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Research Article
Carcass and Meat Differentiation of Burnt and Stripped Sheeps in Benin

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Abstract

Background and Objective: Post-mortem treatments, the cooling regime and the cutting method have a great influence on organoleptic quality of the meat such as the color and tenderness. The aim of this study was to evaluate meat quality of burnt sheep and stripped sheep in Benin. **Material and Methods:** Sixty samples of *Longissimus dorsi*, 30 burnt and 30 stripped Sahelian ewes in Cotonou slaughterhouse were used. Animals were all aged from 2-3 years and they were weighed before and after slaughter. Meat color, pH during 48 h post-mortem, loss of juice by cooking and tenderness were also measured. A sensory analysis (flavor, juiciness, tenderness and overall rating) of the boiled samples was carried out on small identical cubes of the meat. **Results:** The slaughtering lively weight and the hot carcass weight didn't vary from a type of dressing to another. *Longissimus dorsi* of burnt ewes has a lower red index, flavor and shear force than that of stripped ($p<0.05$). On the other hand, the initial and final pH and tenderness were higher in these same burnt. The juiciness and the water retention capacity didn't vary from burnt to stripped ewes. **Conclusion:** The study on the carcass quality and technological and organoleptic quality of the ewes slaughtered at the Cotonou slaughterhouse showed the effect of the type of dressing on the quality of the meat. The burning technique seems to influence the yield of the hot carcass.

Key words: Carcass yield, technological organoleptic, quality meat, sheep burnt, stripped

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Benin, national meat production was estimated to 36822 t of beef, 8243 t of sheep/goats, 12436 t of poultry, 4968 t of pigs, 1875 t of leporidae and 624 of other rodents[1]. Although small ruminants rank third in consumer preferences, they play a very important socio-economic role[2]. Culturally, they are used during festivals and for many sacrifices throughout the national territory[3]. They are accessible anytime of the year and therefore are slaughtered daily in slaughterhouses, or slaughter areas in every locality of the country. Several methods of slaughtering and cutting are used in small ruminants. In sheep, the common practice is to pull the leather manually (skinning), thus exposing the carcass. However, slaughtered sheep or goats are sometimes burnt or singed in order to rid them of their hair and are presented the skin adjoining the carcass. Consumers when buying are moving towards either form of presentation of the carcass. The reasons for this diversity of practices among butchers and choices among Beninese consumers are scientifically unknown. There are certainly tied to overall acceptability of the meat that depends on its general qualities. Those general qualities deserve to be known and discussed. Some research has been done to improve the health and production and reproductive performance of these animals during their lifetime[4-7] in Benin. However limited attention has been dedicated to studying the quality of carcass and meat after slaughtering. From the literature review, it is known that post-mortem treatments in particular, the treatment of animals immediately before or during slaughter, the cooling regime and the cutting method have a very great influence on the subsequent organoleptic quality of the meat such as color and tenderness[8-9]. The same reasons can explain consumers' choices. There is a need to study the influence of burning of animals on the carcass and meat quality. The objective of the study was to assess carcass and meat qualities sheep according to the type of dressing.

MATERIALS AND METHODS

Areas and period of study: The study has taken place from February to July 2018. The slaughterhouse of Cotonou is located in Akpakpa (Commune of Cotonou) and covers 3.5 ha (between 6°21' North latitude and 2°25' East longitude).

