BREEDS VS POST-MORTEM DRESSING METHODS ON MEAT QUALITY AND MICROBIAL ASSAY OF MUTTON

Abstract: The experiment was carried out to evaluate the influence of different breed of sheep (West African Dwarf WAD, Ouda, Balami) and three different post-mortem dressing methods (scalding, singeing, and skinning) on the carcass, physical properties, organoleptic properties keeping quality of mutton in a factorial arrangement. Significant differences were recorded for both the strain and processing methods effect on the carcass characteristics and primal cuts. Balami strain of sheep yielded highest significant values ($p<0.05$) on all the primal cuts except rack and leg cuts which their values are closely related. Highest and lowest significant ($p<0.05$) values were observed for carcass weight (%) in both scalding (43.12) and singeing (37.90) while similar values ($p>0.05$) were recorded for Ouda and Balami breeds in cooking loss and cold loss (%) but least significant ($p<0.05$) value was noticed for balami in terms of drip loss (4.96). Strain and processing methods does not influence ($p>0.05$) pH significantly, however significant ($p<0.05$) values were obtained when pH were observed at intervals (0, 30 and 60mins). On the organoleptic properties, significant differences ($p<0.05$) were recorded in both the strain effect and processing methods as balami and scalding method possess the highest significant ($p<0.05$) values in colour, juiciness, texture, flavor and overall acceptability except for tenderness that was not influenced ($p>0.05$) significantly by different post-slaughter dressing methods. total bacteria count (TBC) was reported at lowest significant level for WAD (1.23×10^{18}cfu/g) and scalded mutton (1.24×10^{18}cfu/g) at 0hr post-mortem however balami strain and scalding method maintained the least significant ($p<0.05$) total bacteria count throughout the storage days (>0hrs to 13weeks). Conclusively, Balami breed of sheep and scalding method of post-mortem dressing gave promising and preferred results in all the quality parameters and are hereby advocated.

Introduction

Quality meat are been demanded all over the world and the consumers are willing to pay the local meat industry to get improved and better quality meat (Ojewole and Onwuka, 2001; Adeniji *et al.,* 2019). However, the quality and size of the meat obtained from the animal are affected by their nutrition, breed, sex, age, handling and slaughtering method, processing of the meat and their carcass (Adeniji *et al.,* 2019). Meat is known to be an excellent source of protein and includes various vitamins and minerals necessary for human consumption (Iromi *et al.,* 2021), nutrition and growth. And it is majorly obtained from grass eating (herbivorous) animals such as sheep, goat, cattle, camel, rabbit, pig, buffaloes, deer (Pal *et al.,* 2018) and also poultry. However, the preference and overall acceptability of these meats are dependent on the processing methods, physical, chemical and/or the organoleptic (sensory) qualities but the production, processing and consumption possess an enormous economic and social importance (Omojola & Adesehinwa, 2006).

Sheep is one of the main livestock producing meat in Nigeria, its roles in the socio-economic life of people in Nigeria is important. Sheep provide about 30% of meat consumed in the Sub-Saharan Africa and contribute about 16% of milk production (Bourn *et al.,* 1994). However, the quality of the meat can significantly be affected by factors such as genetics, age, body weight, feed and other environmental conditions (Jaturasitha *et al.,* 2008; Chen, 2002) and in particular meat for lambs (sheep) is affected by factors like breed (Blasco, *et al.,* 2019), age of slaughter (Sabbioni *et al.,* 2016; D'Alessandro *et al.,* 2013) and weight at slaughter (Camacho *et al.,* 2016; Liu *et al.,* 2019). The post slaughter handling of meat carcass affects the quality properties of the meat to a great extent, Omojola & Adesehinwa (2006) posited that scalding, singeing and skinning are post-slaughter processing methods and they affect the physical, chemical and organoleptic attributes of meat.

The acceptability and commercial value of meat are determined by the physiochemical traits of meat (Martinez-Cerezo *et al.,* 2005), the color of meat is a very important parameter that the consumers use to make judgment about meat quality. Liu, *et al.,* (2015) reported consumers appreciate meat of light and young lambs more than the one from heavier and adult animals in tenderness and flavor. From literature, the post-slaughter processing methods (scalding, singeing, skinning) has relation to the satisfaction that the consumer gets after consuming meats from sheep, goat, rabbits, poultry etcetera. And singeing is described by Okubanjo, 1997 as a method employed to burn off the hair of an animal, given the carcass skin a golden brown colour and an enhanced smoky flavour on the processed meat. While Monin *et al.,* (1995) defined scalding as a method of floating carcass or dipping of well bled animal in hot water to loosen the skin follicles in order to ease its removal. The conventional dressing (Skinning) according to Awosanya and Okubanjo, (1993) is a simple act of pulling the subcutaneous skin, thereby removing some subcutaneous fat and exposing the internal carcass body.

