Influence of Slaughter Methods That Are Indigenous to Nguni People on Meat Physico-Chemical Characteristics of Goat Meat

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Influence of slaughter methods that are indigenous to Nguni people on meat physico-chemical characteristics of goat meat

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Abstract

Background: Resource-limited households in smallholder farming systems slaughter goats use indigenous methods for performing traditional ceremonies and meat consumption. Although extensive research has been done to determine the effect of slaughter methods on meat physico-chemical characteristics, there is paucity of information on methods which are indigenous to Nguni people. Therefore, the objective of the study was to determine meat quality of Nguni goats slaughtered using indigenous slaughter methods.

Methods: Thirty 15-18-month old wethers were randomly assigned to three slaughter methods; transverse neck incision (TNI), suprasternal notch piercing (SNP) and under shoulder blade chest floor point of elbow piercing (CFP) to the direction of the heart. Post-mortem, the *m. longissimus thoracis et lumborum* (LTL) was sampled for meat quality measurements.

Results: Wethers slaughtered using the SNP method had greater ultimate pH values when compared with TNI and CFP slaughter methods. Wethers slaughtered using SNP method had greater rate of pH decline when compared with TNI and CFP slaughter methods. Whethers slaughtered using the SNP method had lower meat redness (a*), yellowness (b*), and chroma (C*) values when compared with TNI and CFP slaughter methods. Slaughter method had no effect ($P \geq 0.05$) on drip loss, water holding capacity, cooking loss and shear force.

Conclusions: Overall, Nguni wethers slaughtered using the TNI and CFP methods produced chevon with fresh meat appearance.

Keywords: chroma, suprasternal notch piercing, transverse neck incision, redness, ultimate pH, yellowness.

1. Introduction

In developing countries (e.g. Africa and the Middle East) where more than 90 % of the world's goat population is found [1], goats are ranked as the second most important and abundant livestock species following cattle. Such importance is due to their ability to graze and browse poor quality forage, survive drought and saline conditions [2]. Furthermore, goats have high profilicay making them a short term investment [3]. Goats are owned and kept by farmers for meat (chevon), milk, manure, skins and hides [4]. Although goats are kept for socio-economic purposes, the primary reason for keeping them is to use them for religious and cultural puporses [5].

In 2018, the world's total goat population was estimated at 1 billion with 40 % of these goats found in Africa [1]. Southern Africa's total goat population contributes approximately 2 %, where 50 % these goats are found in South Africa [6]. In South Africa, where the total goat population is equally distributed between smallholder and commercial farming systems, more than 95 % of goats are sold informally in private markets for slaughter during cultural beliefs [7]. When perfoming cultural practices, goats are slaughtered informally using indigenous slaughter methods [8; 9]. Indigenous slaughter methods include the transverse neck incision (TNI), under shoulder blade chest floor point of elbow piercing (CFP) and suprasternal notch piercing (SNP) to the direction of the heart using a short spear [8]. Goats slaughtered using indigenous slaughter methods (TNI, CFP and SNP) had different bleeding time and efficiency, blood volume in the thoracic cavity, time to loss of sensitivity and cardiac arrest and comparable behavioral responses and dressing pecentages and similar behavioural responses [10]. These slaughter methods are used when when performing traditional ceremonies [4] such as connecting the living and the dead, clensing the deceased, and

celebration of marriages and births. Although these indigenous slaughter methods are permitted under the provision of the South African Meat Safety Act 40 of 2000 [9], animal welfare advocates consider these methods as inhumane as no stunning is involved. Animal rights activists trivialise the religious and cultural functions of these slaughter techniques. Immediately after slaughter and dressing, in most cases, the carcasses are stored under room temperature conditions for 24 hours where they are hanged using hocks for them to cool slowly, dry and allow maximum blood loss. This is important because consuming meat with blood is prohibited as ancestors spirits do not accept meat with blood [11]. Offals are cleaned and consumed on the day of slaughter as they are highly perishable.

