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Influence of Singeing Materials on Post-Singeing Temperature, Ph Decline, Retail Characteristics, and Malondialdehyde Status in Chevon During Cold Storage

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Abstract
This study examined the effects of singeing materials (kerosene, hardwood, scrape-tyre, and liquefied-gas) on various aspects of chevon (goat meat) from singed carcasses stored at 0°C for three weeks. Twelve Red Sokoto buck goats (14-16 kg) were randomly assigned to the treatments, with three replications in a randomized design. The initial post-singeing temperature varied significantly ($P<0.05$), ranging from 45.65°C (tyre) to 56.50°C (kerosene). However, pH levels were similar across all treatments, with Ultimate pH range of 6.00 in hardwood singed-carcass to 6.12 in liquefied-gas singed-carcass. Singeing materials significantly influenced water holding capacity (WHC), ranging from 67.488% to 77.405%. They also had a significant impact ($P<0.05$) on meat marbling and firmness scores. Analysis revealed low levels of Malondialdehyde (MDA) in singed carcasses, ranging from 0.035 to 0.045 mg MDA/g at 24 hours after singeing. Throughout the 21-day cold storage, all treatments experienced a significant increase in MDA values, ranging from 0.300 to 0.344 mg MDA/g in wood-singed and gas-singed carcasses, respectively. To summarize, singeing materials affected post-singeing temperature, pH decline, water holding capacity, and MDA accumulation in chevon from singed carcasses. These findings provide valuable insights for improving singeing techniques and enhancing meat quality in goat production.
Keywords: post-singeing, oxidation, chevon, carcass, products

Introduction

In livestock production, the quality of meat is a critical aspect that influences consumer preference and acceptance. Various factors can affect the quality of meat, including pre-slaughter handling and processing techniques (Smith and Johnson 2022). Singeing which is the combustion of different combustible materials to generate flame removes the fur and reduces the quantity of adherent microorganisms by shrinking and setting the skin and after scrapping leaves an attractive clean appearance for retail display. Different combustible materials such as disposable used motor tyres plastics and other non-biodegradable materials such as kerosene, firewood, and liquefied gas (Kalu *et al*., 2014; Aremo and Omojola (2018), are used as fuel sources for singeing with deposits of Polycyclic Aromatic Hydrocarbons (PAHs) and selected heavy metal (Babatunde *et al.*, 2014) on the meat harvested from the dressed carcass. In addition, the amount of heat emanating from the singeing process has an effect on carcass characteristics and meat quality attributes such as the tenderness of meat, as well as the water-holding capacity and fats to bind together and the texture of the flesh. (Khan *et al.*, 2020), colour, firmness, marbling, water holding capacity (WHC), and metals from the scrape tyre promote the rate of lipid oxidation (Karre *et al.*, 2013) and accumulation of toxic compound during storage resulting in economic loss for meat processor and retailer. The thiobarbituric acid reacting substances (TBARS) is a common analysis to determine fat oxidative stability in foods. Malondialdehyde (MDA) is among the prevalent aldehydes produced during lipid oxidation; it is poisonous and poses a health risk (Ahmadi *et al.*, 2019). The increasing rate of singeing practices in abattoirs, without government regulation and progressive consumption of meat processed through this practice has made it necessary to evaluate the effects of different singeing materials and the emanating singeing temperature on the physicochemical properties of carcass and meat of red Sokoto goats during cold storage.

Materials and Methods

Experimental Animals and Location

The animals were purchased from a Livestock market at Akinyele, Akinyele Local Government, Ibadan, Oyo State, Nigeria. The Sheep and Goat unit at the Teaching and Research Farm, University of Ibadan, Oyo State, Nigeria, served as the location for conducting the experiment. A total of thirty-two buck red Sokoto goats were selected, with an average weight ranging from 14 to 17kg.

They were allowed to acclimatize to the environmental conditions for fourteen days. During the period of adjustment, they received deworming treatments, parasite dips, and vaccinations. The goats were distributed. in a completely randomized design into four treatments with each treatment having eight goats replicated four times with two goats per replicate. Each of the treatments was identified with the following singeing materials: Hardwood (HW), Scrap rubber tyre (ST), Kerosene (KR), and liquefied gas (LG) which were gathered within the University of Ibadan premises. At the end of the adaptation, for the subsequent carcass, four red Sokoto goats (bucks) in each treatment were chosen based on their weights being the closest to the average final weight of the goats in their respective treatments and laboratory analysis.