All these processing methods have varying effect(s) on the carcass characteristics, primal cuts, physicochemical, sensory attributes and microbial assessment etcetera of meat obtained from them. For instance, change in water-binding capacity, tenderness, product appearance, denaturation of protein can be caused by high temperature used in scalding tank (Pena-Ramos and Xiong, 2003), furthermore scalding and singeing reduce the surface bacteria count however reduce the rate of carcass cooling that may influence the pH fall rate (Palumbo *et al.,* 1999; Monin *et al.*, 1995), skinning allows more rapid cooling of the carcass facilitating reduced rate of pH fall (Van Laack, 1991). The usage of any method depends on the convenience and time as singeing is considered for easiness, saves considerable time and energy relative to scalding (Okubanjo, 1997) and widely practiced for home processing of sheep, goat, rabbit and grass cutter.

It is imperative to also note that microbes easily attack meat and meat products due to the richness of several nutrients and Pal *et al.*, (2018) said their presence represent a major concern for preparation of safe and high quality foods for consumers. Meat and its products are highly perishable; hence the needs to be properly processed through a method that will improve the holistic quality attributes and inhibit microbial growth under storage. When the color, texture, odour, and appearance of meat change undesirably and become unfit and inedible as food for human consumption, condition and time of spoilage has thereby set in.

The main breeds of sheep that are native and reared for mutton in Nigeria are namely; Balami, Ouda, which are kept in the semi-arid regions, West African Dwarf sheep in the South and Yankasa throughout the country (Bourn *et al.,* 1994). Adu & Ngere, (1971) said these breeds varied considerably in size, coat colour and other characteristics, however, three of these breeds (West African Dwarf, Ouda and Balami) are concentrated on for the purpose of this research and the processing methods of their meats are assessed for significant differences in organoleptic, physical properties, carcass characteristics, primal cuts and total bacteria count as it is hypothesized in this current study that carcass (mutton) quality attributes and characteristics will vary by the breeds of sheep and processing methods. Again Adu and Ngere (1971) made to understand that the physical characteristics of sheep differ by breed, so do the technological aspects on this note need to be assessed.

MATERIALS AND METHODS

EXPERIMENTAL ANIMAL

The animals used in this experiment were a total of 18 Sheep. Six animals each of West African Dwarf, Ouda and Balami breeds were purchased from a reputable ruminant animal local market in Ogbomoso, Oyo State, Nigeria. The animals purchased were transported to the Livestock unit of Teaching and Research Farm, Animal Nutrition and Biotechnology Department, Ladoke Akintola University of Technology, Ogbomoso where the animals were stabilized and fed for two weeks before slaughtering. The experimental animals were scarified and dressed post-mortem using three different methods (Scalding, Skinning and Singeing)

The following post-mortem treatments were carried out;

Scalding: Carcasses were scalded by pouring hot water on the carcass for the hair to loosen and scraped off with a hand metal scrapper designed for the purpose or blade until the carcass is clean as described by Omojola and Adesehinwa, (2006); Fasae *et al.* (2010) and Apata (2014)

Skinning: The pelts of the carcasses in this group were removed with a sharp scalpel, knife and scissors. A ring was made round one of the hind legs and the knife was inserted under the skin of the leg to open it up, the same was done on the second leg. Another incision was made right from the pelvic up to the neck. The pelt was gradually pulled until it was removed as the procedure described by Omojola and Adesehinwa, (2006); Apata (2014).

Singeing: Hairs of carcasses in this group were flamed off over burning fire made with firewood until all the hairs had been carefully burnt off with minimal damage to the skin as described by Okubanjo, (1997); Omojola and Adesehinwa, (2006) and Apata (2014).

The carcasses were thoroughly washed and scrapped.

