

PAPER

Quality and safety of beef produced in Central African Sub-region

Bawe M. Nfor,^{1,3} Mirco Corazzin,²
Florence A. Fonteh,³ Niba T. Aziwo,³
Marco Galeotti,⁴ Edi Piasentier²

¹Livestock Development Corporation
SODEPA, Yaoundé, Cameroon

²Dipartimento di Scienze Agrarie e
Ambientali, Università di Udine, Italy

³Department of Animal Production,
University of Dschang, Cameroon

⁴Dipartimento di Scienze degli Alimenti,
Università di Udine, Italy

Abstract

Aim of this research is to provide a general situation of cattle slaughtered in Cameroon, as a representative example for the Central African Sub-region. The quality and safety of beef from the abattoir of Yaoundé, the largest in Cameroon, were considered. From January 2009 to March 2012, the pre-slaughter conditions and characteristics of 1953 cattle carcasses were recorded, as well as the pH of *m. longissimus thoracis* 24 h after slaughter. From these carcasses, 60 were selected to represent the bulls slaughtered. The quality parameters and composition of *m. longissimus thoracis* were carried out. The origin of most of the cattle was the Guinea High Savannah (74.6%), and transhumance was the common production system (75.5%). Gudali (45.6%), White Fulani (33.3%) and Red Mbororo (20.3%) breeds were predominant. Carcass weight was affected by rearing system and cattle category, and it markedly varied during year. Considering meat quality, the fat content was low (1.2%) and similar between breeds, moreover Gudali showed the toughest meat. Of the cows slaughtered, 27% were pregnant and the most common abnormal conditions encountered were ectoparasites, fatigue, lameness, fungal-like skin lesions, enlarged lymph nodes, respiratory distress, nodular lesions. More than 20% of the carcasses had some organs condemned, mainly for liver flukes (5.17%), and 1.0% of them were completely condemned due to tuberculosis, that also affected 3.28% of lungs. These data could aid authorities draw up programmes with the aim to strengthen cattle production, improve beef supply, control and prevent the observed diseases, and promote the regional trade.

Introduction

The Central Africa Sub-region is characterised by a low regional trade flow of food products, and EU is its most important commercial partner (Agritrade, 2013). In the next years, this Region is expected to show an annual growth rate in consumption of beef of 3.2%, however, at the same time, also the imports of beef will increase (Livestock Data Innovation in Africa Project, 2013). Consequently, the improvement of beef production and the control of beef hygiene and quality are key factors in this region. Slaughterhouses are nuclear points for monitoring the incidence of animal diseases (Mellau *et al.*, 2011), carcass characteristics and beef quality. Moreover, data collected there can be used in back-tracking to farm (Alawa *et al.*, 2011).

In the Central African Sub-region, of which Cameroon is the main actor, cattle are raised in a range of different production and ecological systems and there are variations in genotypes, housing, diet composition and feed availability which directly or in directly influence carcass and beef quality, as demonstrated in other environments (Piasentier *et al.*, 2009; Corazzin *et al.*, 2012). Also herbage availability and quality for animals is often determined by alternating dry and rainy seasons.

To our knowledge there is little or no information regarding the carcass health, quality and quantity produced in Central African Sub-region. This information along with the understanding of their possibly influencing factors is necessary for the improvement of the beef sector and the regional trade of its products. The aim of this research is to provide a general situation of cattle slaughtered in Cameroon, as a representative example for the Central African Sub-region.

Materials and methods

Measurements and sample collection

At the abattoir of Yaoundé (Cameroon), the slaughtering activities were monitored for a period of three years (January 2009 to March 2012). Within this period data of 1953 cattle randomly selected were collected. The following characteristics were observed and recorded: agro-ecological origin and production system from which the cattle is coming from, means and duration of transportation, breed, sex and age. Body condition score (BCS) of cattle was evaluated using a three scoring

Corresponding author: Dr. Edi Piasentier,
Dipartimento di Scienze Agrarie e Ambientali
(DISA), Università di Udine, via Sondrio 2/A,
33100 Udine, Italy.
Tel. +39.0432.558190 - Fax: +39.0432.558199.
E-mail: edi.piasentier@uniud.it

Key words: Zebu cattle, Beef quality and safety,
Production system, Central African Sub-region.

