

Effects of Storage Time on the Quality of Local Chicken Meat

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Abstract

An experiment was carried out to investigate the proximate composition and effects of aging time on local chicken meat quality. For proximate analysis, 24 male and 24 female breast, thigh and drumstick samples from one half of the carcass were skinned, de-boned and frozen at -20°C. The samples were minced through a 5mm plate meat-grinding machine and vacuum packed prior to analyses. Proximate composition analysis of minced meat samples were performed on wet basis. The other half carcasses samples were chilled for 4, 6, 12 and 24 hours post mortem (PM) at 4°C. pH values were measured for each sample followed by storage at -20°C to arrest further changes in meat. Cooking loss and meat tenderness were determined for these samples. The proximate analysis showed that females had higher ($P<0.05$) overall dry matter and ether contents than males, while CP% and ash content were similar in the two sexes. Breast meat had higher ($P<0.05$) CP and ash content than meat cuts from the leg. Generally, breast meat had lower ($P<0.05$) pH (5.89) compared to meat from the thigh (6.14) and drumstick (6.15). pH of breast meat at 24 hours PM (5.82) was lower than that recorded at 4, 6 and 12 hours PM. Tenderness of meat as measured by shear force values significantly improved with storage time and decline in shear force values was more accentuated in the first six hours of aging. After this period, the values were less than 13.3N for drumstick and 18.9 N for both breast and thigh. The effect of storage time on cooking loss was more pronounced in leg meat than breast meat and cooking loss was much less when meat parts stored for 24 h. For production of acceptable tender meat from local chicken, the ideal cold storage time can be set at between 4 to 6 hours.

Key Words: Local chicken, Aging, Cooking loss, Meat pH, Tenderness, Proximate composition

Introduction

The poultry industry in Tanzania is divided into traditional and commercial production. The traditional poultry sector is the largest contributing to about 70% of the flock and supplying 100% of poultry and eggs consumed in rural and 20% in urban areas. Between 2003 and 2008 the sector grew at 5.6% annually (NBS, 2012) and FAO (2012) projected that by 2030 the indigenous chicken population will reach 63.8 million and production of chicken will reach 170.7 million tons. This implies that poultry meat and eggs will play a leading role in solving the problem of the growing demand for animal protein. Despite the contribution of local chicken in various culinary and the ever increasing demand and consumption of its meat and eggs as sources of protein, limited

research has focused on evaluating meat quality from the local/indigenous chicken stock. Addressing factors that affect meat quality from these chickens will enhance formulation of grading standards and increase acceptability of meat produced from local chicken in various niche market segments such as tourist hotels, supermarkets and mining industry.

However, most of the local poultry are raised under scavenging or semi-scavenging environment and often slaughtered late given their low genetic potential for growth compared to broilers. The slow growth leads to late attainment of sizable slaughter weight, consequently resulting to production of tough meat (Katarzyna, 2011). There are two major aspects of meat quality, nutritional quality which

is objective and “eating” quality as perceived by the consumer - flavour, juiciness, tenderness and colour - which is highly subjective (Sogunle *et al.*, 2010), though, colour and tenderness can be quantified. In the developing world, the nutritional quality of local raised chickens has received less attention in research, though some studies such as that of Cheng *et al.* (2008) reported that free-range chickens tended to have significantly higher percentage of breast crude protein content but, less crude fat content compared to conventional raised chickens.

In addition, it is customary that local chicken are slaughtered and processed for consumption immediately after slaughter. The birds are often stressed immediately or prior to slaughter due to rough handling during transport or at the slaughter point which cause the muscle glycogen to be released into the blood stream in which after slaughter, is rapidly broken down to lactic acid while the carcass is still warm. Short period after slaughter as the glycogen in the tissues is exhausted rigor mortis sets in and the whole carcass become stiff. This is due to the contraction of the muscle fibres when the actin filaments of the muscle fibres slide inwards between the myosin filaments so shortening the myofibrils. This condition can be prevented by “aging” or “ripening” after slaughter which is achieved by storing the meat until the muscles gradually recover their extensibility and become more tender through partial enzymatic breakdown of the muscles fibres (FAO, 1992). Under these circumstances, local poultry meat can therefore benefit from conditioning or aging which is known to improve meat quality especially the textural characteristics (Wattanachant, 2004). The objectives of this study were therefore, to explore the nutritional qualities of local chicken meat and find out to what extent does storage time (or conventionally referred to as aging) influence tenderness, cooking loss and meat pH.