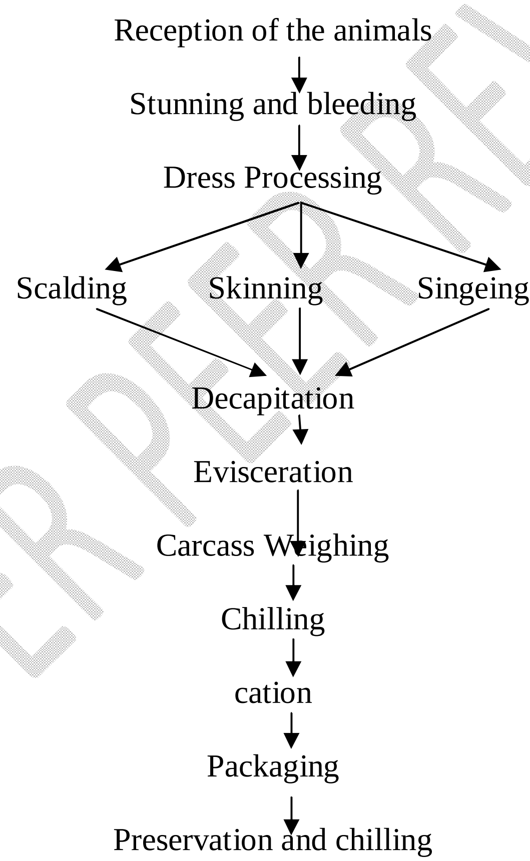

Figure 1: Showing Carcass Processing Chart

DATA COLLECTION

CARCASS ANALYSIS

Carcasses were eviscerated, decapitated and shanked. They were washed and split into two equal halve and further into primal cuts as described by Apata (2014).

PHYSICAL PROPERTIES

pH of meat

The internal pH of the intact carcasses were examined at the loin muscle at the depth of 1 cm at 0 hour post-mortem and subsequently at 30 minutes interval over 1 hour,post-mortem according to the procedure described by Omojola and Adesehinwa, (2006); Apata (2014) using a standardize pH meter.

Internal temperature (T^0) of intact carcasses

The internal temperature of intact carcasses was taken at loin muscle at a depth of 1cm immediately after processing, that is, at 0 hour post-mortem using a digital thermometer as described by Okubanjo, (1997).

Raw meat colour

Raw meat colour was determined with visual method described by AMSA (1995). This was determined by examining the visual colour values based on colour intensity (redness) and homogeneity using a scale ranging from 1 – 8 with the higher score representing a more attractive and homogenous red colour

Meat marbling

The intramuscular fat (marbling) of the meat samples at the rib eye was scored subjectively based on the score described by USDA (1965) but reported by Apata (2014). Rib eye muscle were displayed on a tray in the laboratory and the marbling status of meat was determined using the scale ranging from 1 – 10, where 1 corresponded to devoid and 10 corresponded to abundant.

Drip loss

This was measured by wrapping 10 g of meat samples (*Semimembranosus muscle*) in a polyethylene bags. The bags were hung in a refrigerator at 2^0C so that the exudates would not get in contact with the meat samples. The meat samples were removed after 48 hours and the surface moisture was dried with an absorbing paper and then re-weighed. The percentage (%) weight loss was recorded as the drip loss.

Cooking loss

Approximately 10 g of meat samples (*Semimembranosus muscle*) in a polyethylene bags and cooked in a water bath in the laboratory for 20 minutes. The meat samples were then removed and allowed to equilibrate to room temperature. The meat samples were re-weighed and the percentage (%) change in weight was reported as cooking loss (Malgorzata *et al.,* 2005).

Thermal Loss

The length of the meat was measured and placed in a heat resistant polythene bag immersed in already boiling water and allowed to boil for 20 minutes using water bath at 80^0C. The length of each sample was recorded after cooking. The % change in length of meat is cooking loss.

Chilling Loss

This was determined by measuring the weight of meat before chilling or freezing overnight and the weight of meat after freezing. The % change in weight of meat is chilling loss (Akinwumi *et al.*, 2014)

Cold Shortening

This was determined by measuring the length of meat before chilling and then length of meat after freezing. The % change in the length of meat is cold shortening (Akinwumi *et al.*, 2014)

SENSORY EVALUATION FOR MEAT

Ten (10) panelist comprising of both staffs and students of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, would evaluate the products for appearance and color, tenderness, texture, odour, taste, flavour, juiciness etc

MEAT PRESERVATION/REFREGERATION/ FREEZING

Every two weeks (for 4weeks), samples was evaluated for; Microbial assay; The swabs from the sample were taken to a laboratory where serial dilution, inoculation of diluents into sterile nutrient agar for incubation and catalyst test and gram staining for characterization and identification was conducted.

Microbial analysis

Twenty-five grams of the mutton samples were put into 225 mL of 0.1 per cent buffered peptone water (diluent) and blended for 2 minutes. Serial dilutions were prepared by adding 1 ml of the previous dilution to 9 ml of the sterile diluents and homogenized in a stomacher for 2 minutes.

Determination of total plate counts

1 mL of each dilution was added to a sterile Petri dish and Plate Count Agar (kept at o 45 C in a water bath) added and mixed thoroughly. The preparations were then allowed to gel and were finally incubated at o 37 C for 24 hours and isolated distinct colonies were counted. Average counts obtained were multiplied by the dilution factor and expressed as colony forming unit per gram (cfu/g) (Fawole and Oso, 2001).