Choice of animals: Animals were transported from their natives Department (Borgou and Albori in the north of Benin) at least 48 h before slaughtering. Just after arrival, animals were approved and put to rest and it was during this period that they were identified for the study. The selection criteria were based on the breed (Sahelian), the age (2-3 years old and determined from the dental table) and the livestock system (sedentary or transhumant, natural pasture-fed without supplementation). Data on livestock and slaughter practices were also obtained from animals owners. They were interviewed about the origin of their animals, the breed, the age at slaughter, the pasture used during rearing (natural or artificial) and feed supplementation used during fattening, the livestock production system (transhumance or sedentary), the type of slaughter usually carried out on the sheep (stripped or burnt) etc. This interview allowed confirming the type of breed, the age at slaughter and the type of dressing of the previously selected animals. All of the slaughtered sheep in this study were raised on natural pasture. In total, 60 Sahelian ewes were selected from animals declared healthy by the veterinary inspection service, 30 were burnt while the other 30 were stripped. For this study, the number was chosen according to the standard statistical method of estimating the size of a sample[10]. The study focused only on Sahelian ewes because they are the most slaughtered.

Data collection

Slaughter process: Slaughtering begins at 4:00 am in the morning and finished at noon. The average number of sheep slaughtered was about 200 heads per day. The veterinary inspector first carries out ante-mortem inspection of the identified animals before slaughter. At slaughter, the animals are sent in groups of 5-10 to the slaughter hall. Once in place, they are weighed individually. To hold them, the anterior and posterior limbs are joined and firmly attached by means of a cord provided for this purpose. The animals are then placed on the ground so as to orient the jugular vein towards the throat-cutter and then they are slaughtered with a sharp and clean knife. They were then dressed. Some are burned with a very hot wood fire and then scraped and turned over frequently. For this, they are brought outside the slaughtering hall to the fire pits. At the end of the burning which requires a relatively longer time than the removal of the skin, they are washed with a steel sponge before being eviscerated on the ground. For others, the skin is squarely detached from the muscles, so they are stripped before being eviscerated. The rumen and intestines are taken to the drainage areas for emptying and first cleaned. They are then returned to the casing where they were cleaned before being put up for sale. The legs and head are burned in order to remove the hooves and the hair. The leather is sold directly for use as carpets or leather goods (bags, purses, shoes, etc.). The carcasses presented without the skin, head and feet or with the skin

and the elements of the 5th quarter are all presented at the post-mortem inspection carried out by the veterinary inspector. After receiving the stamp, the carcasses are transported to butchers, markets or various sales outlets.

Carcass quality: The slaughter weight was taken the day before slaughter using a mechanical balance of 1,500 kg of capacity with a precision of 1.5 kg. On the day of slaughter, an electronic balance of 1,500 kg of capacity with a precision of 0.5 kg was used to weigh hot carcass. The carcass yield was then obtained by multiplying the ratio of the hot carcass weight to the slaughter weight by hundred.

Sample collection: Immediately after slaughter, both *Longissimus dorsi* of each identified animal were removed and divided into 2 slices. Packed in a sterile plastic bag and labeled. They were placed in an icebox containing cool packs and brought back to the laboratory for the various analyses. In the laboratory, three slices (numbered 1, 2 and 3) were subjected to different maturation times at 4°C: T0 (no maturation), T1 (maturing for 24 h) and T3 (maturation for 48 h). Once the maturation time was reached, they were used to carry out the analysis on day 0 (slaughter day), day 1 (24 h after slaughter) and day 2 (48 h after slaughter).

pH post-mortem: One of the slices, kept at 4°C for 48 h, was used to measure pH at 1, 2, 4, 6, 12, 16, 18, 24 and 48 h post-mortem using a HANNA portable pH meter. Three repetitions were made for each measurement. The pH at 1 h was taken at the slaughterhouse.