Cultural beliefs invoked when celebrating circumcision, marriages and births, venerating ancestors, avenging evil spirits, and performing a ritual during funerals are integral to most African cultures [11; 12]. Meat consumed after performing traditional ceremonies leads to increased protein intake resulting in to a decrease of protein-energy malnutrition and dietary deficiency [13]. Although several studies has been done to assess the effect of slaughter methods on chevon quality [14; 15; 16], however, the effect of effect of TNI, SNP and CFP methods on chevon quality is poorly understood. Therefore, understanding the effect of TNI, SNP and CFP methods on chevon quality is crucial for communities to improveg food security within local cultural pactices.

The effects of indigenous slaughter methods on chevon quality has, however, not been investigated since resource-limited households interpret carcass characteristics as physical-chemical. Understanding the effect of slaughter methods on meat physico-chemical characteristics could assist farmers to select a slaughter method that promote their culture and enhance modern consumer acceptability without compromising animal welfare and meat

quality. The objective of the current study was, therefore, to assess the effect of TNI, SNP and CFP methods on meat physico-chemical characteristics from Nguni goats. It was hypothesized that meat quality from Nguni goats slaughtered using indigenous slaughter methods are comparable to that of goats slaughtered using conventional methods.

2. Material and methods

2.1. Goats and experimental design

Thirty clinically healthy Nguni wethers (about 15-18 months old based on dentition) with body weight averaging 16.8 ± 1.84 kg where bought from the local rural farmers of Nongoma (27°53′S 31°38′E) were they were managed on communal rangelands dominated by *Vachellia karroo* browse species. Goats were kept in the the same kraal and randomly assigned to each slaughter treatment. Classification of goats as Nguni breed was based on their multiple coat colour patterns, small and compact frame size [17]. Goats were slaughtered randomly after 24 hours of fasting where clean water was provided *ad libitum*. Slaughtering of goats was completed within a day where the process began at 05h00 in morning and ended at 09h00.

2.2. Treatments

Thirty wethers were randomly assigned to three slaughter treatments (n=10/treatment) and subjected to; transverse neck incision (TNI), under shoulder blade chest floor point of elbow piercing (CFP; Figure 2B) and suprasternal notch piercing with a short spear (SNP; Figure 2C). Briefly, goats were slaughtered without stunning using either a sharp knife or a short spear specifically designed for slaughtering of goats. Transverse neck incision slaughter technique involved the use of a sharp knife for cutting the skin, muscles (brachiocephalic, sternocephalic, sternohyoid, and sternothyroid), trachea, oesophagus, carotid arteries, jugular

125 veins and the major, superficial and deep nerves of the cervical region [18]. Cuts were
126 defined as a change in the direction of movement of the knife (e.g. the forward movement of
127 the knife would count as one cut, while the corresponding reverse movement would be
128 recorded as a second cut).
129
130 Suprasternal notch piercing (SNP) targeting the heart was performed by two experienced
131 slaughtermen using short spears. During slaughter, each goat was allowed to stand upright
132 using rear/hind legs. One slaughter man held the left front leg and the head (using horns)
133 while the second slaughter man held the right front leg and the spear which was used for
134 piercing the goat in the suprasternal notch in the direction of the heart. Goats were allowed to
135 bleed into a 5 litre (L) water bucket.
136
137 Under shoulder blade chest floor point of elbow (CFP), piercing involved the use of a short
138 spear and five slaughtermen. These slaughtermen held each goat in dorsal recumbent position
139 by holding all legs sideways. The fifth slaughter man was responsible for piercing each goat
140 on the heart girth position, next to the chest floor and point elbow to the direction of the heart.
141 Goats were also allowed to bleed into a 5 litre (L) water bucket.
142
143 2.3. Meat sampling and storage
144 Following exsanguination, carcasses were dressed as described by [10]. Forty-five minutes
145 after slaughter, *M. longissimus thoracis* (LTL) muscles were removed from the left and right
146 sides of each carcass for meat quality analyses. The LTL muscles were then vacuum-packed
147 and stored in polystyrene cooler boxes and transported to the animal science labolatory at
148 University of KwaZulu Natal, Pitermaritzburg, South Africa for meat quality analyses. The
149 slaughter point and animal science labolatory are 380 km apart. Eleven hours later on arrival

