fillets (Pectoralis major) were individually vacuum packaged and cooked to an internal temperature of 75 ± 1ºC in an 80 ± 0.5ºC water bath for 25-35 minutes. The cooked fillet samples were cooled in cold water for 20 min prior to weighing. Samples were then wrapped and stored at 4ºC overnight for shear force testing the following day. Cooking loss was determined as a percentage of weight lost during cooking [6].

2.2.6 Shear Force

Five rectangular blocks of 1 cm wide, 1 cm high and 3 cm long were cut from each cooked fillet for Warner Bratzler shear force determination [7]. Shear force was determined by using stable micro system TA.XT plus texture analyser equipped with a Warner Bratzler shear blade, which cut the sample perpendicular to the fibre direction. Shear force was calculated as the average shear force from the samples.

2.3 Chemical Changes Analyses

Five birds each out of the sixty slaughtered were selected from both method of slaughter (Halal and Non-Halal) for analyses. About 200g of the breast meat were removed from each carcass, kept in a polythene bag and stored at 4^0C. Analyses were taken on day 1, 3, 5, 7 and 9.

2.3.1 Determination of Mineral Contents

Iron (Fe^{2+}), calcium (Ca^{2+}), zinc (Zn^{2+}), magnesium (Mg^{2+}), copper (Cu^{2+}) and manganese ($Mn^{2+)}$ contents were determined using the wet method of minerals determination. 0.5g was digested in HNO_3/H_20_2 in the ratio 2:1 using a Perkin Elmer microwave reaction system (model Anton PaarMultiwave 3000) equipped with eight high-pressure quartz vessels. After digestion was completed, the mixture was transferred to a volumetric flask and the volume was made up to 100ml with deionised water. The elements were then measured by a Perkin-Elmer Analyst 800 atomic absorption spectrometer. The mineral content was calculated and expressed as mg/kg wet sample.

2.3.2 Determination of Haem iron content

Haem iron content of chicken meat was determined according to the method of Cheng & Ockerman [8] with a slight modification. Ground sample (2g) was mixed with 9ml of acid acetone (90% acetone, 8% deionised water and 2% HCl v/v/v). The mixture was mashed with a glass rod and allowed to stand for 1h at room temperature. The mixture was filtered with a Whatman No 1 filter paper (Whatman International, Ltd, Maidstone, England) and the absorbance of the filtrate was read at 640nm against an acid acetone used as blank. Haem iron content was calculated as follows;

Haem iron content (ppm) = Total pigment (ppm) X 0.0822

Where total haem pigment (ppm) = A_{640} X 680

The haem iron content was expressed as mg/100g of wet sample.

2.4 Microbiological Analyses

On each sampling day, 5g of breast meat samples were aseptically weighed, transferred to a sterile blender and blended. The ground sample was transferred to a sterile bottle and mixed thoroughly with sterile distilled water for about 2 minutes. After mixing, the appropriate dilutions were prepared. One ml of appropriate dilution of homogenate was transferred to already prepare plate count agar in duplicate and incubated at 35^0C for 24 hours to enumerate the aerobic plate counts.

2.5 Data Analysis

The data obtained were analysed using the Student's t-test of Minitab 16 and the level of significance was determined at $P \leq 0.05$.

III. Results And Discussion

The effect of slaughtering on quality parameters measurements is presented in Table 4.1. The drip loss ranged between 0.43 and 0.58%, thaw loss ranged between 3.31 and 3.42% and cooking loss ranged between 16.64 and 18.12. Cook and thaw losses did not show any significant difference based on the method of slaughter but the values recorded for the CSM was higher than that recorded for the HSM. The implication of this is that samples with the higher values lost more water during the thawing and the cooking process thereby reducing the size of the meat portion and also making the meat product of poor quality due to the loss of valuable protein and flavour compound [9]. The effect of slaughtering method had a significant effect on the drip loss. The CSM had a significantly higher ($P<0.05$) drip loss value (0.58) after the 24hrs drip test post mortem compared to the value obtained for the HSM (0.46).

Meat pH which has been reported to be related to the biochemical state of the muscle at the time of slaughter and following the development of rigor mortis also showed a significant difference. It was observed from this study that birds slaughtered using the CSM had a significantly ($P<0.05$) higher pH (6.17) compared to birds slaughtered with HSM. This may be as a result of stress the birds slaughtered using the CSM went through during slaughtering because after poking the throats of the birds, the birds struggled for some minutes before it finally died and during this struggling, the glycogen content in the muscle will be used up and hence reduces the level of lactic acid which is necessary to produce meat. Also the high pH can also be attributed to the residual blood in the carcass of the birds slaughtered using the CSM which will have a profound effect on the pH and keeping quality of the meat.