Slaughter Procedure

The chosen goats (four goats per treatment) were taken to the Department of Animal Science's slaughterhouse at the University of Ibadan, where pre-slaughter live weight was measured following a 12-hour fast with unrestricted access to water. The carotid arteries, jugular veins, trachea, esophagus, and spinal cord were severed during exsanguination by making an incision on the jugular furrow at the occipital-atlantal junction near the head. Following the removal of the head, the carcass was pulley-hung by the legs and singed.

Singeing

Red Sokoto goat (buck) carcasses were tagged: HWS, STS, KRS, and LGS. Each method was replicated four times with two goats per replicate. Each of the carcasses was supported with a metal tripod stand for easy singeing. The quantity of each singeing material and the time to complete singeing were recorded with a stopwatch according to Okubanjo (1997) description, the batch singed with hardwood. Each carcass was exposed to flame from *Albizia Zama* hardwood until the fur was gently burned off with little harm to the flesh. To remove as much of the burnt surface as possible, fresh clean water and a sponge were utilized. Thereby, reducing carcass contamination. The group of carcass-tagged STS was singed with rubber tyres as a source of heat. The burnt surface was washed off with fresh, clean water and a sponge to lessen the amount of pollution on the carcass. Kerosene was used to burn the third set of KRS-tagged animals. Kerosene was applied liberally to the carcass before being ignited to delicately burn off the fur with little harm to the skin. To lessen the amount of pollution on the carcass, fresh, clean water was applied with a sponge to wash off the charred surface as much as possible. LGS was singed with the liquefied weight of the cylinder and the content (liquid gas) was weighed before singeing and the gas was used to burn the fur on the skin with a hand-held gas nozzle flame. (Okubanjo, 1997) claims that it took 25 minutes to carefully burn all of the fur with little skin damage. To lessen the amount of pollution on the carcass, fresh, clean water was applied with a sponge to wash off the charred surface as much as possible.

6.4 Internal temperature and pH of Intact Carcasses

The initial temperature of intact carcasses was taken within 3 minutes post-mortem at loin muscle at a depth of 2cm, depicting 0-hour post-mortem, followed by 30-minute intervals during a 3-hour period after singeing using a digital probe the thermometer (model 16454, Pyrex-accessories Robinson Knive Company, China) as described by (Okubanjo,1997).

Muscle pHu: The pH of the muscles was measured using a pH meter after the carcasses were frozen for 24 hours at 1-4 °C. (INGOLD-WTW-pH 91) as well as a glass electrode probe inserted in the lumbar region's longissimus dorsi muscle

Carcass and Muscle Sampling
After dissection into primal cuts, the loins of the left half carcasses were sampled for longissimus dorsi muscle for analysis. Carcasses were immediately chilled in a 4°C cooler for 24 hours, following which colour, texture, and taste were assessed. Firmness and Marbling appraisals were conducted on the carcass. Samples of Longissimus dorsi (LD), on each carcass' right side were harvested for muscle. The LD muscle sample was taken at the 13th thoracic rib, vacuum-packed, and stored at 4° cover a period of 21 Days for TBAR analysis and also divided for sensory evaluation in the meat Science Laboratory.

Raw Meat Colour, Firmness, and Marbling of Carcass
The colour of raw beef was assessed using a visual approach described by (AMSA, 1991). In the laboratory, a tray containing meat samples from the leg cut was exhibited to replicate the retail environment. Color values were established visually. The MSA technique (Meat Standards Australia, 2007) was used to evaluate the marbling and firmness score, with the grader visually assessing the sliced surface of the striploin muscle (cut between the 12th and 13th rib).

Water holding capacity of meat
The Water Holding Capacity (WHC) of meat samples from the leg was examined using a slightly modified press technique (Suzuki et al. 1991). A sample of beef weighing about 1g was placed between two Whatman No1 filter sheets (Model C, Caver Inc, Wabash, USA), squeezed for 1 minute at about 35.2 kg/ cm3 absolute pressure in a vice between two 10.2 X 10.2 cm2 plexi panes, and then oven dried for 24WHC = 100 – (Aw – Am) x 9.47 X 100

Wm X Mc

Where: Aw = Area of water released from meat samples (cm2)

Am = Area of meat samples (cm2)

Wm = Weight of meat samples (g)

Mc = Moisture content of meat samples (%)

9.47 = a constant factor

TBARS Analysis
In this experiment, the TBARS technique is used to measure the degree of lipid oxidation (Pensel 1990). 2 grams of sample were weighed into a blender or marsh thoroughly in 20mls distilled water in a mortar and pestle. Filter into a conical flask. A blank is also prepared along with the sample. Then add 20-ml water. Filter and add 20ml 0f 5% trichloroacetic acid in a 1.6% m-phosphoric acid solution. Each tube receives five milliliters of freshly prepared 0.02 M Thiobarbituric Acid, which is mixed for 4-5 seconds. For 1 hour, tubes were kept in the dark for colour development. The colour was measured using Spectrophotometer at a wavelength of 530nm.