150 at the lab, meat samples were unpacked from the cooler box and stored at room temperature
151 (23 ℃) until 24 hours after slaughter.
152
153 2.4. Measurements
154 2.4.1. Meat pH
155 Post-mortem pH were measured 45 minutes after slaughter and thereafter for a period of 24
156 hours (11, 13, 15, 17, and 24). Post mortem rate of decline of pH in meat were measured
157 using a portable pH meter probe (CRISON pH25, CRISON instrument SA, Spain).
158
159 2.4.2. Meat colour
160 Meat colour was measured 24 hours after slaughter using a colour meter (HunterLab,
161 ColorFlex EZ Spectrophotometer). The parameters used to evaluate meat colour followed
162 colour CIE (1976) coordinates which measured: lightness *(L*)*, redness *(a*)* and yellowness
163 *(b*)* from three locations on the cut surface of individual meat samples. Three replicate
164 measurements were done. Areas of connective tissue and intramuscular fat per sample were
165 avoided. Colour saturation was calculated as the square root of the sum of a^{*2} and b^{*2}.
166
167 2.4.3. Drip loss and water holding capacity
168 Drip loss was determined by the standard bag method [19]. Drip loss was measured as the
169 weight loss during the suspension of a standardized muscle sample (40–50 g and
170 approximately 30 × 60 × 25 mm) in an airtight transparent plastic bag over 48 h at 4°C. Drip
171 loss was expressed as a percentage of the weight loss in 48 hours over the initial weight
172 sample.
173

174 Water holding capacity (WHC) was determined by compressing approximately 3 – 4 gram of
175 meat with 30 kg of weight for 5 minutes using a texture analyser (Stable Micro System,
176 Model TA.XT 2i/25, UK). The water content of meat was determined by multiplying the
177 initial weight of meat with 0.7. Water loss was determined by subtracting final weight from
178 the initial weight. Water holding capacity was therefore calculated by subtracting water loss
179 from water content, dividing by water content and multiplying by 100.
180
181 2.4.4. Cooking loss and shear force
182 Fresh LTL meat samples were cut and weighed (initial weight) to form individual
183 standardazed slices of approxiamately 50 mm thick. Prepared meat samples were then placed
184 in a RATIONAL Granite-enamelled container 20 mm deep. A RATIONAL SCC 61E self-
185 cooking centre (Landsberg, Munich, Germany) was used to roast *M. longissimus thoracic*
186 (LTL). Briefly, the hot plate was preheated for 5 min to 205 ℃. Immidiately after preheating,
187 RATIONAL Granite-enamelled container 20 mm deep was placed onto a RATIONAL Grid,
188 stainless steel 1/1GN were meat was roasted for 4 min. After completing the cooking process,
189 meat samples were cooled at room temperature and weighed. Therefore, the cooking loss was
190 calculated as the percentage difference in weight before and after cooking.
191
192 Following cooking, sub-samples of specified core diameter parallel to the grain of the meat
193 was used. Samples were sheared perpendicular to the fibre direction using a texture analyser
194 model TA.XTplus, texture analyser (Stable Micro System, Model TA.XT 2i/25, UK) as
195 outlined by [20]. The mean maximum load recorded for the three cores were represented as
196 the average of peak force in Newton's (N) for each sample.
197
198 2.5. Statistical analyses

All data were analysed using [21]. A general linear model (GLM) procedure with repeated measures analysis was used to test the effect of indigenous slaughter method on the rate of pH decline of meat in hours.