Proximate analysis

At the age of five month, 48 birds were randomly sampled from the two rearing system half of them being males and the other half being females. For proximate analysis, 24 male and 24 female breast, thigh and drumstick samples from one half of the carcass were skinned, de-boned

and frozen at -20°C. The samples were minced through a 5mm plate meat-grinding machine and vacuum packed prior to analyses. The other half carcasses samples were chilled for 4, 6, 12 and 24 hours post mortem (PM) at 4°C. Chemical composition analysis of minced meat samples was performed on wet basis by proximate analysis to determine dry matter, ash, crude protein and fat content (AOAC, 2007). Dry matter of fresh samples was analyzed by oven method set at 105°C. Ash was determined after subjecting the samples to a furnace set at 500°C. For protein and fat determination, frozen breast, thigh and drumstick meats were thawed for 24 hours. Protein was analyzed by the Kjeldahl method using a 2200 Foss Tector Kjeltec distillation unit (Foss, Höganäs, Sweden). Fat was analyzed by Soxhlet method using a 2050 Soxtec Avanti Extract unit (Foss, Höganäs, Sweden). Breast, thigh and drumstick meat samples from 48 half-carcasses were used to determine cooking loss and shear force, as well as pH. First readings were on fresh meat samples and subsequently at 4, 6, 12 and 24 hrs PM. A portable digital pH meter (Knick Portamess® 910, Germany) was used to measure the pH of the breast, thigh and drumstick samples of each individual bird carcass. The pH meter was standardized by a two-point method against buffers of pH 4.0 and pH 7.0 standard solutions before each sample measurement.

For determination of cooking loss aged samples of chilled breast meat, thigh meat and drumstick meat weighing 20–30 g were cut, weighed and sealed in a plastic bag (30 microns) and cooked in a thermostatically controlled water bath (Fisher Scientific, Pittsburgh, PA) at 75°C for 45 minutes as described by Rizz *et al.* (2007). Then, the samples were cooled under running water for 15 minutes, dried with soft tissue and weighed. Cooking loss was calculated as percentage loss of weight during cooking relative to the weight of raw meat (Petracci and Baéza, 2009).

Analysis of meat tenderness was done by taking uncooked muscle strips measuring about 1.0×1.0×2.5 cm cut parallel to the muscle fibres. The shearforce (N/cm²) required to cut through the meat cube at a right angle to the muscle fibre direction was determined using Warner Bratzler

shear blade attached to Zwick/Roell (Z2.5, Germany) instrument.

Data analyses

Data were subjected to analysis of variance using a General Linear Model (GLM) procedure of SAS (2006). For proximate analysis, rearing system, sex and meat cut were fitted as fixed effects, including their interactions (model 1). For the analysis of meat tenderness, cooking loss and pH; storage time, cut type and interaction between aging time and cut type as well as rearing system were fitted as fixed effects (model 2). In both analyses Duncan's multiple range tests was used to separate group means.

$$Y_{ijkl} = \mu + S_i + M_j + (S \times M)_{ij} + R_k + e_{ijkl} \quad (1)$$

Where,

Y_{ijk} = the meat proximate variables

μ = overall mean to all observations

S_i = effect of sex (male and female)

M_j = effect of meat cut (breast, thigh and drumstick)

(S*M)_{ij} = interaction effect between sex and meat type

R_k = effects of rearing system

e_{ijkl} = the residual error.

$$Y_{ijk} = \mu + A_i + M_j + (A \times M)_{ij} + R_k + e_{ijk} \quad (2)$$

Where,

Y_{ijk} = the meat quality variables (shearforce, cooking loss and pH)

μ = overall mean to all observations

A_i = effect of aging time (4h, 6h, 12h and 24h)

M_j = effect of meat type (breast, thigh and drumstick)

(A*M)_{ij} = interaction effect between aging time and meat type

R_k = effects of rearing system

e_{ijkl} = the residual error.

Results and discussion

Proximate composition of meat cuts

The results of the proximate composition of local chicken meats are presented in Table 1. Females had higher (P<0.001) overall dry matter (DM) and ether extract (EE) contents than males, while crude protein (CP) and ash content were similar

in the two sex. To the contrary, Suchý *et al.* (2002) reported higher DM and CP % in males than female Ross 308 broiler chickens, while De Marchi (2005) reported no differences between males and females for chemical composition of the breast except for percentages of dry matter and ash (female > male). The observed high ash content in female than males by De Marchi (2005) was contrary to what was revealed in the current study where sexes did not differ in ash content whilst, higher ether (fat) content in females may indicate more tender cuts as was reported by Sanka and Mbaga (2014).

