EFFECTS OF POST-MORTEM PROCESSINGS AND FREEZING ON WATER HOLDING CAPACITY, WARNER BRATZLER VALUE AND CHEMICAL COMPOSITION OF CHEVON

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ABSTRACT

This study was carried out to investigate the effects of post-mortem processing methods and freezing on Water Holding Capacity (WHC), Shear force Value, proximate composition and pH of goat meat. Nine Red Sokoto buck goats of 10 – 12 months old and of weight between 18 – 20 kg were used for this study. They were purchased, stabilized for two weeks on cowpea chaff and a standard diet, fasted for 16 hours and slaughtered. Their carcasses were randomly assigned to and processed with scalding, skinning and singeing methods, eviscerated, washed and fabricated into primal cuts. Meat samples (semi membranosus muscle) were removed from frozen leg cuts on 0,7,14 and 21 days to determine parameters. Data collected were subjected to analysis of variance (ANOVA) for a 4x3 factorial experiment The Results showed that WHC was higher ($p<0.05$) in scalded meat (72.18%), least ($p<0.05$) in singed meat and decreased ($p<0.05$) as freezing period increased ($p<0.05$). Shear force value was higher ($p<0.05$) in singed meat, least ($p<0.05$) in skinned meat, (56.41%) and decreased ($p<0.05$) as freezing period increased ($p<0.05$). Moisture and fat were higher ($p<0.05$) in scalded meat, ash and pH were higher ($p<0.05$) in singed meat, while skinned meat gave highest ($p<0.05$) protein (20.47 %) all decreased as freezing period increased except pH. Skinning furnished higher attributes of frozen chevon measured in this study. Also freezing of goat meat for 21 days was adequate, beyond which the wholesomeness and acceptability of the meat could be affected as the meat attributes evaluated were decreasing.

Keywords: Post-mortem processing, Freezing, Water holding capacity, Shear force, Chemical composition, Red Sokoto buck meat

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INTRODUCTION

Paramount among the post-mortem handlings that affect meat quality are dressing and preservation methods. (Omojola and Adesehinwa, 2006) reported that processing methods widely used for dressing animal carcasses post-mortem are singeing, scalding and skinning. (Kondratowicz and Matusevicius, 2002) reported that freezing of meat causes changes in their quality as it leads to physicochemical and organoleptic deterioration of meat due to thawing and refreezing of meat (F.A.O. 2007). Water holding capacity is the ability of meat to retain its naturally occurring water during application of external force (Dennis, 2002). It was reported that water holding capacity was least in meat from singed carcasses, while those of scalded and skinned carcasses were statistically similar (Omojola and Adesehinwa, 2006). Shear force measures objective tenderness which is force needed to shear one cubic centimetre meat sample (Omojola, 2008). (Awosanya and Okubanjo, 1993) reported that skinning method produced significantly tougher meat, while (Okubanjo, 1997) reported higher shear force value for goat meat due to singeing processing. (Altermann and VonLergerken, 2005) reported that freezing of meat resulted in lower shear force value. (Omojola and Adesehinwa, 2006) reported significant differences in proximate composition of rabbit meat processed with singeing, scalding and skinning, while (Qiaofen and Da-Wen, 2005) reported significant increase in moisture content and decrease in protein during freezing. This study aimed at investigating the effects of post-mortem processing and freezing on water holding capacity, shears force value and chemical composition of Red Sokoto buck meat.

MATERIALS AND METHODS

Experimental Animals

Red Sokoto bucks, 9 in number, of age 10 to 12 months and body weight 18 to 20 kg were used for this study. The animals were purchased and allowed to acclimatize to the research area's conditions for two weeks. They were fed cowpea chaff and a standard diet. They were fasted for 16 hours with access to clean and enough water before they were slaughtered. Their carcasses were randomly assigned to three post-mortem processing (dressing) methods viz; scalding, skinning and singeing.

Carcass Processing

Scalding: was carried out by modifying the method described by (Monin *et al.*, 1995) Hot water of 75 to 90^{0}C was poured on each carcass to soften the hairs and were scrapped with a metal scrapper.