The model used was the following:

$$Y_{ij} = \mu + S_i + T_j + (S \times T)_{ij} + b_l W_k + \varepsilon_{ijlk}$$

Where:

Y_{ijk} = Response variables (pH, , a*, b*, L*, water holding capacity, shear force, and cooking loss);

μ = population mean common to all observation;

S_i = effect of indigenous slaughter methods;

$(S \times T)_{ij}$ = the interaction between slaughter method and time (hours);

$b_l W_k$ = co-variant (initial temperature or pH); and

ε_i = residual error.

A general linear model was used to test the effect of the slaughter method on meat physico-characteristics of Nguni goats. Comparisons of least-square means were done using the PDIFF option of [21]. The significance threshold was set at $P \leq 0.05$.

PROC REG was also used to determine relationships between slaughter methods and meat pH over time. The slope of each curve was tested if it was significantly different from each other using the TEST statement of regression procedure for each slaughter method.

3. Results

222 Slaughter method had no effect ($P \geq 0.05$) on initial meat pH (Table 1) and pH changes
223 (Figure 1), however its interaction with time was signficant ($P \leq 0.05$). Initial meat pH was
224 highest for TNI followed by SNP and CFP slaughter methods. Ultimate meat pH was highest
225 for SNP followed by TNI and CFP methods. Ultimate meat pH was greater ($P \leq 0.05$) for the
226 SNP slaughter method when compared with TNI and CFP slaughter methods (Table 1). Rate
227 of pH decline in meat was highest for SNP followed by TNI and CFP slaughter methods.
228 Rate of pH decline in meat was higher ($P \leq 0.05$) for SNP when compared with TNI and CFP
229 slaughter methods (Table 2).
230
231 Slaughter method had an effect ($P \leq 0.05$) on meat redness and yellowness (Table 1). Meat
232 redness was highest for TNI followed by CFP and SNP slaughter methods. Redness (a*)
233 values of meat from goats slaughtered using SNP method were lower ($P \leq 0.05$) compared
234 values of meat from goats slaughtered using TNI and CFP methods (Table 1). Meat
235 yellowness (b*) values of goats slaughtered using SNP method were lower ($P \leq 0.05$)
236 compared values of meat from goats slaughtered using TNI and CFP methods (Table 1).
237 Slaughter method had no effect ($P \leq 0.05$) on the lightness (L*) and hue (H*) coordinates of
238 meat (Table 1). Slaughter method had an effect ($P \leq 0.05$) on chroma coordinates. Chroma
239 coordinates were highest for TNI followed by CFP and SNP slaughter methods. Chroma
240 coordinates for meat from goats slaughtered using SNP was lower ($P \leq 0.05$) than those of
241 meat from TNI and CFP slaughter methods (Table 1). Slaughter method had no effect ($P >$
242 0.05) on drip loss, WHC, cooking loss and shear force.
243
244 **4. Discussion**
245 The high ultimate pH value reported for SNP slaughter treatment could be explained by
246 prolonged stress before and during slaughter, which may have lead to reduction in glycogen