Acknowledgements: this research was motivated by the international collaboration between the Universities of Yaoundé I and Dschang, Cameroon and the University of Udine, Italy and was supported by the Regional Decentralised Cooperation programmes of Friuli Venezia Giulia region (Italy) (LR 19/2000), the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA), Yaoundé, and the Livestock Development Corporation (SODEPA), Yaoundé, Cameroon.

Received for publication: 19 September 2013.
Accepted for publication: 27 March 2014.

This work is licensed under a Creative Commons
Attribution NonCommercial 3.0 License (CC BY-
NC 3.0).

©Copyright B.M. Nfor *et al.*, 2014
Licensee PAGEPress, Italy
Italian Journal of Animal Science 2014; 13:3114
doi:10.4081/ijas.2014.3114

points scale (1=lean, 2=medium, 3=fat), corresponding to the three main conditions of the method described for *Bos indicus* cattle by Nicholson and Butterworth (1986). The presence of trauma on animals was evaluated visually and recorded, distinguishing from broken leg and body traumatisation. The results of the *ante-mortem* inspection, carried out by the official veterinarian service at the abattoir, were also recorded. Age of fetuses harvested from pregnant cows was estimated from *concepti* morphology and morphometry (Eley *et al.*, 1978).

Immediately after slaughter, the carcass weight (CW) was recorded. On the same day, the carcasses were graded for conformation and fatness according to a five point scale (EU Regulation No 1208/81, 1026/91; European Commission, 1981, 1991). The lean colour was assessed on the pelvic region, on the exposed section of the *semimembranosus* muscles, and scored on a 1 to 3 scale (1=pink, 2=red, 3=dark red). Subcutaneous fat colour was scored on a 1-to-3 scale (1=white, 2=cream, 3=yellow). Details of partial or whole carcass condemnation were recorded. After chilling at 4°C for 24 h, the ultimate pH was measured by

a glass piercing electrode connected to a pH-meter (HI 8484; Hanna Instruments, Woonsocket, RI, USA) inserted into *longissimus thoracis* muscle. From all the animals considered, 60 were selected from Gudali (GU; n=19), White Fulani (WF; n=20) and Red Mbororo (RM; n=21) breeds, in order to assess the breed effect on beef quality within the most important category of slaughtered animals, *i.e.* zebu bulls of 3 to 5 years old. As recorded at slaughtering time, these bulls were raised on natural pasture. After chilling at 4°C for 24 h, from the left side of carcass, a sample of approximately 400 g of *m. longissimusthoracis* was taken, by cutting a 3-cm thick steak from the section dividing the thoracic and lumbar parts of the muscle, *i.e.* between the 12th and 13th rib. The sample was vacuum-packed, aged for a week at refrigeration temperature and then frozen and stored at -20°C, for further measurements and analysis. The proximate analysis of meat was performed following AOAC (2000) procedures. All the samples were then processed after thawing at refrigeration temperature. Colour was evaluated, according to CIE L*, a*, b* colour system, after a 1-hour blooming period at 4°C, by a Minolta CM-2600d spectrophotometer (Minolta, Tokyo, Japan) with D65 as light source. Then, cooking loss was measured in a 75°C-water bath for 45 min (Spanghero *et al.*, 2004) and shear force was measured on the cooked sample, using a Warner-Bratzler device (WBSF), with a triangular hole in the shear blade, mounted on a Lloyd TAPlus texture analyser (ELIS Electronic Instruments & Systems S.r.l., Rome, Italy). The measurement was recorded as the peak yield

force in N, required to shear, at a 100 mm/min crosshead speed, perpendicular to the direction of the fibres, three cylindrical cross-section replicates, 10 mm diameter × 30 mm length, from each sample.