The effect of slaughtering methods on colour parameters of broiler chicken meat is presented in Table 4.3. The meat colour L* (lightness), a* (redness) and b* (yellowness) values were also significantly higher ($P<0.05$) for birds slaughtered using the Chinese method. The increase in the values of a* and b* causes the pink colouration which is as a result of improper bleeding leading to poor quality meat rejected by consumers. The L* value (56.42) from the meat samples slaughtered with the Chinese method produces a pale colour which is as a result of improper bleeding. This result obtained is in line with the observations of many researchers [4, 11]. A significant negative correlation was reported [12, 13] between breast meat L* value and breast pH. The statement contradicts the results obtained from this present work because the L* and pH shows a significant positive correlation i.e the higher the L* value, the higher the pH.

Qiao et al., [14] classified breast fillets into three groups according to their L* values as follows; lighter than normal (light, $L^*>53$), normal ($48<L^*<53$) and darker than normal (dark, $L^*<46$). According to this classification, meat samples in the halal method of slaughter can be classified as normal (51.46) while the meat from the Chinese slaughter method can be classified as lighter than normal (56.42).

Mineral Contents Determination

The mineral contents of the chicken meat as affected by different slaughtering methods (Halal and Non-Halal) are shown in Table 4.4.Mg was recorded to be the most abundant mineral in the chicken meat irrespective of method of slaughter. The HSM recorded the lowest Mg content ($P<0.05$) when compared with the CSM. Ca was the second predominant mineral followed by Fe. The CSM had the highest Fe content (13.77mg/kg sample, $P<0.05$) compared to the HSM (10.00mg/kg sample, $P<0.05$). Cu content also followed the same pattern with the CSM having the highest value (1.48mg/kg sample) compared to the value from HSM (0.76mg/kg sample). Zn and Mn followed different pattern with the HSM having the highest values of 7.20 and 8.58mg/kg sample respectively compared to values of 0.80 and 1.48mg/kg sample obtained for the CSM. This data obtained is similar to the one reported by Addeen et al.,[15] where Fe, Mg, Cu, and Ca contents all had the highest values for other methods of slaughter except the Islamic method. The Zn and Mn for the Islamic slaughter were also reported to be the highest among all the methods of slaughtering used. It has been reported that Fe and Cu acts as pro-oxidants in the chicken meat during refrigerated storage and they also serve as major catalysts of oxidation [16]. This result demonstrates the varied rate of residual blood left in the carcass of the chicken. It was observed that the Fe content was lowest in the birds slaughtered by HSM ($P<0.05$) indicating the most effective method of blood removal from the chicken. The HSM ensures the cutting of the major vein carrying blood to the brain hence facilitating maximum bleeding [17]. Although the CSM also ensures bleeding but poking the throat with a sharp object did not create the necessary pathway for the blood to

drain properly hence there was residual blood left in the carcass which was evident in the high Fe value which is a major source of pro-oxidant.

Fig. 1 shows the effect of slaughtering methods on microbial count of broiler chicken meat during the nine days refrigerated storage post mortem. At day 1, slaughtering methods had no significant (P>0.05) effect on microbial count but as storage time increases, the microbial count also increased for both slaughter methods. The increase in the microbial count for both methods of slaughter might be as a result of residual blood in the carcass which serves as nutrient for microbial growth. A drop in the blood pressure after slaughtering affect total drainage of blood from the numerous capillary in the muscle hence some amount of blood is retained within the carcass (Alvarado et al., 2007). Birds slaughtered using CSM showed a significantly (P<0.05) higher microbial growth than the birds slaughtered using HSM and this can be attributed to low blood loss as a result of method of slaughter. The result obtained from this research was consistent with the result obtained by Ali et al., [3], Addeen et al., [15] and Nakyinsige et al., [18] where they all reported a positive correlation between residual blood and microbial growth. Thus, effective bleeding is essential for low microbial count in chicken meat.

Haem Iron Content

The effect of storage time on haem iron content is shown in Table 4.5. At day 1, the haem iron content for both methods of slaughter were the highest with the CSM having the highest value of 3.25mg/100g sample (P<0.05). This result is confirming the highest Fe content in CSM samples (Table 4.4) showing that there was residual blood in the carcass of birds slaughtered by CSM. Haem iron content of 2.55 mg/100g sample was recorded for HSM and thus reaffirming that this slaughter method ensure effective blood removal via bleeding. Haemoglobin which is a major constituent of blood is made up of four polypeptide chains with each chain containing one haem group; each haem consists of an iron atom coordinated inside the porphyrin ring [19]. As storage time increases, the values of the haem iron content decreases which may be due to haem breakdown resulting in the release of non-haem content [20]. Lipid oxidation of muscle is activated by this released iron during extended storage periods [21]. At 8 days of refrigerated storage, the value of haem iron content for HSM was lower when compared to the value obtained for the CSM (1.31 and 2.05 mg/100g of sample at P<0.05) thus confirming the research by Griffiths et al., [22] that Islamic or Halal method produced chicken meat with lowest haem oglobin content compared with other methods of slaughter.