247 levels, and therefore low post-mortem lactic acid production [22; 23; 15]. The high pHu
248 observed in meat from animals slaughtered using the SNP method suggest these animals were
249 more stressed than those slaughtered using other methods. The the causes of stress are,
250 however, not immediately clear. The prolonged stress could be related to the nature,
251 frequency, strength, severity, intensity, and/or duration of stressor(s) before and during
252 slaughter. Such stressors include animal handling before and during slaughter and pain
253 experienced by the animal during sticking and exsanguination. These factors were not
254 measured in the current study and merit investigation.
255
256 The lower meat redness (a*) observed for whethers slaughtered using the SNP slaughter
257 method may be related to the high pH observed for this slaughter method. The pH effect on
258 a* has been asociated with oxygen consumption [24; 25]. High pH often results in low
259 protein denaturation, which creates a more closed tissue structure. The closed structure of
260 meat reduce the diffusion of oxygen into the meat from the surface and any oxygen that do
261 not reach the interior is then utilised by high cytochrome activity encouraged by high pH
262 [26]. As a result less oxygenated myoglobin is formed, and consequently meat looks less red.
263
264 The observation that the SNP method had lower meat yellowness (b*) values than other
265 methods could also be explained by the effect of high muscle pH on oxygenation of the
266 myoglobin [27; 28; 29]. The lower chroma (C*, color intensity) values observed for the SNP
267 slaughter method compared to other methods also corresponds high pH values, which
268 negatively correlates with low oxymyoglobin content in the meat [30]. It is well known that a
269 decrease in oxymyoglobin content in meat is accompanied by lower values of a*, b* and C*
270 [31; 32].
271

The finding that slaughter method had no effect on drip loss, WHC, cooking loss and shear force agree with earlier reports [33; 34; 16]. Overall, the high pHu (6.4-6.8), WHC, and low drip loss, a*, b*, and chroma values reported across slaughter methods are a characteristic of dark firm and dry (DFD) meat [26]. This implies that all the goats across treatments had prolonged stress before and/or during slaughter and that could be related to the high temperamental behaviour of the Nguni goat breed among other stress factors [35]. Further studies to determine the pre-, peri- and post-mortem glycogen reserves, lactic acid concentration in muscles and stress hormones in Nguni goats could be important in explaining the effect of their temperamental behaviour on meat quality. Causes of pre- and peri-mortem stress which could be important in minimising in DFD meat from Nguni goats also merit investigation.

5. Conclusions

Nguni goats slaughter using SNP slaughter method had higher pHu which resulted in lower meat redness, yellowness and chroma values .. It was concluded that Nguni goats slaughtered using TNI and CFP methods produce chevon with better meat colour than those slaughterd using the SNP method. The high meat pHu, WHC, and low drip loss and colour (a*, b*, and chroma) are indicative of DFD meat. Further studies to determine causes of DFD meat in Nguni goats slaughtered using indigenous methods coud be important.

List of abbreviations

TNI - transverse neck incision

SNP - suprasternal notch piercing

CFP - under shoulder blade chest floor point of elbow piercing

LTL - *m. longissimus thoracis et lumborum*

a* - Redness

b* - Yellowness

C* - chroma values

FAOSTAT - Food and Agriculture Organization Corporate Statistical

L – litre

WHC - Water holding capacity

GLM – general linear model

SAS – statistical analysis software

PDIFF - Requests that p-values for differences

DFD - dark firm and dry

Declarations

Ethics approval

Ethical clearance for this study was granted by the Animal Ethics Committee of the University of KwaZulu-Natal (AREC/001/018D).

Consert for publication

Not applicable.

Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authours conributions

ZMM designed, collected and analysed data and wrote the manuscript. MC supervised the study and the writing of the manuscript. CM read and approved the final version of the manuscript.