The TBAR of each sample was calculated using the formula below.

TBA mg MA/g=K×O.D. 530nm

Where k=9.242

MA= Malondialdehyde

Statistical analysis

Data collected during this experiment was analyzed using ANOVA (SAS, 2002) to separate the means while the post-hoc test was carried out using Duncan Multiple Range Test.

Results

Table 1. Temperature and pH of the carcasses of Red Sokoto buck singed with different materials

	Singeing Materials				
Time (min)	**KRS**	**HWS**	**STS**	**LGS**	**SEM**
T^0C	56.50 ^{a}	52.33 ^{b}	45.65^c	46.50^c	0.55
T_{30}	40.10	38.13	37.60	36.23	1.65
T_{60}	36.73	35.43	34.47	34.20	0.90
T_{90}	34.83	33.93	33.77	33.33	0.71
T_{120}	33.33	33.03	32.73	32.67	0.61
pH					
pH_0	6.67	6.60	6.42	6.48	0.09
pH_{30}	6.67	6.58	6.29	6.48	0.22
pH_{60}	6.57	6.56	6.29	6.46	0.24
pH_{90}	6.55	6.41	6.20	6.43	0.20
pH_{120}	6.50	6.40	6.18	6.39	0.21
pH*u*	6.02	6.08	6.00	6.12	0.19

^{abc}: along the row with the same superscript are not significantly differently (p>0.05) KRS-Kerosene-Singed-Carcass. STS- Scrap-Tyre-Singed-Carcass. HWS- Hardwood-Singed-Carcass. LGS- Liquified-Gas-Singed-Carcass

Data on the Temperature and pH of singed carcasses with different materials are given in Table 1. Carcass temperature at 0hr post singeing varied significantly (P<0.05) and ranged from STS (46.50ºC),, LGS (45.65ºC), HWS (52.33ºC) to (KRS) 56.50ºC, while the temperature at 30Minute, 60 Minutes, 90Minutes and 120Minutes are statistically similar (P>0.05) across the treatments. The temperature declined uniformly irrespective of singeing material till 2h post singeing to 32.67ºC, 32.73ºC, 33.03ºC, and 33.33ºC in LGS, STS, HWS, and KRS, respectively. The pH of the carcass for all the treatments was similar (P>0.05) at 0hr and the 30-minute interval pH evaluation for 2hrs. The ultimate pH of carcasses singed with different materials is 6.00, 6.02, 6.08, and 6.12 for STS, KRS, HWS, and LGS respectively.

Table 2. Carcass and Meat Characteristics of Red Sokoto buck carcasses singed with different singeing materials

Treatment	**KRS**	**HWS**	**STS**	**LGS**	**SEM**
WHC (%)	68.580^{ab}	77.405^a	76.692^{ab}	67.488^b	1.826
Colour	5.667	5.533	5.400	5.367	0.385
Firmness	5.867^a	5.000^b	4.967 ^{b}	4.733 ^{b}	0.200
Marbling	5.075 ^{a}	3.290 ^{c}	3.119 ^{c}	3.885 ^{b}	0.809

^{abc}: along the row with the same superscript are not significantly differently (p>0.05)

The result of the physical characteristics of the red Sokoto Goat singed with different materials is shown in Table 2. Water Holding Capacity (WHC) of meat from carcass singed with HWS (77.41%) was significantly higher (P<0.05) than STS (76.69%), KRS (68.58%), and LGS (67.49%). Firmness and Marbling score of carcass varied significantly across the treatments (P<0.05) with the firmness score of

KRS having a higher score of (5.867) compared to HWS (5.000), STS (4.967) and LGS (4.733) likewise having the highest Marbling Score of (5.075) followed by LGS (3.885), HWS (3.290 and least in STS (3.119). the colour score of the differently singed carcass was significantly similar.