Skinning: Carcasses skins were removed following the procedures of (Omojola and Adesehinwa, 2006) a ring was made on the hind legs just above the hock with a sharp knife. It was inserted into the legs skin and was opened to the root of the tail. Another incisions were made from the pelvic girdle to the neck. The skins were pulled until they were removed.

Singeing: Carcasses were put on fire of temperature between 230 and 250^{0}C made with hard Teak wood (*Tectona grandis*) until the hairs were carefully burnt off with minimal damage to the skin according to (Okubanjo, 1997).

Evisceration and Carcass Fabrication

Carcasses were eviscerated, decapitated and shanked. They were washed and split into two equal halves hot with a hand meat saw. They were split further into primal cuts, following the procedures of (Field *et al.*, 1976).

Preservation of Meat

Leg cuts from carcasses were preserved between – 16 and – 18^{0}C in a freezer for, 0,7,14 and 21 days. The leg cuts were thawed and meat samples (*Semimembranosus muscles*) were removed from them for determining water holding capacity, shear force value and chemical composition of the meat samples.

Water Holding Capacity (WHC)

This was carried out using press method according to (Suzuki *et al.*, 1991). An appropriately 1g of meat sample (*Semimembranosus muscles*) from leg cut was placed between two 9cm Whatman No 1 filter paper (Model C, Caver Inc., Wabash, USA). The sandwich was pressed between two 10.2x10.2cm^2 Plexiglas at about 35.6kg/cm^3 for 1 minute with a vice. The pressed meat samples were removed and oven dried at (100 -105^{0}C) for 24 hours to determine their moisture contents. The amount of water released from the meat samples was measured indirectly by measuring the area of filter paper wetted relative to the area of pressed meat samples. Thus:

$$WHC = \frac{100 - (Aw - Am) \times 9.47}{Wm \times Mc} \times 100$$

Where: Aw = Area of water released from meat samples (cm^2)

Am = Area of meat samples (cm^2)

Wm = Weight of meat samples (g)

Mc = Moisture content of meat samples (%)

9.47 = Constant factor.

Shear Force Value

Weighed meat samples (*Semimembranosus muscles*) (approx. 20g) were removed from frozen leg cuts after thawing at 0,7,14 and 21 days and were wrapped in thermo resistant polythene bags and cooked in a pre-heated pressure cooking pot at 80^{0}C for 20 minutes on an adjustable PIFCO JAPAN ELECTRIC HOT PLATE model (No. ECP 202) to an internal temperature of 72^{0}C. They were removed and cooled to room temperature (27^{0}C) for 10 minutes. The meat samples were reweighed and wrapped in polythene bags and chilled at 4^{0}C for 18 hours. They were removed and were allowed to equilibrate to room temperature before removing approx. 1.25cm diameter cores parallel to muscle fibre orientation using a cork borer (Qiaofen and Da-Wen, 2005). The cores were sheared at three locations with Warner – Bratzler V-noch blade shearing instrument according to (Honikel, 1998).

Proximate Composition

Proximate composition of frozen meat samples was determined following the procedures of (AOAC, 2000). Meat samples (*Semimembranosus muscles*) were removed from frozen leg cuts after thawing at 0,7,14 and 21 days and used for determining proximate composition as follows:

Moisture content: of meat was determined by drying the meat samples (2g) from leg cut in each treatment in an oven at (100 – 105^{0}C) until a constant weight was obtained.

Crude Protein: was determined using Kjeldahl method which comprised meat digestion distillation of the digest and titration of the distillate, crude protein values were obtained by converting nitrogen (N%) content obtained by titration with a constant factor (6.25). Thus crude protein was obtained as (6.25 x N %).