Statistical analysis

The normality of the data distribution was tested using the Kolmogorov-Smirnov test. Contingency tables with chi-square analysis were used to compare frequencies of production systems and agro-ecological zone (AEZ), and to compare frequencies of animal category and genetic type. The effect of the production systems on BCS and carcass characteristics of bulls was carried out using Kruskal-Wallis test, pair-wise comparisons were performed according to Mann-Whitney U test with Bonferroni adjustment. The trends of CW for bulls and cows along month of the year were studied considering breed as block, and animals' age within sex as covariate. The effect of breed and animal category, treated as fixed effects, was studied: i) on CW, using a two way ANOVA design, with Tukey-Kramer test for unequal sample size as *post-hoc* test; and ii) on the other carcass characteristics and BCS, using the Scheirer-Ray-Hare test for non-parametric data, with the non-parametric Mann-Whitney U-test and Bonferroni adjustment as *post-hoc* test. Interaction between breed and animal category was considered, but the P values were not reported in Tables because they were not significant. Means of transport, days of travel, sex, breed and carcass condition (normal, *i.e.* healthy animals, trauma or condemned and with both condemnation and trauma) were separately treated as fixed factors for

testing their effect on pH₂₄ of carcasses in one way ANOVA model. The effect of breed on WBSF, cooking loss, colour and chemical composition of *m. longissimus thoracis* was assessed by one-way ANOVA with breed treated as fixed factor. Tukey-Kramer test for unequal sample size was used as *post-hoc* test. Rho Spearman coefficients were used to determine associations between variables.

Results and discussion

Cattle origin and production system

Most of the cattle came from the Guinean High Savannah AEZ, comprising the Adamawa and East regions, followed by the Centre and South regions in the humid forest ecological zone, then the West and North West regions of the Western High plateau zone and finally from the North and Far North regions in the Sudano-Sahelian zone (Table 1). The cattle proportion recorded from Sudano-Sahelian was much smaller than that indicated by Pamo (2008), who reported that cattle in Cameroon are mainly reared in the Guinea high savannah (40%) and Sudano-Sahelian (38%) zones, because of favourable conditions of herbage availability for animals or limited proliferation of disease such as trypanosomiasis. Considering that the Sudano-Sahelian is the farthest geo-climatic zone from the slaughterhouse of Yaoundé, it could be hypothesised that beef produced in the northern regions is mainly consumed within that zone. Moreover, it is also possible that some of the animals that

Table 1. Cattle distribution by agro-ecological origin and production system.

AEZ	Production system				Total cattle
	Sedentary	Transhumance	Nomadism	Ranching	
Guinea high savannah					
Cattle, n	26	1121	2	307	1456
Within AEZ, %	1.8	77.0	0.1	21.1	74.6
Western high plateau					
Cattle, n	61	17	0	15	93
Within AEZ, %	65.6	18.3	0.0	16.1	4.8
Humid forests					
Cattle, n	49	326	11	7	393
Within AEZ, %	12.5	83.0	2.8	1.8	20.1
Sudano-Sahelian					
Cattle, n	0	10	1	0	11
Within AEZ, %	0.0	90.9	9.1	0.0	0.6
Total					
Cattle, n	136	1474	14	329	1953
Production system, %	7.0	75.5	0.7	16.8	100.0

AEZ, agro-ecological zone. Pearson Chi-square=689.35; DF=9; P=0.000.

left Ngaoundere by train may have been of Sahelian origin. It is also interesting to stress the contribution of humid forest zone, probably linked to an increased cattle breeding activity due to climate change and the interest of some elites within this region in developing animal husbandry. In agreement with the reports by Pamo (2008), transhumance was the predominant farming system within each AEZ, with the exception of Western High plateau where the sedentary system is most practiced. Transhumance is characterised by the organised displacement of cattle herds during the dry season, while in ranching cattle herds are kept permanently on demarcated and rationally exploited fields throughout the year. Our findings indicate that nomadism characterised by haphazard and continuous movement of cattle are almost extinct (Table 1).

The 99.2% of cattle studied were zebus, belonging to three main breeds: 45.6% GU, 33.3% WF and 20.3% RM. Pamo (2008) reported that 99% of cattle reared in Cameroon are zebus, 65% of which are GU. Ibeagha-Awemu and Erhardt (2006) reported that 55-65% of the total cattle populations in Cameroon and Nigeria belong to RM and WF. These breeds are fattened essentially for beef, however, the WF is also important for the provision of milk. The frequency of the different animal categories was as follows: 60% bull, 24.6% cows, 13.5% castrated, 1.9% heifers. Within each breed, the category with the highest frequency was bulls ($P < 0.01$). As expected, cows were the oldest (6.4 years on average; $P < 0.05$), and heifers the youngest (4.2 years on average; $P < 0.05$), while bulls (4.7 years) and castrated males (5.4 years) had intermediate age.