Table 3. TBARS of Stored Red Sokoto buck carcasses singed with different Singeing materials

SINGEING MATERIALS		Tbars mg/g
KRS		0.188[a]
HWS		0.167[b]
STS		0.192[a]
LGS		0.191[a]
SEM		0.0033
STORAGE DAYS		**Tbars mg/g**
One		0.042 [d]
Seven		0.136 [c]
Fourteen		0.232 [b]
Twenty-one		0.328 [a]
SEM		0.0033
SINGEING MATERIALS	**STORAGE DAYS**	**Tbars mg/g**
KRS	One	0.045[ad]
KRS	Seven	0.145[ac]
KRS	Fourteen	0.225[ab]
KRS	Twenty-one	0.338[aa]
HWS	One	0.043[bd]
HWS	Seven	0.115[bc]
HWS	Fourteen	0.210[bb]
HWS	Twenty-one	0.300[ab]
STS	One	0.046[ad]
STS	Seven	0.146[ac]
STS	Fourteen	0.241[ab]
STS	Twenty-one	0.330[aa]
LGS	One	0.035[ad]
LGS	Seven	0.138[ac]
LGS	Fourteen	0.248[ab]
LGS	Twenty-one	0.344[aa]
P-Value		0.0108

[abc]: along the column with the same superscript are not significantly differently ($p>0.05$)

The degree to which lipids are oxidized in singed carcass was measured by TBARS as shown in Table 2. Tbars values in the carcass for the twenty-one day experiment varied significantly ($p>0.05$). HWS has the lower concentration of accumulated Malondialdehyde compare to KRS (0.188), LGS (0.191) and STS (0.192).the total value of Malondialdehyde accumulated in carcass of all the treatments was significantly lower ($p>0.05$). on day one (0.042) and increased progressively till day twenty-one (0.328)

Temperature and pH of the carcasses of Red Sokoto buck singed with different materials

In the immediate post-mortem period, goats dissipate heat quickly, whereas large carcasses with high-fat cover are associated with a slower temperature decline (Ali *et al.,* 2017; Liu *et al.,* 2016), which may account for the observed similarity in temperature decline between the treatments. No apparent difference in pH levels ($P>0.05$) was seen in meat samples from KRS, HWS, STS, and LGS from initial post singeing pH to the ultimate pH (pHu), while initial post-singeing pH values ranged from 6.42-6.67, it decreases gradually to ultimate pH values of 6.00 (STS), 6.02 (KRS), 6.08 (HWS) and 6.12 (LGS). This study established a higher ultimate pH value range (6.00-6.12) for goat carcass singed with STS, HWS, LGS, and KRS which corresponds with the works of (Lokman *et al.,* 2016) who had reported higher pHu for goat meat which is higher the than ultimate pH values of 5.74 for sheep as reported by (Shija *et al.,* 2013). 5.96

for beef as reported by (Gebrehiwot *et al.,* 2018), 5.44 for raw camel meat (Yam et al., 2016), and 5.84 for broiler; a poultry specie (Hascik *et al.*, 2015). The higher pHu from this result might be a result of the depletion in the muscular glycogen reserves. Another known fact is that higher ultimate pHu increases the risk of cold shortening resulting in very tough meat (Kannan *et al.,* 2014).

Carcass and Meat Characteristics of Red Sokoto buck singed with different singeing materials