Table 1 also reveals that thigh cuts had higher (P < 0.05) dry matter content than breast and drumstick cuts. Breast cut had higher CP content than thigh and drumstick cuts, the values being higher by 1.93 and 2.75% compared to drumstick and thigh cuts, respectively. Thigh cut had the lowest CP content probably due to the numerically highest ether extract. Overall, CP values were within range reported in broilers by Suchý *et al.* (2002) (22.5 to 22.6%) and Jaturasitha *et al.* (2008) in indigenous Thai chickens (23.6 and 24.8%). Although breast cut was found to have higher CP content, it had lower fat content than leg meat (thigh and drumstick). These results conforms the findings by Petracci *et al.* (2007) and Sogunle *et al.* (2010). Similarly, ash content in breast cuts was much higher (p<0.001) compared to values obtained for thigh and drumstick meats and values were generally higher than the value (1.03±0.04%) reported for Thai indigenous chicken by Wattanachant *et al.* (2004); Lee *et al.* (2003) and Cheng *et al.* (2008). The large difference in ash content between these studies could not be explained since similar method was used and the fact that both stock were indigenous. Nonetheless, ash in food determines largely the extent to which the dietary minerals would be available in a particular food sample. Whilst, the difference in ether extract was not significant among cuts, thigh muscle had slightly higher EE than breast and drumstick implying that thigh stored more energy than other parts, presumably as a source of energy for walking. The variability in the proximate composition of different meat have also been reported by other scholars (Suchý *et al.*, 2002., Jaturasitha *et al.*, 2008 and Tougan *et al.*

Table 1. Least square means (\pm SEM) for proximate composition of local chicken meat summarized by sex and type of meat

Parameter	Sex		SEM	P-value	Type of Meat			SEM	P-value
	Male	Female			Breast	Thigh	Drumstick		
DM (%)	26.37	28.66	0.34	0.0001	27.32b	28.45a	26.78b	0.42	0.0186
CP (%)	21.88	21.59	0.18	0.2426	23.29a	20.57b	21.36c	0.21	0.0001
EE (%)	1.38	3.24	0.22	0.0001	2.10	2.68	2.14	0.27	0.2483
ASH (%)	4.26	4.20	0.09	0.6674	4.55a	3.96b	4.18b	0.11	0.0009

^{abc}Means within the same row with different superscript letters differs significantly at $p < 0.05$

et al., 2013). This implies that consumers can have a choice on the meat cut based on its expected nutritional value in addition to other physical attributes, such as tenderness.

Effect of meat cut and storage time on pH

Generally, breast meat had lower pH values ($P < 0.05$), followed by thigh, and the least was drumstick (Table 2). The findings are in agreement with those reported by Wattanachant (2008) who observed similar pattern in Thai indigenous chicken meat. The pH at the beginning in the current study was in accordance with Lesiak *et al.* (1996) who reported the postmortem pH values of 6.27 for breast and 6.44 for thigh at 25 minutes post slaughter. Meat with high ultimate pH retains moisture but may appear dark (Husak *et al.*, 2008). The trend in pH of local chicken breast, thigh and drumstick with storage time (Table 2) shows that during the first 4 to 5 hours of storage, pH declined more rapid and thereafter, the decline was gradual. Nevertheless, the rates of pH decline between the three meat cuts were similar, but, being slightly higher in the thigh cut. This observation is similar to what were reported by Lyon *et al.* (1985) and Thielke *et al.* (2005). Husak *et al.* (2008) contends that the rate and the extent of pH decline have a large influence on meat quality characteristics and variation in meat pH is likely to influence color and the ability of meat to hold water. Accordingly, the postmortem pH decline is a clear indication of the biochemical status of the meat and the rate of intramuscular glycolysis (Bendall, 1979, cited by Thielke *et al.*, 2005). The down trend in pH decline is explained by the fact that energy metabolism postmortem proceeds anaerobically (mainly glycolysis) producing lactic acid as the end product which

is responsible for pH decline PM. The decline in pH ceases upon onset of rigor, following depletion of glycogen reserves (FAO, 1992). Based on the results from the present study, it can be postulated that the beginning of the onset of rigor mortis was around 6 hours postmortem. On the other hand, the relatively lower pH of breast muscles both at slaughter and at 24hrs PM may indicate that breast muscles are rich in white muscle fibres types which metabolise energy mainly anaerobically, even when an animal is alive. Berri *et al.* (2005) reported that regardless of the chicken line, increased glycolytic potential in breast muscle was associated with lower ultimate pH and higher drip loss. Such muscle types are recruited by animals to produce sprint movements.