Carcass and meat characteristics

The effect of production system on carcass characteristics of animals (Table 2) was analysed using only the bull category of GU population. This category was chosen because it was the most frequent at slaughter and it was adequately represented in the most important production systems. Transhumant bulls were the oldest in age and showed the highest CW at slaughter ($P < 0.05$). Ranching bulls showed the lowest BCS ($P < 0.05$) and the highest subcutaneous fat colour score ($P < 0.05$), corresponding to the highest yellow tendency. Sedentary bulls had the highest conformation ($P < 0.05$) and fatness score ($P < 0.05$), but the lowest subcutaneous fat colour score (white colour tendency; $P < 0.05$). Röhrle et al. (2011) reported a less yellow colour of adipose tissue in bulls given supplements than in forage only fed bulls, due to the high β -carotene content of forage. The use of feed supplements is com-

mon in the sedentary production system. The use of supplements and reduced physical activity (such as trekking) and consequently the higher energy available to bulls, could explain why the highest fatness score was observed in sedentary bulls.

In Figure 1 the annual evolution of CW in relation to the significant effect of cattle sex ($P < 0.05$) is showed. The month of year greatly influences CW ($P < 0.05$). The trends of CW were similar for bulls and cows. They increased from March to September and decreased from September to March. These results are in agreement with the study of Deffo et al. (2011) working in the Adamawa region of Cameroon. These authors identified the presence of a critical period in cattle production from December to April, during which they recorded an average loss in animals' body weight of 13.3 kg/month due to the poor quality of forage. This period coincides with the dry season (from November to March) in Cameroon.

Breed had only a limited effect on the carcass characteristics of cattle (data not tabulated). However, GU tended to produce the fattest carcasses (2.2 vs 2.0 point; $P = 0.07$) and showed the highest carcass conformation (2.0 vs 1.9 point; $P < 0.05$). The CW mean values

ranged between 152 kg for GU and 158 kg for WF, and these were not statistically different from each other ($P > 0.05$). The effect of animal category on BCS and carcass characteristics is reported in Table 3. Body condition score was highest in castrated males and lowest in cows ($P < 0.05$). Carcass weight was highest in castrated males and lowest in heifers and cows ($P < 0.05$), but heifers had the least average weight. Cows had the lowest carcass conformation score ($P < 0.05$), while castrates had the best ($P < 0.05$). Considering fatness score, heifers showed the highest value, bulls the lowest, while castrates and cows had intermediate scores ($P < 0.05$). Bulls recorded the lowest subcutaneous fat colour score ($P < 0.01$). In a similar study, Park et al. (2002) reported a yellower fat colour in cows than in bulls. Across breeds and animal categories, there was a positive significant correlation between BCS and carcass fatness ($r = 0.451$; $P < 0.01$) and between fatness and subcutaneous fat colour ($r = 0.183$; $P < 0.01$; data not tabulated).

The chemical composition of meat is showed in Table 4. The meat produced by GU had higher protein content than those produced by WF and RM breeds. However, this difference was relatively low from a quantitative point of view. Considering both *Bos taurus* and

Table 2. Influence of production system on body condition score and carcass characteristics of Gudali bulls.

	Sedentary (n=29)	Transhumance (n=410)	Ranching (n=115)	SEM
Age, years	4.0 ^b	4.4 ^a	4.1 ^b	0.078
BCS ^o	1.9 ^a	1.9 ^a	1.6 ^b	0.049
CW, kg	141 ^b	161 ^a	143 ^b	2.64
Carcass conformation [#]	2.3 ^a	2.0 ^b	1.8 ^b	0.068
Fatness ^s	2.4 ^a	2.0 ^b	1.8 ^b	0.058
Subcutaneous fat colour [^]	1.5 ^c	1.8 ^b	2.1 ^a	0.048

BCS, body condition score; CW, carcass weight. ^o1=lean, 2=medium, 3=fat; ^s5=excellent, ..., 1=poor; ¹1=very lean, ..., 5=very fat; [^]1=white, 2=cream, 3=yellow. [#]Means within the same row with different superscript letters differ significantly at $P \leq 0.05$.