STATISTICAL ANALYSIS

All data obtained will be subjected to analysis of variance using SAS (2002) where statistical significance will be observed. The means will be compared using the Duncan Multiple Range test of the same software.

RESULTS

Carcass Characteristics and Primal Cuts of Mutton as affected by Strains and different processing methods.

It can be observed in table 1 that strains of sheep have significant effect ($p<0.05$) on the carcass characteristics and the primal cut except rack and leg. Similarly, different processing methods have significant effect on the carcass characteristics and primal cut except for leg, shank, and neck where no significant differences were recorded. West African Dwarf (WAD) and Ouda breed of Sheep have similar live weight ($p>0.05$), however Ouda maintained highest significant ($p<0.05$) in Bled (94.00%), plunk (83.60%), eviscerated (51.60%) and Carcass weight (42.53%). Balami breed proved to have highest significant values ($p<0.05$) in flank (2.40), shoulder (4.43) and neck (4.34) in terms of primal cuts. In comparison with Ouda breed, its head was only the highest significant value (8.23) amongst it primal cuts but no significant differences was observed in the shoulder and Neck of Ouda and WAD breed.

As significant differences were observed in different processing methods, skinning present the highest significant values ($p<0.05$) in the plunk weight (86.34%), eviscerated weight

(50.62%) and most of the primal cuts; flank (2.03), rack (10.5), shoulder (4.44) and loin (7.23) while least significant was noted in the carcass weight of singeing post-slaughter processing method. Furthermore, singeing exhibit average level of significance amongst the three processing methods in terms of plunk weight (85.62%), eviscerated weight (49.17%), live weight (18.19%), Head (7.97), flank (1.66), rack (9.65) and shoulder (3.93) when compared with least significant value ($p<0.05$) observed in rack (8.95) of scalding method.

Physical properties of mutton as affected by Strains and different processing methods.

Table 2 depicts the effect of strain and processing methods of mutton on the physical properties. The strains effect is evident ($p<0.05$) on all the physical properties of mutton except pH, however significant difference was observed as the minutes of testing the pH increases for each breed. In all the strains, zero (0) minute was confirmed to have highest significant pH values and decrease significantly until 60 minutes when pH was further recorded in WAD. Ouda strain of mutton had the highest significant values ($p<0.05$) of thermal loss (49.62%), cold loss (15.85%), cold shortening (14.39%), drip loss (12.90%) however it possessed the lowest significant values of cooking loss (29.77%) and temperature (31.23^{0}C) but no significant difference was observed in the cooking and cold loss of Ouda and Balami strains of mutton. Also the colour and marbling proved to be significantly highest ($p<0.05$) in balami (6.06 and 4.56 respectively) as compared to West African Dwarf that has the least significant value in colour (4.33) and thermal loss (38.30%) but balami mutton portrayed averagely in terms of cooking loss (30.53%), thermal loss (47.02), cold shortening (12.23%) and drip loss with the least significant value (4.96%).

The effect of different processing methods on the physical properties was significant ($p<0.05$) except the pH however there was significant ($p<0.05$) differences as the period (minutes) of recording pH for each processing method increases. Scalding had the highest values of cooking loss (35.30%) and thermal loss (44.48%), singeing exhibited the same for cold loss (16.26%) and drip loss (12.7%) while skinning method had highest value of cold shortening (16.43%). However, no significant difference was observed in the scalding and skinning processing as regards their thermal loss, drip loss and marbling of muscle.

Organoleptic properties of mutton as affected by Strains and different processing methods.

All organoleptic properties are significantly ($p<0.05$) affected by the strains and different processing methods of mutton as observed in table 3. Balami strains proved significantly highest in most the colour (6.54), flavor (5.34), juiciness (5.22), texture (6.00), and overall acceptability (7.35). This was followed by Ouda strain in its colour (5.83), flavor (4.30) and juiciness (4.90) but not significantly different ($p>0.05$) from WAD mutton. However, WAD present highest significant value in the tenderness of mutton. The different processing methods are also significant ($p<0.05$) on the different organoleptic properties except the tenderness. Scalding was significantly ($p<0.05$) appealing in terms of color (6.10), in juiciness (5.00), texture (5.20) and overall acceptability (6.50) and highest numerically in the non-significant ($p>0.05$) difference observed in tenderness (4.95) amongst the three processing methods. And in terms of color, and overall acceptability, there was no significant difference ($p>0.05$) between the singeing and skinning.

Microbial Coliform Count on mutton as affected by Strains and different processing methods.