Effect of aging on meat tenderness

The effect of rearing system was found to be insignificant on meat tenderness (Sanka and Mbage, 2014), while the post-mortem storage significantly improved ($p < 0.05$) tenderness of meat cuts (Table 2). Generally, all cuts showed a more accentuated decline in shear values in the first six hours of aging. After this period, the declines was gradual with values less than 13.3 N for drumstick and 18.9 N for both breast and thigh within 12 hours PM. Dransfield (1992) postulated that the change in tenderness during the period of accentuated decline is not just due to proteolysis, but also as a consequence of actin/myosin cross-bridge interaction from resting (weak) state to a contractile (strong) meat state, followed by a gradual weakening of the contractile meat state. Thus, improvement in meat tenderness, commonly called meat aging, during refrigerated postmortem storage occurs due to weakening of skeletal muscle structure.

Table 2. Least square means (\pm SEM) for Shearforce (SF), cooking loss (CL) and pH local chicken breast, thigh and drumstick meat aged at different time intervals

Traits		Storage time (Hours)				SEM	P-Value
		4	6	12	24		
SF (N)	Breast	22.80a	20.19b	18.93bc	17.69c	0.50	0.0001
	Thigh	22.21a	18.89b	18.92b	18.27b	0.51	0.0001
	Drumstick	20.97a	18.86b	13.25c	13.85c	0.52	0.0001
CL (%)	Breast	22.82a	23.61a	20.59b	19.82b	0.52	0.0001
	Thigh	21.44b	23.01a	19.86c	18.21d	0.45	0.0001
	Drumstick	19.15b	21.71a	17.78c	16.09c	0.50	0.0001
pH	Breast	5.96a	5.90ab	5.91ab	5.83b	0.03	0.0206
	Thigh	6.27a	6.17ab	6.12b	6.09b	0.04	0.0096
	Drumstick	6.24	6.19	6.15	6.13	0.03	0.0725

^{abcd} Means within the same row with different superscript letters differs significantly at $p < 0.05$.

The weakening is due to the breakdown of myofibrillar proteins by proteolytic enzymes mainly calpains and cathepsin (Zhang and Barbut, 2005 and Muchenje *et al.*, 2008a, b). Stewart *et al.* (1984) and Northcatt *et al.* (2001) suggested a minimum aging time of 4 hours in poultry meat, while Perlo *et al.* (2010) recommended 6 hours aging at around 4°C to obtain meat of high quality. Takahashi (1996) contended that, in addition to improvement in tenderness as aging time advances there is also a corresponding improvement flavor. Thus, the difference in shear force values observed in the current study may as well be related to among others the composition of the meat and the type of fibers the meat contains.

Effect of aging on cooking loss

Cooking loss was highly ($P < 0.0001$) affected by aging time as presented in Table 2. Interaction of meat type and chilling time was also noted to be significant ($p < 0.05$). Although breast meat had a higher cooking loss than thigh and drumstick meat, aging time had a greater effect on drumstick meat compared to the other two cuts and at 24 hours drumstick showed the lowest cooking loss. This pattern corresponds to what was observed for tenderness among the three meat types (Table 2). Furthermore, cooking loss in meats depend on ultimate pH (Mushi *et al.*, 2009), and intramuscular fat content (Safari, 2010). In this regard, breast had less intramuscular fat, but lower pH, hence, less tender with highest cooking loss implying

lower water holding capacity. This observation is similar to what was reported by Petracci *et al.* (2004) in broilers. Significantly higher cooking losses at 6 h may be related to the pH and optimum time for the meat to relax after rigor mortis.

Conclusions

It is concluded that breast meat had higher CP and ash content than leg muscles and breast meats displayed highest cooking loss across storage time while drumstick was the tenderest cut. Furthermore, storage at 4°C influence meat pH, tenderness and cooking loss. It is recommended that poultry meat from local chicken should be chilled for at least 4 to 6 hours postmortem before further processing.

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