Meat color: The color of the meat was determined on day 0, 1 and 2, respectively on slices number 1, 2 and 3 using a Minolta CR400 colorimeter (Minolta Corporation, Ramsey, NJ, USA) according to the system of the International Commission on Illumination (CIE L * a * b *) after storage of the samples in contact with atmospheric air for 1 h 30 min at 4°C. L * corresponds to brightness, a * index of red and b * index of yellow. The saturation or chromaticity (C) and hue (h) were determined respectively according to the equations[10]:

$$C = (a^{*2}+b^{*2})^{1/2}$$

and:

$$h = \frac{\tan^{-1}b^{*}}{a^{*}}$$

Loss of water during cooking: At the end of ripening and after taking color, the slices of *Longissimus dorsi* used were divided into 2 parts; one was used to measure the loss of juice during cooking and the shearing force while the other was frozen at -20°C for subsequent sensory analysis. Each unfrozen portion was weighed, placed in a labeled cooking bag and then placed in the water bath for cooking to a core temperature of 75±0.5°C. At the end of the cooking, the samples were cooled under jet of water and then removed from the sachet and sponged. They were subsequently weighed and the loss of juice by cooking (LC)was determined.

Warner-bratzler shear force: For the same carcass, shear forces were measured on sample at the 3 maturation times (T0, T1 and T2). Ten cores of the previously cooked samples were cut and sheared using a Universal testing machine equipped with a Warner-Bratzler attachment (LLYOD Instruments). The shear force was expressed in Newton and was the average value of the ten evaluated cores of each sample[4].

Sensory analysis: The frozen samples were thawed and boiled in water (1 h at 75°C.) without seasoning and salt and thereafter presented in small identical cubes. The sensory quality was evaluated by a panel of 10 tasters previously trained. They appreciated the juiciness, tenderness and flavor of the meat on a scale ranging from 1-5. For tenderness, 1 corresponds to very hard, 2 to hard, 3 to acceptable, 4 to tender and 5 to very tender. As for the juiciness, 1 corresponds to very dry, 2 to dry, 3 to acceptable, 4 to soft and 5 to very mellow. Finally, the intensity of the flavor corresponds to very low (1), low (2), acceptable (3), strong (4) and very strong (5). An overall score ranging from 1-10 was assigned to each piece on the basis of a general appreciation taking into account consumer satisfaction. For the tasting, each judge received simultaneously 3 pieces of meat from the same carcass dressed with the skin but matured respectively at times T0, T1 and T2 and three pieces of the same carcass dressed without the skin and also matured respectively at times T0, T1 and T2. The total of 6 pieces of meat was arranged in a dish whose inside was divided by the manufacturer into 6 parts of different colors.

Statistical analysis: Data were analyzed using the General Linear Model procedure (GLM) of SAS (SAS, Cary, NC)[11]. The factors of variation considered were the type of dressing (stripping or burning) and the day of measurement, i.e., the

ripening times. The F-test was used to determine the significance of type of dressing effect. The means were estimated and compared by the student-test.

RESULTS

Carcass quality: The live weight, the weight of the hot carcass and the yield of the carcass of sheep slaughtered by type of dressing are presented in the Table 1. No significant differences were found between mean live weight, hot carcass weight and carcass yield (25.83, 13.00 and 50.76 kg) of the burned ewes and those of the stripped ewes (28.76, 14.04 and 50.42 kg).

Evolution of the post-mortem pH of *Longissimus dorsi* of stripped and burnt sheep: The post-mortem pH of *Longissimus dorsi* of stripped and burnt ewes is presented for each hour of measurement in Table 2. At 1 h post-mortem, the pH was 6.21 in burnt ewes and 5.94 in the stripped sheep. At the end of the 48 h of maturation the pH was 5.79 and 5.46, respectively for burned and stripped sheep. The values of each time of measurement significantly varied ($p<0.01$) from one type of dressing to another and the burned ewes had the highest values.

Color of *Longissimus dorsi* of stripped and burnt sheep: The color parameters of the *Longissimus dorsi* of the stripped and burnt ewes for each day of measurement and type of dressing are shown in Table 3. The luminance, the yellow index and the hue did not vary significantly from one type of dressing to another for each day of measurement. The red index was higher on the day of slaughter ($p<0.01$) and 48 h post-mortem ($p<0.05$) in favor of *Longissimus dorsi* of stripped sheep. The same result was obtained for the chromaticity ($p<0.05$).