WHC is described as the capacity of meat and meat products to bind water during processing (Pearce et al. 2011). The higher values of WHC (67.48-77.41%) from this research support the conclusions of the previous research of Okoh and Omojola (2018) who reported 69.8% for singed red Sokoto goat, lower WHC values of 66.57% and 66.74% for skinned and scalded goat respectively. WHC of the differently singed carcass from this study is higher than 62.82% in pork (Omojola *et al.*, 2014), 64.79% in chicken breast fillet (Garcia *et al.,* 2010) but lower than 74.22% from UDA sheep (Akinleye *et al.,* 2019). At different temperatures, muscle tissue shrinks laterally and longitudinally to varying degrees. (Koutsidis, 2020) During singeing a series of biochemical reactions starts which denatures meat protein and causes a part of its ionized basic or acidic amino acid group to break thereby releasing water molecules attracted to them. Denaturation increases if low pH is combined with high temperature. However, in this current study, it was found that the combination of high meat pH with heat from the singeing materials only caused mild denaturation and there is little loss of functionality, little reduction in interfibrillar space, and increased water retention capacity lower drip loss in retail packaging which positively influence product yield and appearance and juiciness of meat after cooking. Colour is valued as a quality signal by consumers (Kadim and Maghoub, 2012). The impact of the singeing materials was similar (P>0.05) on the carcass colour score with KRS (5.67) having the highest score and LGS (5.37) having the lowest score. Because it is darker in color and has a poor level of tenderization even after cooking, meat with a higher pH is unattractive (Huff-Lonergan, and Lonergan, 2017). The meat colour in this study is attributed to heat-induced myoglobin and pH changes in the structure during singeing periods, Heat from the singeing materials denatured myoglobin thereby enhancing the susceptibility of the pigments to coagulate and insoluble in aqueous solutions thereby giving a slightly dark red appearance of meat, (Cornforth and Jayasingh, 2004). Panelist score carcasses firmness indicated a significant difference (P<0.05) with a higher score in KRS (5.87) followed by HWS (5.00), STS (4.97), and LGS (4.73). This study shows that the singeing materials impact significant differences on the firmness of carcass at the retail display with KRS (5.87) more significantly rated as moderately firm; HWS (5.00) was also rated as moderately firm but was similar to STS (4.97) and LGS (4.73) that were rated slightly soft. The different singeing materials showed significant changes in carcass marbling (P<0.05), KRS scored 5.075, followed by LGS 3.885, HWS 3.29, and STS 3.119. The quantity and the pattern of visible white fat flecks in the longissimus dorsi (LD) muscle are referred to as marbling. (Weiwei *et al.,* 2014). The juiciness, tenderness, palatability, and flavour of meat are all improved by the right amount of marbling (Liu *et al.*, 2020). A significant difference exists (P<0.05) in the marbling score for the singed goat carcass: KRS (5.07) was significantly marbled and rated as slightly abundant marbling followed by LGS (3.88), HWS (3.29), and STS (3.12) rated as possessing slight marbling. The comprehensive differences in tenderness between the chevon of the singed carcasses may be a reflection of differences in the size of muscle fiber.

TBARS of the chevon of Red Sokoto buck stored at different periods of storage

There was remarkable variation (P<0.05) in the cumulative TBARS for the singeing materials. The values recorded were 0.192mg/g, 0.191mg/g, 0.188mg/g, and 0.167mg/g for STS, LSC, KRS, and HWS respectively. Besides, the TBARS values for different singeing materials, it was observed that the TBARS value increased with an increase in the storage days, in which the TBARS value on day 21 (0.328 mg/g) was significantly higher (P>0.05), than (0.232 mg/g), (0.136mg/g), and (0.042 mg/g) for days 14, 7 and 0 respectively. The interaction resulted in substantial changes, which followed a similar pattern. Post-singeing storage oxidative rancidity of Chevon from carcasses differently singed as the concentration of Malodialdehydes (mg/g) was determined by TBARS. TBARS values at singeing were similar (P>0.05) varying between 0.035mg/g in LGS to 0.046mg/g in STS while significant differences (P<0.05) exist in storage days 7, 14, and 21 between the treatments. TBARS values increased notably (P<0.05) in all the treatments from 0.042mg/g on the first day of singeing to 0.136mg/g on day 7, 0.232mg/g on day 14, and 0.328mg /g on day 21 of storage making this work to agreeing with the findings of Rey et al. (2001), that cold storage of meat over time increases the accumulation of lipids oxidation. More so, TBARS values in HWS increased at a reduced rate and had significantly lower values of 0.115mg/g on day 7, 0.210mg/g on day 14, and 0.300mg/g on day 21 this reduction can be attributed to the excellent antioxidant activity of *Albizia* wood (Lau et al. 2007), smoke produced by the slow burning of wood inhibits microbial growth and activity, decreases fat oxidation, and enhances the flavour of the meat. On the contrary, other treatments are without antioxidants, and lipid peroxidation proceeds at an increased rate. In meat lipid peroxidation during post-mortem aging degenerates meat flavor, colour, odour, quality, and nutritional value (Karami et al, 2011) it also leads to the production of Malondialdehyde (MDA) as secondary lipid oxidation products, in human cells, MDA is genotoxic, interacting with DNA to generate highly mutagenic adducts. (Okolie *et al.,* 2009) a highly toxic molecule that has potential mutagenic and carcinogenic effects thereby leaving objectionable status in terms of safety and wholesomeness of meat and meat products

Conclusions

The findings from this study indicated that carcass pH decrease after singeing follows a similar trend and terminates at higher ultimate pH, retail display characteristics such as firmness and marbling of goat carcass were significantly affected by the singeing materials while carcass color was not affected by the materials. Despite the cold storage Malondialdehyde which is mutagenic progressively develops in all the meat from the study. Though the Firewood singed carcass has a lower oxidative product on storage, it also gives fresh meat with the highest water holding capacity while the trained panelist adjudges overall acceptability of meat from tyre-singed-carcass favorably has mostly liked on the Hedonic scale.

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