Crude fat: was determined with soxhlet extraction method using petroleum ether. Two grams of chopped meat from each treatment was put into a thimble in an extractor and petroleum ether was poured into the flask. The flask was heated and the solution was allowed to siphon to the flask for at least 10 – 12 times. The flask containing the oil was weighed and dried in an oven to a constant weight and fat values were obtained thus:

$$\% \text{ fat} = \frac{\text{Weight of oil}}{\text{Weight of Meat samples}} \times 100$$

Ash content: This was determined by igniting meat samples in crucibles in a Muffle furnace set between 550 and 600^{0}C for 4 hours. The crucibles and their contents were cooled in a desiccator at room temperature (27^{0}C) and were reweighed. The percentage ash was derived thus:

$$\% \text{ Ash} = \frac{\text{Weight of Ash}}{\text{Weight of Meat Samples}} \times 100$$

pH was measured after thawing meat samples (*Semimembranosus muscles*) from leg cuts from each treatment at 0,7,14 and 21 days. 10g of meat samples was homogenised for 5 minutes with 90ml distilled water using a blender (plate 5mm) model 242, NAKAI, JAPAN. The meat samples pH was measured with a potable pH meter model H18424 micro–computer, HAVANNA INSTRUMENTS, ROMANIA (Marchiori and deFelicio, 2003).

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

4x3 factorial experimental design was used for this study. Data obtained from this study were subjected to analysis of variance (ANOVA) using (SAS, 2002) and significant differences among the means were separated with Duncan multiple range test of the same software.

RESULTS AND DISCUSSION

There were significant ($p<0.05$) differences in the WHC of the meat samples of Red Sokoto buck carcasses that were scalded, skinned and singed and frozen for 21 days (Table 1). Meat samples from scalded carcasses had highest ($p<0.05$) WHC (72.18%) followed by that of meat samples from skinned carcasses (67.62%) and least ($p<0.05$) in meat from singed carcasses (56.41%).

It decreased ($p<0.05$) steadily in meat samples from scalded and skinned carcasses, while it was delayed ($p>0.05$) in meat samples from singed carcasses frozen between 0 and 7th day and then decreased ($p<0.05$) between 7th and 21 days.

Water holding capacity is the ability of a piece of meat to retain its naturally occurring water during application of any external force such as cutting, grinding or pressing (4; 5) It is one of the most important meat properties in processing meat products because it affects the yield colour, tenderness, juiciness and texture of raw and cooked meat (Aduku and Olukosi, 2000).

(Honikel, 1998) reported that water holding capacity is temperature (heat) and pH dependent and that protein denaturation and coagulation by heating reduce the space within the myofibrillar protein network with the consequent decrease in water and lowering of water holding capacity of the meat. It was also reported (Hedrick *et al.*, 1994) that water holding capacity can be increased or decreased in meat base on the increase or decrease in pH above or below the iso-electric point of proteins, which is the pH at which the numbers of positive and negative charges (ion and anion) are the same or the net charge is zero, that is, pH between 5.4 – 5.6 (Hedrick *et al.*, 1994).

At this pH, the space between proteins is minimal, then there would be low water holding capacity, but if the pH of meat proteins is raised above 5.6, the space within protein increases hence, high water holding capacity ensues in meat. The results obtained on water holding capacity of frozen meat in this study can be based on three factors. The most obvious two factors are the temperature (heat) and freezing effects, while the third factor is inherent in the frozen meat samples. Heat denatures and reduces the space within the myofibrillar proteins network thereby reducing water holding capacity of meat from singed carcasses.

Normally, meat from skinned carcasses supposed to have highest water holding capacity based on the fact that no heat was applied to the carcasses, however scalded carcasses had skin cover which might have shielded the loss of moisture or juices during freezing. Also much water was poured on scalded carcasses during scalding process, hence more water would have been accumulated and be retained in the meat from scalded carcasses which might have raised its level of water retention than meat samples from other treatments especially in singeing. In another hand, thawing and refreezing of meat samples might also have aggravated the damage to the meat samples from singed carcasses. Singeing might have created some damage on the skin through which juices could have escaped, but damage to meat from skinned carcasses could be direct structural destruction as a result of lack of skin cover.

The results of water holding capacity of frozen Red Sokoto buck meat obtained in this study were in agreement with the findings of (Banani *et al.*, 2006) who reported decrease in water holding capacity of frozen goat meat from 18.06 to 3.24% over 15 days of freezing preservation. Table 2 shows the results of Warner-Bratzler values (shear force) of frozen Red Sokoto buck meat as influenced by post-mortem processing methods.