Loss of juice during cooking: The loss of water during cooking of non-mature, mature for 24 and 48 h *Longissimus dorsi* from the stripped and burnt ewes is shown in Table 4. For non-mature samples (samples from the day of slaughter or day 0) and those mature for 2 days, the loss of juice during cooking did not significantly vary from one type of dressing to another. About 24 h mature *Longissimus dorsi* of stripped ewes has a higher loss of cooking juice ($p<0.01$).

Shear force of *Longissimus dorsi* of stripped and burnt sheep matured at different times: For each day of measurement and for each type of dressing, the shear force of *Longissimus dorsi* of stripped and burnt sheep is presented in Table 5. On day 0 and 1, the shear force of *Longissimus dorsi* was significantly higher in stripped sheep (103.08 N, 94.81 N) than in burnt sheep (81.96 N, 81.12 N) ($p<0.001$). At day 2, after 48 h of maturation, no significant

Table 1: Carcass yield of stripped and burnt sheep

	Stripped ewes		Burnt ewes		
Variables	Means	SE	Means	SE	Test of significance
slaughter weight (kg)	25.83	1.36	28.76	1.36	NS
Hot carcass weight (kg)	13.00	0.71	14.04	0.71	NS
Carcass yield (%)	50.42	0.97	50.76	0.97	NS

NS: Not significant, SE: Standard error

Table 2: Post-mortem pH of *Longissimus dorsi* of stripped and burnt ewes

	pH of stripped ewes		pH of burnt ewes		
Measurement time (h)	Means	SE	Means	SE	Test of significance
1	5.94	0.03	6.21	0.03	***
2	5.94	0.03	6.21	0.03	***
4	5.74	0.03	6.04	0.03	***
6	5.69	0.03	6.00	0.03	***
12	5.62	0.03	5.97	0.03	***
16	5.58	0.03	5.93	0.03	***
24	5.50	0.03	5.88	0.03	***
48	5.46	0.04	5.79	0.04	***

***p<0.001, SE: Standard error

Table 3: Color parameters of the *Longissimus dorsi* of the ewes, for each measurement day and type of dressing

		Stripped ewes		Burnt ewes		
Variables	Days	Means	SE	Means	SE	Test of significance
L*	0	43.05	0.66	43.20	0.66	NS
	1	37.35	0.79	37.15	0.79	NS
	2	38.72	0.87	38.58	0.87	NS
a*	0	22.50	0.44	20.85	0.44	**
	1	19.99	0.59	19.39	0.59	NS
	2	19.28	0.64	17.49	0.60	*
b*	0	10.74	0.53	9.96	0.53	NS
	1	8.58	0.53	8.40	0.53	NS
	2	8.79	0.51	7.85	0.51	NS
Hue	0	2.20	0.33	2.67	0.33	NS
	1	4.94	1.28	2.51	1.28	NS
	2	2.34	0.13	2.29	0.13	NS
Chromaticity	0	25.09	0.55	23.26	0.55	*
	1	22.00	0.70	21.20	0.70	NS
	2	21.32	0.73	19.24	0.73	*

*p<0.05, **p<0.01, NS: Not significant, SE: Standard error, a*: Index of red, b*: Index of yellow, L*: Brightness

Table 4: Loss of juice during cooking of *Longissimus dorsi* of stripped and burnt sheep at different times of maturation

	Stripped ewes		Brunt ewes		
Variables	Means	SE	Means	SE	Test of significance
Day 0	40.71	1.36	38.59	1.36	NS
Day 1	42.51	1.51	39.31	1.51	**
Day 2	43.96	1.73	39.16	1.73	NS

**p<0.01, NS: Not significant, SE: Standard error

Table 5: Shear force of *Longissimus dorsi* of ewes, for each day of measurement and type of dressing