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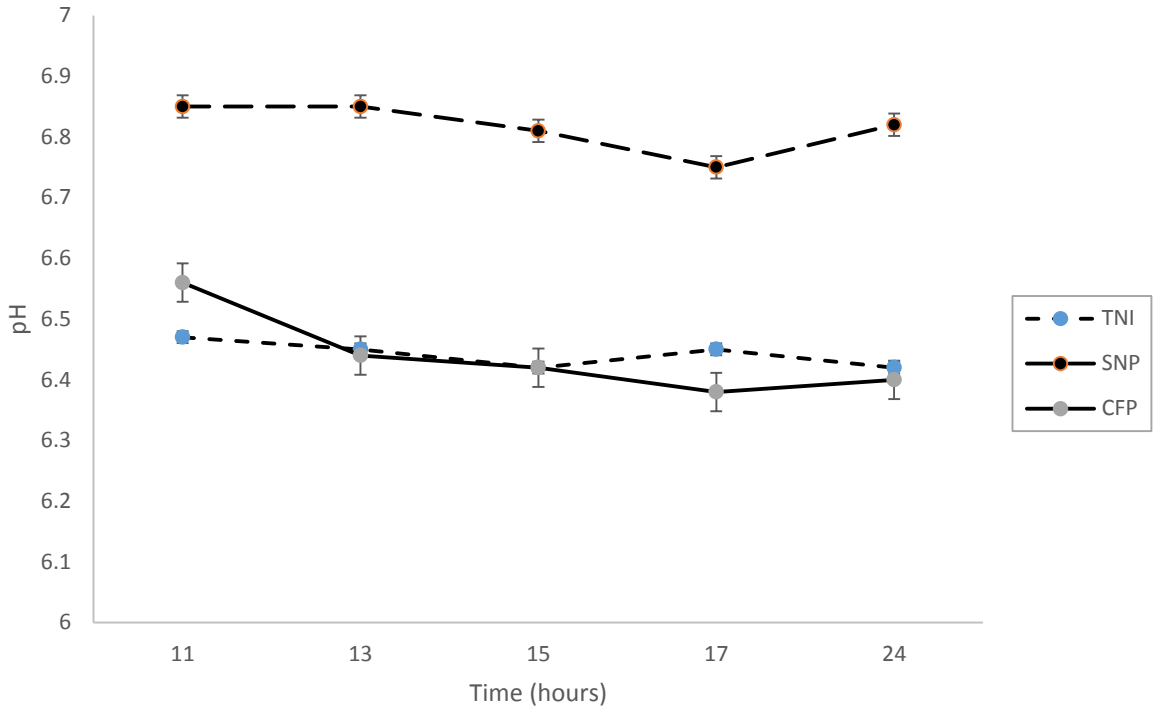
429 Figure 2: Visual pictures of a spear (A), chest-floor point-of-elbow (B), and suprasternal
430 notch piercing (C).

431 Adapted from [10].



432

433 Figure 1: The relationship between meat pH and time for TNI, SNP and CFP slaughter
434 methods.

435 Table 1: Effects of TNI, SNP and CFP slaughter methods on colour parameters (a*, b*, L*, h and C), drip loss, cooking loss, shear force and

436 water holding capacity of goat meat

Variable	**Slaughter method**			**Significance**
	TNI	SNP	CFP	
$pH_{45\ min}$	7.8 ± 0.102	7.7 ± 0.102	7.6 ± 0.102	NS
pH_{24h}	6.42 ± 0.13[a]	6.82±0.13[b]	6.40 ± 0.13[a]	*
Drip loss (%)	3.0 ± 0.75	1.75 ± 0.87	1.88 ± 0.75	NS
Water holding capacity (%)	74.18 ± 1.28	75.64 ± 2.21	72.88 ± 1.57	NS
Colour parameters				
a*	16.4 ± 0.56[a]	14.7 ± 0.56[b]	16.3 ± 0.56[a]	*
b*	13.5 ± 0.61[a]	11.5 ± 0.61[b]	13.2 ± 0.61[a]	*
L*	29.5 ± 1.02	28.3 ± 1.02	30.6 ± 1.02	NS
H*	0.69 ± 0.01	0.66 ± 0.01	0.68 ± 0.01	NS
C*	21.24 ± 0.78[a]	18.68 ± 0.78[b]	21.02 ± 0.78[a]	*
Cooking loss (%)	22.73 ± 2.3	21.6 ± 3.0	19.4 ± 2.6	NS
Shear force (N)	9.52 ± 0.72	10.73 ± 0.83	10.55 ± 0.72	NS

437 [a, b, c]Means in the same row with different superscripts are significantly different at P≤0.05; *p ≤ 0.05; **p ≤ 0.01; NS-p > 0.05. NS: not
438 significant; L*: lightness; a*: redness; b*: yellowness