Table 4 showed that the strains and processing methods had significant differences ($p<0.05$) on the total bacteria count (TBC) and at varying storage time. It was observed that balami strain of mutton has the least significant ($p<0.05$) value at 2weeks (1.56×10^{18}cfu/g), 4 weeks (4.52×10^{18}cfu/g), 6weeks (5.35×10^{18}cfu/g), 8weeks (7.54×10^{18}cfu/g) and 13weeks (17.23×10^{18}cfu/g) period of storage and moderately significant at 0 day (1.34×10^{18}cfu/g). Ouda had the highest initial load of TBC (1.40×10^{18}cfu/g) which is relatively evident until 6weeks of storage of the mutton however no significant differences was observed between Ouda and WAD total bacterial count at 2weeks, 4weeks and 6weeks of storage period.

Generally it was noted in the table that the increase in the period of storage resulted into significant ($p<0.05$) increase in total bacteria count (TBC) in all the strains and processing methods of mutton. Scalding had the least significant value ($p<0.05$) in almost all the storage period when the mutton are assessed for TBC except 8weeks which had same significant level with skinning. While skinning had the highest significant values at 0day (1.41×10^{18}cfu/g), 2 weeks (4.41×10^{18}cfu/g), 4weeks (6.65×10^{18}cfu/g), 6weeks (8.67×10^{18}cfu/g), 8weeks (10.50×10^{18}cfu/g) and 13weeks (21.00×10^{18}cfu/g) but it is not significantly ($p>0.05$) different with singeing at 2 weeks and 4weeks of storage period.

Table 1: Effects of Strains and different processing methods on the Carcass Characteristics and Primal Cuts of Mutton.

Parameters	Live weight kg	Bled weight (%)	Trunk weight (%)	Eviscerated weight (%)	Carcass weight (%)	Head (%)	Flank (%)	Rack(%)	Shoulder (%)	Leg (%)	Shank (%)	Neck (%)	Loin (%)
							Strains / Breeds						
WAD	39.33^{a}	91.44^{c}	83.06^{b}	46.69^{ab}	38.31^{b}	6.57^{c}	2.41^{a}	1.85	4.05^{b}	10.00	4.90^{b}	3.54^{b}	6.92^{a}
OUDA	39.6 ^{a}	94.00^{a}	83.60^{a}	51.60^{a}	42.53^{a}	8.23^{a}	1.38^{b}	1.94	4.12^{b}	9.95	5.23^{a}	3.43^{b}	6.73^{b}
BALAMI	38.03^{b}	93.00^{b}	82.93^{b}	45.67^{b}	37.08^{c}	7.23^{b}	2.40^{a}	2.01	4.43^{a}	10.44	5.22^{a}	4.34^{a}	6.65^{b}
SEM	3.01	2.93	2.32	1.45	1.21	0.76	0.32	0.23	1.20	2.07	1.43	0.92	1.08
P-value	*	*	*	*	*	*	*	**NS**	*	**NS**	*	*	*
							Processing Methods						
Scalding	17.97^{b}	93.24^{a}	80.96^{c}	48.18^{c}	43.12^{a}	8.52^{a}	2.00^{a}	8.95^{c}	3.96^{b}	9.87	4.85^{b}	3.42	6.70^{b}
Singeing	18.19^{b}	91.59^{b}	85.62^{b}	49.17^{b}	37.90^{c}	7.97^{b}	1.66^{c}	9.65^{b}	3.93^{b}	10.1	5.00^{ab}	3.27	6.54^{b}
Skinning	22.27^{a}	**89.27**^{c}	86.34^{a}	50.62^{a}	40.24^{b}	5.76^{c}	2.03^{b}	10.50^{a}	4.44^{a}	9.97	5.33^{a}	3.76	7.23^{b}
SEM	3.92	2.37	2.12	2.14	2.11	0.76	0.34	1.54	1.27	1.23	1.23	0.23	1.23
P-value	*	*	*	*	*	*	*	*	*	NS	*	NS	*

^{abc} Mean values in the same column with the same letters did not differ significantly (p>0.05)

SEM – Standard Error of Means **WAD –** West African Dwarf

Table 2: Effects of Strains and different processing methods on the Physical Properties of Mutton.