	Stripped ewes		Brunt ewes		
Variable	Means	SE	Means	SE	Test of significance
Shear force (N)					
Day 0	103.08	3.08	81.96	3.29	***
Day 1	94.81	3.37	81.12	3.37	***
Day 2	88.76	3.28	78.66	3.50	NS

***p<0.001, NS: Not significant, SE: Standard error

Table 6: Sensory quality of *Longissimus dorsi* of sheep by type of dressing and for each day of measurement

		Stripped ewes		Burnt ewes		
Variables	Days	Means	SE	Means	SE	Test of significance
Flavor	0	3.07	0.11	2.64	0.11	**
	1	2.76	0.11	2.62	0.11	NS
	2	2.99	0.09	2.89	0.09	NS
Juiciness	0	3.02	0.09	2.90	0.09	NS
	1	2.96	0.09	2.98	0.09	NS
	2	3.21	0.09	3.15	0.09	NS
Tenderness	0	2.91	0.11	3.51	0.11	***
	1	3.07	0.11	2.67	0.11	***
	2	3.40	0.10	3.63	0.10	NS
Acceptability	0	3.02	0.09	3.20	0.09	NS
	1	3.04	0.09	3.24	0.09	NS
	2	3.28	0.10	3.32	0.10	NS

NS: Not significant, **p<0.01, ***p<0.001

difference was found between the shear force of the *Longissimus dorsi* of the stripped and burned ewes. From 0-2 day, only the stripped ewes showed significant decrease during maturation ($p<0.05$).

Sensory quality of *Longissimus dorsi* of stripped and burnt sheep: The sensory quality of *Longissimus dorsi* of sheep for each day of measurement and type of dressing is presented in Table 6. Only flavor and tenderness varied from one type of dressing to another. The flavor was higher on the day of slaughter in the stripped sheep compared to the burnt. The contrary was observed for tenderness on the day of slaughter and 24 h post-mortem. No significant variation was observed for the other parameters.

DISCUSSION

The carcass yield of burned ewes (50.76 kg) is not significantly different from that of the stripped ewes (50.42 kg). The post-mortem pH values of *Longissimus dorsi* of burned ewes observed (6.21 at 1 h and 5.79 at 48 h post-mortem) was significantly higher than those of stripped ewes (5.94 at 1 h and 5.46 at 48 h). Regarding the color of meat, the red index was higher on the slaughter day in favor of *Longissimus dorsi* of stripped sheep. Twenty four hours mature *Longissimus dorsi* of stripped ewes has a higher loss of cooking juice and a higher shear force. But the tenderness appreciated by a jury on the slaughter day and 24 h post-mortem was higher for *Longissimus dorsi* of burned ewes. Adeniji *et al.*[12] obtained values not significantly different for Slaughter weight, hot carcass and, of singed and skinning West African Dwarf sheep. For the dressing percentage, singed carcass has higher values. The similar observation has been done for this study except for dressing percentage (yield carcass) in which, despite the absence of significant difference, yield carcass of burnt ewes is slightly above that of stripped ewes. Which strengthens the author's idea that skin influences the weight of carcass. Wattanachant *et al.*[13] obtained too higher values for singed goat versus skinned goat. So, the type of dressing influences the yield of the carcass. However, this study should be repeated on a larger population and on other breeds in order to properly assess the impact of burning on carcass yield. Wattanachant *et al.*[13] obtained too higher values of singed goat. The yield carcass obtained for burnt ewes is close to those obtained by Adeniji *et al.*[12], Adu[14] and Fasae *et al.*[15] for indigenous local sheep.