There were significant ($p<0.05$) differences in the shear force values of the frozen meat samples from the three treatments. Meat samples from singed carcasses had highest ($p<0.05$) shear force values followed by that of meat samples from scalded carcasses and least ($p<0.05$) in meat samples from skinned carcasses frozen for 0,7,14 and 21 days respectively. The results also showed that shear force values decreased as freezing period increased in all the treatments. The heat meted to the carcasses could be responsible for the results of shear force obtained in this study in one hand and the damaging effects of thawing and refreezing on the other. This is because, rigor shortening or stiffening is heat/temperature dependent especially during the first 24 hours post-mortem for release of calcium from the sarcoplasmic reticulum, which is important to meat tenderness (Wheeler and Koohmaraie, 1994). Therefore, the rapid development of heat induced contraction and rigid setting of muscle fibres during singeing and scalding might have been responsible for the toughening of meat from singed carcasses in particular and scalded carcasses which might have culminated in high shear force values in meat samples from singed and scalded carcasses against lower shear force values recorded in meat from skinned carcasses because they did not pass through heat treatment.

It had been reported (King *et al.*, 2003) that ageing and freezing of meat could result in lower shear force values during post-mortem preservation. This is because freezing causes muscle fibres and connective tissues to rupture and induces stretching and tenderness of meat as observed in meat samples from skinned carcasses with lower shear force values in this study as against those of meat samples from singed carcasses that might have been toughened by heat and were not able to stretch and be tendered like those from skinned carcasses.

High shear force values observed in meat from singed carcasses could also be due to lower moisture content of the meat probably because of loss of juices during singeing and shrinking effect of freezing on the meat. The results obtained on shear force values from this study were in agreement with those of (Omojola and Adesehinwa, 2006) who reported higher shear force values for meat samples from singed carcasses and (Veiseth *et al.,* 2001) who reported lower shear force values for lamb meat after freezing it for 11 days as well as (Altermann and VonLengerken, 2005) who reported decrease in shear force values of mutton meat frozen for 2 days from 8.8 to 5.7kg/cm^3.

Table 3 shows the results of chemical composition of frozen Red Sokoto buck meat as affected by post-mortem processing methods. Scalding method furnished higher ($p<0.05$) moisture and fat values, skinning gave higher ($p<0.05$) protein and lower ($p<0.05$) fat, ash and pH values, while singeing gave higher ($p<0.05$) ash and pH as well as lower ($P<0.05$) moisture and protein contents of frozen Red Sokoto buck meat.

Moisture, protein, fat and ash contents values for Red Sokoto buck meat frozen for 0 day were higher ($P<0.05$) while pH was lower ($P<0.05$). pH was highest ($P<0.05$) on 21st day, while moisture, fat and ash values of frozen Red Sokoto buck meat were lower ($P<0.05$). Meat samples from scalded carcasses had highest ($P<0.05$) moisture content (75.40 – 76.55%) and fat (3.00 – 3.37%) irrespective of the preservation time, while meat samples from singed carcasses had least ($P<0.05$) moisture (72.37 – 72.60%) and fat (2.07 – 2.23%) contents.

Protein content (20.19 – 20.33%) was highest ($P<0.05$) in meat samples from skinned carcasses frozen for 21days, followed by meat from scalded carcasses (19.32 – 19.65%), while meat from singed carcasses had lowest ($P<0.05$) crude protein (18.16 – 18.37%). There were significant ($P<0.05$) differences in the ash content as well as the pH of meat samples across the treatments with singeing method having the highest ($P<0.05$) values. It was however, observed that moisture, protein, fat and ash contents of the meat samples decreased in all the treatments as the time of freezing increased, while pH of the meat increased as the time increased. Meat from scalded carcasses had higher moisture content probably because hot water was poured directly on them during scalding and some of which might have been absorbed and retained in the meat.