Table 3. Effect of animal category on body condition score and carcass characteristics of 1924 not nomadic cattle belonging to the three main zebu breeds.

	Bull (n=1155)	Castrate male (n=262)	Heifer (n=34)	Cow (n=473)	SEM
BCS ^o	1.8 ^b	2.4 ^a	1.7 ^{bc}	1.5 ^c	0.033
CW, kg	158 ^b	194 ^a	131 ^c	138 ^c	1.8
Carcass conformation [#]	1.9 ^b	2.2 ^a	2.1 ^{ab}	1.7 ^c	0.041
Lean colour ^s	2.2	2.2	2.1	2.2	0.020
Fatness [^]	1.9 ^d	2.1 ^b	2.4 ^a	2.0 ^c	0.037
Subcutaneous fat colour ^s	1.8 ^b	2.5 ^a	2.4 ^a	2.5 ^a	0.034

BCS, body condition score; CW, carcass weight. ^o1=lean, 2=medium, 3=fat; ^s5=excellent, ..., 1=poor; ¹1=pink, 2=red, 3=dark red; [^]1=very lean, ..., 5=very fat; ¹1=white, 2=cream, 3=yellow. [#]Means within the same row with different superscript letters differ significantly at $P \leq 0.05$.

Bos indicus animals, Bressan *et al.* (2011) showed an effect of diet, pasture *vs* grain supplementation, but not of breed on protein content of beef. However the average protein content of beef (21.8%) was similar to the values previously reported by many other authors in *Bos taurus* breeds (Maher *et al.*, 2004; Bureš *et al.*, 2006; Piasentier *et al.*, 2009; Corazzin *et al.*, 2012). Effect of breed on fat content of beef was not statistically significant. The average fat content of beef (1.2%) fell below the range recommended by Savell and Cross (1988) and reported by Zorzi, *et al.* (2013) (more than 3 to 4%) able to ensure acceptable palatability of beef. The low values recorded in our study probably reflected the feeding condition with particular regards to the low energy provided to animals by the natural pasture. The ash content of beef was similar among breeds. Our results are in agreement with the study of Do Prado *et al.* (2009), who concluded that ash content vary slightly according to breed. Beef produced by GU bulls was tougher than the other two breeds ($P < 0.05$; Table 4). The average Warner Braztler Shear Force was 86.1 N. Fakolade (2012) found lower shear force in GU than WF meat; however, in that study GU meat showed a higher fat content than WF beef, a condition that could contribute to explain the different results of our study (Christensen *et al.*, 2011). A breed effect for cooking loss was not found ($P > 0.05$; Table 4). Conversely, Cuvelier *et al.* (2006) found that cooking loss of meat are highly related to breed because of different water and collagen content of meat and fibre types of muscle. However, the average value recorded in this study (38.3%) was outside the range reported by Muchenje *et al.* (2009), *i.e.* 13.1 to 34.5%, likely because of the cooking method and the freeze storage. Gudali showed darker (L^*) meat than WF ($P < 0.05$; Table 4). A breed effect on L^* parameter was found in agreement with King *et al.* (2010), who found differences in L^* , but not in a^* and b^* in the meat of different breeds.

Influence of animal welfare on carcass pH₂₄

In order to ensure meat of good quality, animal welfare should be guaranteed so that glycogen depletion is minimal prior to slaughter. Mullen and Troy (2005) suggested that meat in the pH range 5.4 to 5.6 has the most desirable properties for table cuts, although an ultimate pH value up to 5.87 is accepted as a reasonable threshold for good quality carcasses (Page *et al.*, 2001). In our studies, the average pH₂₄ was 5.68 in healthy animals. Beef samples with values greater than 5.80 made up 28% of the total sampled population. These

results indicate that about a quarter of all the animals were stressed up prior to slaughter.