Okoh and Omojola[16] obtained pH values immediately after slaughtering of 6.44 and 6.13, respectively for singed and skinned goat carcass; which are higher than those obtained in this study but the evolution trend from skinned (stripped) to singed (burnt) remains the same. The burnt (singed) animals presented the highest pH. This result is in line with the findings of Omojola *et al.*[17] concerning pH values of 5.70 and 5.54 of singed and skinned carcasses of Red Sokoto buck taken at *Longissimus dorsi* muscle at 0 h post-mortem. Similarly, Omojola and Adesehinwa[18] and Adeniji *et al.*[12] reported no significant ($p>0.05$) difference respectively in the pH of skinned and singed carcasses of rabbit and ram carcasses but with the highest pH recorded for singed carcass. Talmant *et al.*[19] observed slightly higher pH values in flamed pigs compared to those depilated. The significant difference observed between the post-mortem pH values of *Longissimus dorsi* of stripped ewes and that of burnt ewes reveals a great difference of practices in the treatment of animals during slaughter. The burning technique does not allow a normal decrease in post-mortem pH.

Concerning the color, the study shows that meat from stripped ewes has higher values of red index. This result is contrary to that of Okoh and Omojola[14] in which meat from singed goat has higher values of color score. Adeniji *et al.*[12], Omojola and Adesehinwa[18] as well as Omole *et al.*[20] found no significant difference for meat from singed and skinned carcasses. However, color value of meat from singed carcasses

is slightly above that of skinned carcasses[12]. Those authors assessed meat color in panels. In this study, color parameters are measured by colorimeter. The inferiority of the red index of the *Longissimus dorsi* of burnt ewes compared to that of stripped ones may be related to the burning technique. Burning resulted in the beginning of protein denaturation and myoglobin and obviously a reduction of glycogen into simple sugars that interact with amino acids to alter the meat color. This was confirmed by a higher pH.

For cooking loss, flavour, juiciness and overall acceptability, Adeniji *et al.*[12] obtained higher values for Singed sheep meat comparatively to skinning sheep meat. The same trend is observed in the results of Wattanachant *et al.*[13] about drip loss and cooking loss percentages and in the results of Okoh and Omojola[14] about drip loss and cold loss of singed and skinned goat. In this study, the cooking loss, the juiciness and the overall acceptability of the meat do not vary according to the dressing type.

Furthermore, the inferiority of the shear force on 0 and 1 day post-mortem of the *Longissimus dorsi* of burnt ewes compared to stripped ewes can be explained by the effect of the heat of the fire which began by denaturing the structure of the muscular proteins; which softened the meat. The absence of a significant difference between the forces obtained on day 2 for the 2 types of cladding allows concluding that at 48 h of maturation the meat tenderness obtained could be identical to that obtained by burning the slaughtered animal. Moreover, the non-variation of shear forces from day 0-2 days proves that the maturation of the carcass has no effect on the final tenderness of the burnt animals' meat. This idea corroborates the findings of Wattanachant *et al.*[13] who also did not obtain difference between shear force values of loin meat of goat skinned and those singed after 5 days of maturation.

The low tenderness of the *Longissimus* of stripped sheep compared to that of burned ewes is in line with the shearing forces obtained for these two types of dressing. Adeniji *et al.*[12] obtained values not significantly different for meat tenderness from both processing methods.

The results obtained in this study are in part different from those of the literature reviewed. This can be explained by the non-standardization of the different methods of dressing; particularly, that of singeing and on the temperature and the singeing time for example, which surely differs from one region to another. This implies the need for additional studies on the processes in order to standardize them by regions.

CONCLUSION

The study on the carcass quality and technological and organoleptic meat quality of the ewes slaughtered at the Cotonou slaughterhouse revealed the effect of the type of dressing on the quality of the meat. The burning technique seems to influence the yield of the hot carcass. *Longissimus dorsi* of slaughtered and burnt animals have a lower, redness and shear force and greater tenderness than *Longissimus dorsi* in slaughtered and stripped animals. On the other hand, the evolution of the post-mortem pH varied for burnt sheep.

SIGNIFICANCE STATEMENT

This study discovered the influence of the burning of animals in order to remove hair from skin on the meat quality. That can be beneficial for butchers and consumers. This study will help the researchers to uncover the critical areas of meat quality according to the type of dressing.

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