Meat from singed carcasses underwent intensive heat treatment which might have resulted in moisture loss from the meat due to shrinkage of muscle fibres and connective tissues. Crude protein was highest in meat from skinned carcasses, probably due to the fact that skinned meat did not pass through heat treatment meted to singed and scalded meat, hence protein denaturation was not pronounced in skinned meat. Fat content was lower in meat from skinned carcasses probably because the carcasses skins were removed and most of the subcutaneous fat that are more abundant in carcass might have been removed along the skins, thereby reducing the percentage fat content of the meat. The results obtained on chemical composition of meat samples from the three treatments were in agreement with those reported by (Omojola and Adesehinwa, 2006). Moisture contents of the meat samples decreased while other proximate components of the meat – protein, fat and ash decreased significantly over 21 days of freezing. The decrease in moisture content could be responsible for the decrease of other meat components since they form part of juice that was lost in the process of meat shrinkage during thawing and drainage in the freezer during freezing (Qiaofen and Da-Wen, 2005).

CONCLUSION

Post-mortem processing of carcasses and freezing of meat are two essential post-handling operations required for producing wholesome meat and making it available to consumers. It was concluded from this study that skinning method favoured adequately all the variables of Red Sokoto buck meat measured in this study. Also freezing of Red Sokoto buck meat for 21 days was adequate, beyond which it could be detrimental to the wholesomeness and acceptability of the meat since the meat attributes evaluated were decreasing.

Table 1: Water holding capacity (%) of Red Sokoto buck meat as influenced by post-mortem processing methods and time of preservation

Parameters		Variable Water Holding Capacity
Processing Methods		
Scalding		72.18 ± 7.67^{a}
Skinning		67.62 ± 8.90^{b}
Singeing		56.41 ± 7.38^{c}
Day		
0		66.19 ± 7.46^{a}
7		62.65 ± 8.27^{b}
14		60.77 ± 9.06^{c}
21		57.53 ± 9.77^{d}
Interaction		
Day×Processing Methods		
0	Scalding	72.18 ± 2.31^{aa}
	Skinning	67.62 ± 4.22^{ba}
	Singeing	55.41 ± 6.22^{ca}
7	Scalding	66.70 ± 5.39^{ab}
	Skinning	61.57 ± 8.82^{bb}
	Singeing	55.27 ± 6.88^{cb}
14	Scalding	63.87 ± 7.16^{ac}
	Skinning	59.72 ± 9.46^{bc}
	Singeing	53.32 ± 8.28^{cc}
21	Scalding	60.64 ± 9.94^{ad}
	Skinning	57.15 ± 10.29^{bd}
	Singeing	49.61 ± 8.13^{cd}

abcd: Means with different superscripts within the same column are statistically significant ($p<0.05$)

Table 2: Shear force (kg/cm^3) of Red Sokoto buck meat as affected by post-mortem processing methods and time of preservation

Parameters		Variable Shear Force
Processing Methods		
Scalding		5.70±0.74^{b}
Skinning		4.68±0.64^{c}
Singeing		6.72±0.84^{a}
Day		
0		5.33±1.00^{a}
7		5.12±1.06^{b}
14		4.72±0.97^{c}
21		4.45±1.05^{d}
Interaction		
Day×Processing Methods		
0	Scalding	5.70±0.76^{ba}
	Skinning	4.68±0.42^{ca}
	Singeing	6.32±0.70^{aa}
7	Scalding	5.00±0.68^{bb}
	Skinning	4.15±0.54^{cb}
	Singeing	6.21±0.72^{ab}
14	Scalding	4.50±0.75^{bc}
	Skinning	3.95±0.60^{cc}
	Singeing	5.44±0.56^{ac}
21	Scalding	4.20±0.88^{bd}
	Skinning	3.23±0.72^{cd}
	Singeing	5.38±0.71^{ad}

abcd: Means with different superscripts within the same column are statistically significant ($p<0.05$)

Table 3: Proximate composition (%) and pH of Red Sokoto buck meat as influenced by post-mortem processing methods and time of preservation