The cattle were transported by: train (59.6%), truck (39.0%), and only 1.4% trekked to Yaoundé for slaughter. The duration of travel varied greatly from 24 h to 6 days (average value=48 h) thus many animals were likely stressed with a depletion of their glycogen reserves, which can explain the relatively high proportion of high pH₂₄ values recorded. Indeed Gallo (2008) reported that a travel duration of 24 h, compared to 3 h, is able to increase by 5.4 times the probability of having a pH₂₄ value of meat higher than 5.80. Before slaughter, animals were given an average peri-

od of lairage of 24 h (min. less than 1 h, max. 20 days) in which they grazed on natural pasture near the slaughterhouse. Marenčić *et al.* (2012) suggested that a lairage period is beneficial for cattle after a long journey because, during this period, they are able to partly recover the glycogen reserve. In our study, the 24 h lairage period did not seem sufficient to reduce the pH₂₄ of meat. However, Liotta *et al.* (2007) showed that a period of lairage over 36 h was not beneficial for cattle welfare, and that conversely it increased the pH of beef.

Healthy carcasses with no trauma had the lowest pH₂₄ value (5.68), carcasses with both condemned tissues and trauma presented the

Table 4. Estimated marginal means of the main characteristics of *m. longissimus thoracis* as affected by breed.

	GU (n=19)	WF (n=20)	RM (n=21)	SEM
Warner-Bratzler shear force, N	112.1 ^a	72.3 ^b	78.4 ^b	4.56
Cooking loss, %	38.3	38.9	37.9	0.40
Colour				
Lightness, L*	27.7 ^a	31.3 ^b	29.4 ^{ab}	0.54
Redness, a*	7.7	7.3	6.6	0.20
Yellowness, b*	12.1	11.5	11.6	0.38
Chemical composition, %				
Moisture	74.9	75.5	75.8	0.17
Protein	22.1 ^a	21.5 ^b	21.6 ^b	0.10
Fat	1.1	1.4	0.9	0.11
Ash	1.2	1.2	1.2	0.01

GU, Gudali; WF, White Fulani; RM, Red Mbororo. ^{ab}Means within the same row with different superscript letters differ significantly at $P \leq 0.05$.

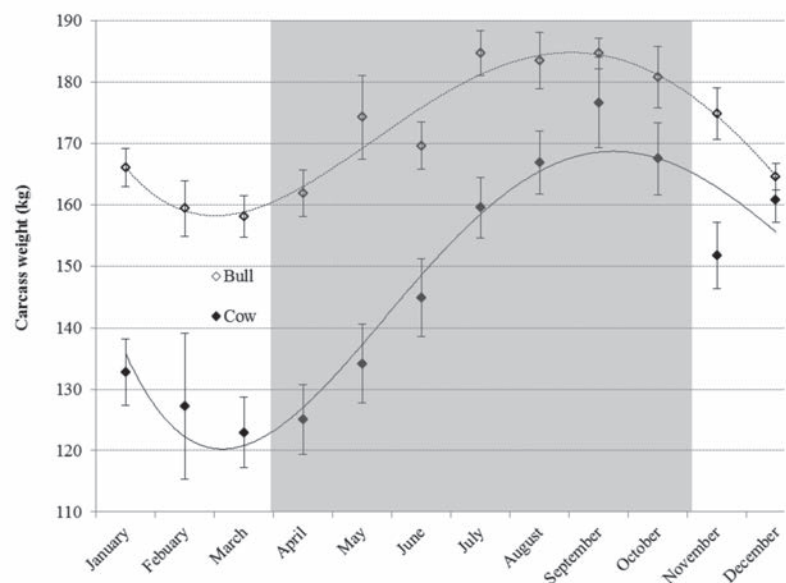


Figure 1. Annual evolution of the carcass weight in relationship to cattle gender. The raining season is represented by the grey area (least square means and standard error of means).

highest pH₂₄ values (5.89), while carcasses with trauma or with condemned tissues had an intermediate value (5.77; P<0.05; data not tabulated). The effect of animals' trauma and carcass condemnation on pH₂₄ is explained by stress conditions of the animals which could be due to many factors such as inappropriate handling, transport, diseases, injuries (Ferguson and Warner, 2008).