439 Table 2: The relationship between meat pH and temperature for TNI, SNP and CFP slaughter

440 methods

Independent variable	**Parameter estimates (time)**				
	Intercept	*P* intercept	Slope	*P* slope	RMSE
pH					
TNI	6.31 ± 0.65	≤.0001	0.02 ± 0.03[a]	0.591	0.54
SNP	6.7 ± 0.13	≤.0001	0.04 ± 0.017[b]	0.033	0.44
CFP	9.44 ± 1.39	≤.0001	-0.20 ± 0.10[a]	0.055	0.49

441 [a, b, c]Means in the same column with different superscripts are significantly different at p ≤

442 0.05; *p ≤ 0.05; **p ≤ 0.01; NS-p > 0.05.

443

Figures

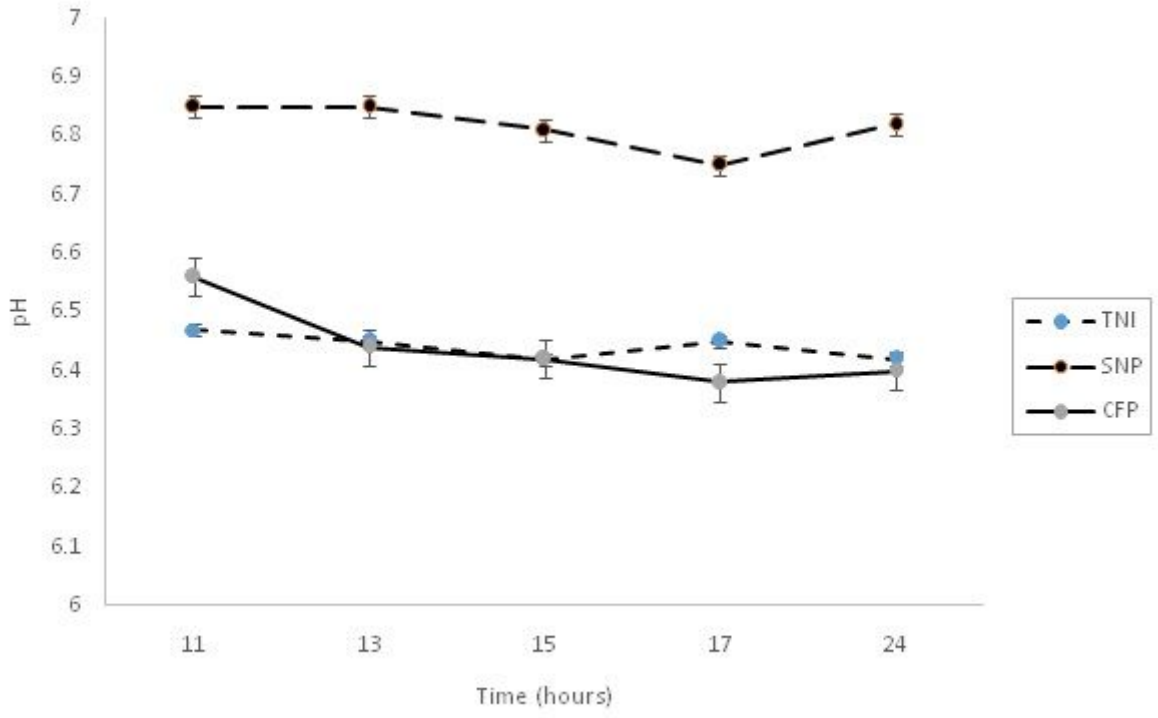


Figure 1

The relationship between meat pHand time for TNI, SNP and CFPslaughter methods.

Figure 2

Visual pictures of a spear (A), chest floor point of elbow (B), and suprasternal notch piercing (C).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- HighlightsJASB.docx
- HighlightsJASB.docx
- HighlightsJASB.docx