Parameters	Cooking loss (%)	Thermal Loss (%)	Cold loss (%)	Cold Shortening (%)	Drip loss (%)	Colour (%)	Marbling (%)	pH			Temperature (^{0}C)
								0 mins	30 mins	60 mins	
Strains / Breeds											
WAD	38.47^{a}	38.30^{c}	8.24^{b}	12.24^{b}	5.52^{b}	4.33^{c}	3.40^{b}	7.23	6.70	6.53	33.03^{a}
OUDA	29.77^{b}	49.62^{a}	15.85^{a}	14.39^{a}	12.90^{a}	5.40^{b}	3.00^{c}	7.73	6.53	6.53	31.23^{b}
BALAMI	30.53^{b}	47.02^{b}	14.52^{a}	12.23^{a}	4.96^{c}	6.06^{a}	4.56^{a}	7.34	6.54	6.65	33.23^{a}
SEM	**0.85**	**1.24**	**0.82**	**1.56**	**1.33**	**1.21**	**0.32**	**0.20**	**0.32**	**0.10**	**0.21**
P-value	*	*	*	*	*	*	*	**NS**	**NS**	**NS**	*
Processing Methods											
Scalding	35.30^{a}	44.48^{a}	10.60^{b}	13.50^{b}	7.90^{b}	6.00^{a}	3.25^{ab}	7.45^{a}	6.80^{b}	6.75^{b}	31.70^{b}
Singeing	33.46^{b}	43.28^{b}	16.26^{a}	10.03^{c}	12.7^{a}	5.15^{b}	3.00^{b}	7.60^{a}	6.40^{d}	6.30^{d}	32.60^{a}
Skinning	33.61^{b}	44.12^{a}	9.28^{c}	16.43^{a}	7.02^{b}	3.45^{c}	3.35^{a}	7.40^{a}	6.65^{c}	6.55^{c}	32.10^{ab}
SEM	**1.04**	**1.52**	**1.00**	**1.91**	**1.63**	**2.12**	**1.31**	**0.00**	**0.00**	**0.00**	**0.00**
P-value	*	*	*	*	*	*	*	*	*	*	*

^{abc} Mean values in the same column with the same letters did not differ significantly (p>0.05)

SEM – Standard Error of Means **WAD –** West African Dwarf

Table 3: Effects of Strains and different processing methods on the Organoleptic Properties of Mutton.

Parameters	Color	Flavor	Tenderness	Juiciness	Texture	Overall acceptability
			Strains / Breeds			
WAD	5.17^{b}	4.13^{b}	5.90^{a}	4.83^{b}	5.27^{b}	6.70^{b}
OUDA	5.83^{b}	4.30^{b}	3.67^{c}	4.90^{b}	4.30^{c}	5.87^{c}
BALAMI	6.54^{a}	5.34^{a}	5.34^{b}	5.22^{a}	6.00^{a}	7.35^{a}
SEM	**0.23**	**0.28**	**0.32**	**0.33**	**0.36**	**0.26**
P-value						
			Processing Methods			
Scalding	6.10^{a}	3.70^{c}	4.95	5.00^{a}	5.20^{a}	6.50^{a}
Singeing	5.20^{b}	4.70^{a}	4.80	4.10^{b}	4.85^{b}	6.20^{b}
Skinning	5.20^{b}	4.25^{b}	4.60	5.50^{a}	4.30^{c}	6.15^{b}
SEM	**0.28**	**0.34**	**0.39**	**0.41**	**0.44**	**0.31**
P-value			**NS**			

[abc] Mean values in the same column with the same letters did not differ significantly ($p>0.05$)

SEM – Standard Error of Means **WAD –** West African Dwarf

Table 4: Effects of Strains and different processing methods on the Total Bacteria Counts of Mutton.

Parameters	Microbial Count (Total Bacteria)					
	0 day (cfu/g)	**2 weeks (cfu/g)**	**4 weeks (cfu/g)**	**6 weeks (cfu/g)**	**8 weeks (cfu/g)**	**13 weeks (cfu/g)**
Strains / Breeds						
WAD	1.23×10^{18c}	3.27×10^{18a}	4.52×10^{18a}	6.57×10^{18a}	10.10×10^{18a}	21.07×10^{18a}
OUDA	1.40×10^{18a}	3.50×10^{18a}	4.83×10^{18a}	6.85×10^{18a}	9.20×10^{18b}	19.70×10^{18b}
BALAMI	1.34×10^{18b}	1.56×10^{18c}	3.45×10^{18c}	5.35×10^{18c}	7.54×10^{18c}	17.23×10^{18c}
SEM	0.23	0.53	0.45	0.35	1.32	2.31
P-value	*	*	*	*	*	*
Processing Methods						
Scalding	1.24×10^{18c}	4.34×10^{18b}	5.69×10^{18b}	6.50×10^{18c}	10.90×10^{18a}	16.70×10^{18c}
Singeing	1.30×10^{18b}	4.40×10^{18a}	6.70×10^{18a}	7.95×10^{18b}	9.05×10^{18b}	19.45×10^{18b}
Skinning	1.41×10^{18a}	4.41×10^{18a}	6.65×10^{18a}	8.67×10^{18a}	10.50×10^{18a}	21.00×10^{18a}
SEM	0.21	1.25	1.68	1.83	1.68	2.13
P-value	*	*	*	*	*	*