IV. Tables And Figures

Table 4.1: Effect on Slaughtering Methods on Broiler Meat Quality Parameters

Parameters	HSM	CSM	Statistical Significance
pH	5.95±0.14	6.17±0.15	*
Drip loss (%)	0.43±0.08	0.58±0.05	*
Thaw loss (%)	3.31±0.43	3.42±0.95	N.S
Cook loss (%)	16.64±1.27	18.12±1.54	N.S
Firmness (kg)	1.57±0.39	1.25±0.32	*
Toughness (kg/s)	7.52±2.03	7.85±2.56	N.S

Abbreviations: HSM: Halal slaughter method; CSM: Chinese slaughter method, * means significant at P<0.05, NS means not significant at P<0.05.

Table 4.2: pH Rating Scale for Chicken Meat (Gigaudet al.,) [10]

Quality Defects	Normal range	HSM	CSM
PSE defect	<5.70	____	____
Normal Meat	5.70<pH<6.20	5.95	6.17
DFD defect	>6.20	____	____

Table 4.3: Effect of slaughtering methods on the colour parameters of Broiler Chicken Meat

Method of slaughter	L*	a*	b*
Halal Method	51.46±3.73	6.88±0.81	18.13±5.02
Chinese Method	56.42±1.17	8.36±0.71	19.20±3.74
Statistical Significance	S	S	N.S

L*=lightness, a*= redness, b*=yellowness, S means significant at P<0.05, NS means not significant at P<0.05.

Table 4.4: Effect on slaughtering methods on Mineral contents of broiler chicken meat

Mineral Contents (mg/kg)	HSM	CSM	Statistical Significance
Zn	7.20±0.71	0.80±0.43	*
Mg	302.34±2.49	317.10±1.46	*
Fe	10.00±1.64	13.77±2.76	*
Cu	0.76±0.39	1.48±0.61	N.S
Ca	120.30±2.41	147.87±2.70	*
Mn	8.58±2.74	1.48±1.90	*

Abbreviations: HSM: Halal slaughter method; CSM: Chinese slaughter method, * means significant at P<0.05, NS means not significant at P<0.05.

Table 4.5:Effect of slaughtering methods on Haem iron content of broiler chicken meat

Storage time (days)	HSM	CSM	Statistical Significance
1	2.55±0.21	3.25±0.29	*
3	2.17±0.08	2.97±0.11	*
5	1.98±0.14	2.75±0.07	*
7	1.76±0.16	2.36±0.29	NS
9	1.31±0.26	2.05±0.20	*

Abbreviations: HSM: Halal slaughter method; CSM: Chinese slaughter method, * means significant at P<0.05, NS means not significant at P<0.05.

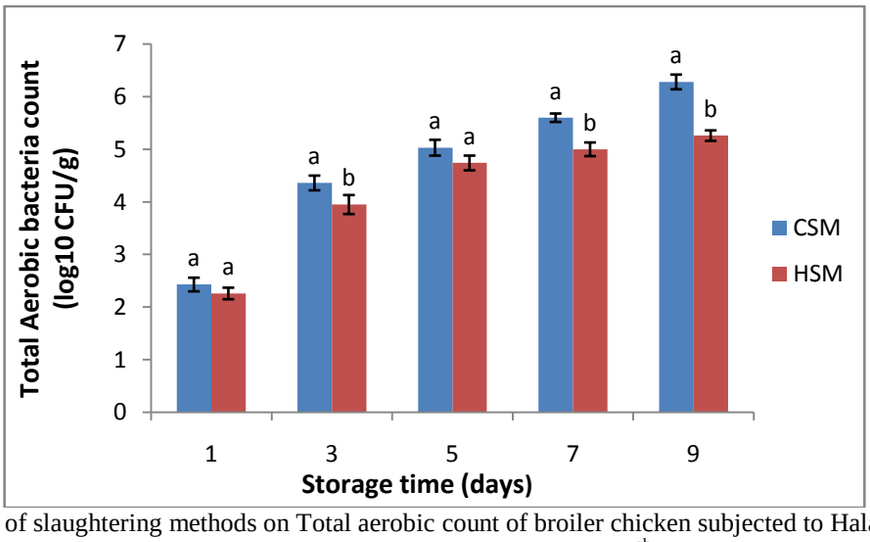

Fig 4.1: Effect of slaughtering methods on Total aerobic count of broiler chicken subjected to Halal and Chinese slaughter. HSM: Halal slaughter method; CSM: Chinese slaughter method. [ab] Means with different letters differs significantly at P<0.05.

V. Conclusion

Slaughtering methods significantly affect the meat quality of broiler chicken meat and Halal method favours high blood drainage and hence better meat quality and better keeping quality during refrigerated storage.

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