		Variables			
Parameters	**Moisture**	**Protein**	**Fat**	**Ash**	**pH**
Processing Methods					
Scalding	75.89 ± 0.37^{a}	19.54 ± 0.13^{b}	2.77 ± 0.42^{a}	1.95 ± 0.18^{b}	5.63 ± 0.02^{b}
Skinning	74.65 ± 0.50^{b}	20.47 ± 0.33^{a}	1.30 ± 0.12^{c}	1.42 ± 0.10^{c}	5.54 ± 0.02^{c}
Singeing	72.75 ± 0.56^{c}	18.39 ± 0.21^{c}	2.65 ± 0.39^{b}	2.02 ± 0.14^{a}	5.72 ± 0.02^{a}
Day					
0	74.57 ± 1.48^{a}	19.57 ± 0.94^{a}	2.46 ± 0.80^{a}	1.84 ± 0.29^{a}	5.67 ± 0.04^{d}
7	74.43 ± 1.38^{b}	19.48 ± 0.91^{b}	2.26 ± 0.77^{b}	1.81 ± 0.31^{b}	5.70 ± 0.02^{c}
14	74.39 ± 1.38^{c}	19.44 ± 0.86^{b}	$2.16v0.72^{c}$	1.78 ± 0.31^{c}	5.72 ± 0.03^{b}
21	74.33 ± 1.36^{d}	19.37 ± 0.88^{c}	2.08 ± 0.69^{d}	1.75 ± 0.32^{d}	5.75 ± 0.01^{a}
Interaction					
Day x Processing Methods					
0 Scalding	76.55 ± 0.44^{aa}	19.65 ± 0.09^{ba}	3.37 ± 0.44^{aa}	2.01 ± 0.11^{ba}	5.70 ± 0.05^{b}
Skinning	74.76 ± 0.58^{ba}	20.33 ± 0.40^{aa}	1.48 ± 0.02^{ca}	$1.46v0.08^{ca}$	5.45 ± 0.03^{cc}
Singeing	72.60 ± 0.59^{ca}	18.37 ± 0.23^{ca}	2.23 ± 0.49^{ba}	2.06 ± 0.11^{aa}	5.72 ± 0.02^{a}
7 Scalding	75.48 ± 0.32^{ab}	19.58 ± 0.07^{bb}	3.25 ± 0.48^{ab}	1.97 ± 0.17^{bb}	5.72 ± 0.03^{b}
Skinning	74.67 ± 0.49^{bb}	20.28 ± 0.34^{ab}	1.30 ± 0.06^{cb}	1.43 ± 0.08^{ca}	5.58 ± 0.04^{cb}
Singeing	72.56 ± 0.58^{cb}	18.30 ± 0.21^{cb}	2.22 ± 0.34^{bb}	2.04 ± 0.13^{aa}	5.74 ± 0.03^{a}
14 Scalding	75.45 ± 0.31^{ab}	19.51 ± 0.10^{bb}	3.17 ± 0.37^{ac}	1.94 ± 0.19^{bb}	5.72 ± 0.03^{ba}
Skinning	74.60 ± 0.51^{bb}	20.21 ± 0.29^{ab}	1.23 ± 0.03^{cc}	1.41 ± 0.09^{ca}	5.62 ± 0.05^{ca}
Singeing	72.43 ± 0.59^{cb}	18.23 ± 0.25^{cc}	2.10 ± 0.32^{bc}	2.00 ± 0.15^{ab}	5.75 ± 0.02^{a}
21 Scalding	75.40 ± 0.33^{ac}	19.32 ± 0.14^{bc}	3.00 ± 0.29^{ad}	1.90 ± 0.23^{bb}	5.74 ± 0.03^{ba}
Skinning	74.57 ± 0.49^{bc}	20.19 ± 0.28^{ac}	1.19 ± 0.04^{cd}	1.37 ± 0.12^{cb}	5.64 ± 0.02^{ca}
Singeing	72.37 ± 0.59^{cc}	18.16 ± 0.18^{cc}	$2.07+\_0.33^{bc}$	1.96 ± 0.18^{ac}	5.77 ± 0.01^{a}

abcd: Means with different superscripts within the same column and for the same parameter are statistically significant ($P<0.05$)

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