[abc] Mean values in the same column with the same letters did not differ significantly ($p>0.05$)

SEM – Standard Error of Means **WAD –** West African Dwarf

DISCUSSION

Carcass and Primal Cut

The processing methods and strains of sheep proved significant ($p<0.05$) on all the Carcass characteristics, however Okoh (2019) reported non-significant value ($p>0.05$) for eviscerated weight percentage of West African Dwarf goat processed under different methods (scalding, singeing and skinning). It can be understood from table 1 that the primal cuts and carcass characteristics values are relative and dependent on the initial weight of the sheep in each processing methods. The least significant value (37.90%) observed in the carcass weight percentage of Singeing method can be related to the dehydration during singeing process which might have reduced the moisture content from that could have constituted the weight of the carcass through the shortening of space between myofibrillar protein network (Hamm, 1969) and reducing its water holding capacity (Honikel, 1998). However, Omojola and Adesehinwa (2006) reported highest significant value ($p<0.05$) for dressed meat (%) processed through singeing although the singed animal live weight was also the highest significant value ($p<0.05$) in his work which contradict the carcass weight (%) stated above.

The highest significant values observed in the primal cuts of skinning processing method might be due to initial live weight of the skinned sheep which had the most significant highest value (22.27kg). Meanwhile Okoh (2019) reported all the primal cuts in his study to be significantly different ($p<0.05$) whereas, in this study, leg and neck were seen to have similar values ($p>0.05$) in the three processing methods adopted but all other primal cuts were in accordance with his work. In this study again, the carcass weight percentage is reported to have significant difference ($p<0.05$) between singed and skinned meat, while the opposite was the case with which Salifou *et al.,* (2020) reported; where carcass yield percentage for stripped (skinned) and burnt (Singed) ewe were not significantly ($p>0.05$) different from each other.

Physical properties

The significant differences reported for cooking loss for various strains of sheep was in line with Markovic *et al.,* (2014) and Suliman *et al.,* (2021) who reported significant difference in cooking loss between breed of sheep. However, the drip loss (%) in the present study ($p<0.05$) contradicted what Suliman *et al.,* (2021) made in his own findings that drip loss % is not significantly different in the breed of sheep used. Also the non-significant difference reported pH for strains of mutton was in line with Belhaj *et al.,* (2021) who did reported non-significant ($p>0.05$) effect of breed of sheep on ultimate pH value of the meats.

The cooking and cold loss percentage reported to be significantly influenced by processing methods corroborated with the result of Adeniji *et al.,* (2019) and Okoh & Omojola (2018) respectively. However, the significant level ($p>0.05$) obtained for cooking loss % between singed and skinned mutton follows the same with what Salifou *et al.,* (2020) reported for burnt (singed) and stripped (skinned) ewe meat and the probability of recording highest significant ($p<0.05$) values for cold and drip loss (%) for singeing was because of the denaturalization of muscle collagens to retain water.

Omojola and Adesehinwa (2006) reported scalding, singeing and skinning to have no significant ($p>0.05$) effect on the cooking loss (%) while this current study reported significant differences ($p<0.05$) for cooking loss between the different post slaughter processing methods assessed. However, the disparity in these two works might be due to the difference in the research animal used for research where Omojola & Adesehinwa, (2006) assessed rabbit carcass and their physiological composition.

Meat pH is an important physicochemical quality parameter used to assess meat quality (Calnan, *et al.,* 2016). Decreased meat pH values largely depend on the rate of glycolysis, and the enzyme activity related to temperature affects the glycolysis (Redmond *et al.,* 2000; Vieira & Fernández, 2014). The progressive decrease in pH values that was observed in strain comparisons and different processing methods from 0min to 60mins can be attributed to the production of lactate as a result of anaerobic glycolysis that lowers the intracellular pH which starts to fall to ultimate pH (5.4-5.7) during rigor mortis formation (Tougan *et al.,* 2013). Also this study follows same trend with Omojola and Adesehinwa (2006) work where singed meat had the highest numerical ($p>0.05$) value of pH at 0hr post-slaughter and this is closely followed by scalding and skinning. The increased value ($p>0.05$) in singeing and scalding pH at 0mins might be due to the modification of acid groups electric charge, separation of peptide chain and production of new component (Grau, 1978) as a result of heat treatment. Furthermore, similar range of post-slaughter temperature was recorded for skinning method of processing animal but higher significant value was recorded for singeing (48.42^0C) by Omojola & Adesehinwa (2006). And this variation is expected due to the slaughter weight and size of the test animal as the heat will be more even or higher in singeing small sized animal.

Organoleptic Properties

The influence of breed that is reported significant ($p<0.05$) on the organoleptic properties in table 3 is in accordance with Salihu *et al.,* (2020) who reported significant ($p<0.05$) of breed effect on all sensory properties and also with what Prache *et al.,* 2022 reported in his review that breed has effect, however low on the sensory properties of meat. Meat colour hold the most impacting criterion in the purchase decision, through its intensity or instability or alteration, and it remains the major visual parameter used by consumers (Prache *et al.,* 2022; Mancini & Ramanathan 2020). The colour of fresh meat is however shaped by its myoglobin content and its pH. Salihu *et al.,* (2020) reported that Balami strain was rated significantly highest ($p<0.05$) for all organoleptic properties, which this study also corroborated with except for tenderness that was rated ($p<0.05$) moderately significant. Scalding, singeing and skinning had significant ($p<0.05$) effect on the colour and not on the tenderness ($p>0.05$), this supported the study of

Adeniji *et al.,* (2019) who reported significant and non-differences for colour and tenderness respectively.

Tenderness is the most important eating quality characteristic, and it determines consumer acceptability (Miller *et al.,* 2001). Okoh, 2019 reported highest value ($p>0.05$) for West African Dwarf meat tenderness processed under scalding method, this study proved similarly to Okoh, (2019) but contradicted the Omojola & Adesehinwa, (2006) who reported the processing method to have significant on the tenderness of rabbit meat. Furthermore, the different significant level ($p<0.05$) observed for singed and skinned meat in this study affirmed what Salifou *et al.,* 2020 reported similarly in her work for flavor and juiciness.

The meat tenderness, juiciness, flavour, and overall acceptability are positively related to Intramuscular fat content, even though these relationships can vary between countries (Pannier *et al.,* 2018). However, the lowest ($p<0.05$) significant score obtained in singed mutton in terms of juiciness (4.10) is expected due the dehydration that has occurred during burning treatment. Also this study depicted that there is linear correlation between Tenderness and Overall acceptability because the order with which the panelists rated each processing methods for meat tenderness is the same with that of Overall acceptability, that is scalding was rated highest in tenderness and Overall liking and least in skinned mutton for both organoleptic parameters, though tenderness was not significant in this study.

Total Bacteria Count

Animal foods remain useful for man as linked to the supply of protein, on the other hands they serve as substrate for pathogen-producing organisms that also cause rapid food spoilage. Despite the efforts made in recent decades, it is still difficult to eradicate or obtain animal foods that are free from pathogenic microbes (Wilfred and Fairoze, 2011). Raw meats will spoil within hours or days and the spoilage is typically caused by the post-slaughter handling methods, unavoidable infection, decomposition by bacteria and fungi borne by the animal itself (Pal *et al.,* 2018; Tutenel *et al.,* 2003). However, Salihu *et al.,* (2020) reported a decreasing trend of Total bacteria count (TBC) of chilled mutton from 0hrs to 48hrs (2days) while in this report the TBC trend at storage time followed an increasing pattern as the number of hours of storage increased from 0hr to 13 weeks under chilled condition. Again, the lowest significant value ($p<0.05$) of Total bacteria count (TBC) observed for West African Dwarf at 0day of storage might probably be due to only the handling effect at the time of slaughtering and processing because as the storage days progressed, the TBC appeared to be the most significant of all the three strain assessed for TBC, however the opposite was experienced for balami strain of mutton subjected to same storage temperature while its initial TBC was seemly moderate and apparently it maintained the lowest significant values ($p<0.05$) throughout the storage days. The resistivity of this strain (balami) to microbe manifestation could be a possible reason for recording lowest TBC throughout the storage days.

Also, it was observed that the initial count of bacteria relatively affected or determined the count of total bacteria at other increasing storage periods. However, the highest significant values of Total bacteria count observed in all the storage days analyzed for skinning method can be traced to the initial load of bacteria and non-application of any hurdles (heat application) that could reduce this initial count of TBC.

CONCLUSION AND RECOMMENDATION

Balami strain of sheep has the most significant ($p<0.05$) values of primal cuts despite the highest live weight (kg) possessed by West African Dwarf. It is also preferred as it was most significantly rated in organoleptic parameters, moderately for cooking loss (%), thermal loss (%), cold shortening (%), highest color (%) and least of drip loss (%) value and total bacteria counts in all the three strains of mutton examined under this study. Furthermore, mutton obtained from scalding method is remarkable in marbling effect, color, and juice retention, texture and overall acceptability though it has high significant cooking and thermal loss percentage. Also, highest carcass yield % and least significant values of Total bacteria count at 0hrs (initial) were recorded in scalded meat and throughout the storage days.

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