Pathological condition of cattle

Of the cows studied, 27% (143 cows) were found to be pregnant. The period of pregnancy ranged from 1 to 9 months. The highest number of foetus was harvested from cows with a pregnancy age between 1 and 3 months (73.7%). Similar results were obtained in Nigeria by Raji et al. (2010). This could be due to inadequate management of the herd. Moreover poverty of the breeders could force them to sell pregnant cows in exchange for emergency revenue for the family. The slaughtering of pregnant cows represents huge economic losses for the cattle sector and for the country in general.

Table 5. Abnormal conditions encountered at ante-mortem inspection.

Abnormal conditions	Affected cattle	
	n	%
Emaciation	32	1.64
Fungal like skin lesion	61	3.12
Ectoparasites	94	4.81
Nodular lesions	33	1.69
Respiratory distress	36	1.84
Enlarged lymph nodes	49	2.51
Lameness	76	3.89
Fatigue	84	4.30
Trauma	154	7.89

Table 6. Pathological conditions and the proportion of organ condemnation encountered at post-mortem evaluation.

Organ	Cause for condemnation	Condemned organs	
		n	%
Liver	Fascioliasis	101	5.17
	Cirrhosis	16	0.82
	Abscess	20	1.02
	Total	137	7.01
Lungs	Tuberculosis	64	3.28
	Abscess	25	1.28
	Total	89	4.56
Carcass	Tuberculosis	19	0.97
Heart	Pericarditis	12	0.61
Lymph node	Abscess	41	2.10
G I T parasites	Endo parasites	121	6.20
Head	Actinomycosis	1	0.05
Total		420	21.51

Tables 5 and 6 summarise the results of ante-mortem inspection and post-mortem organ evaluation, respectively. More than 20% of the carcasses had some organs condemned, and among them 1.0% of the carcasses was completely condemned due to tuberculosis. The main organs condemned were liver and lungs. The main reasons for condemnation of liver were the presence of fascioliasis abscesses and cirrhosis. Raji et al. (2010) recorded a higher liver condemnation rate of 10.4% due to cirrhosis at the Zaria abattoir in Nigeria. Liver flukes (*Fasciola gigantica*) are of public health importance due to their ability to cause clinical diseases in humans (Ibironke and Fasina, 2010). The prevalence of liver flukes is an indication of the lack of a routine de-worming practice by livestock farmers. Bovine tuberculosis was found in 64 lungs and 19 carcasses (4.25% of cattle as a total). Awah-Ndukum et al. (2010) revealed a detection rate of tuberculosis in cattle ranging from 0.18 to 4.25% in Cameroon. Considering the zoonotic nature of bovine tuberculosis, from a public health concern, it can present devastating health situations to the veterinary inspectors, the abattoir workers and beef consumers. This is particularly important because Fulani farmers, who are the main cattle owners (Pamo, 2008), tend to share the same water sources with their animals. The animals slaughtered with trauma were 7.89% of the total and 3.89% presented lameness. The most common pathological conditions encountered were: gastro-intestinal parasites (Cestodes and Nematodes), ectoparasites, fatigue, fungal-like lesions, nodular lesions and emaciation. A single case of Actinomycosis was found.

Conclusions

Records from carcass quality and meat inspection obtained at the main country abattoir give an interesting and updated snapshot of the cattle conditions, beef quality and security in Cameroon, which is the main actor and the only net agricultural exporter of Central African Sub-region. These data could aid authorities draw up programmes with the aim to strengthen cattle production, improve beef supply, control and prevent the observed diseases, and promote the regional trade. Cattle reared in sedentary system had the best carcass conformation and fatness; the results highlight the importance of supplementary feeding, especially during critical periods of the year. Further analysis should be addressed to study the effect of transport mean and duration as well as lairage period on cattle welfare and beef quality in tropical environmental conditions. Some of the diseases diagnosed at inspection were of public health or zoonotic importance such as tuberculosis and liver flukes. Moreover, a high proportion of cows were found pregnant, emphasising the importance of adequate herd management and a correct diagnosis of pregnancy to avoid foetal wastage.

References

Agritrade, 2013. Central Africa: agricultural trade policy debates and developments. Available from: <http://agritrade.cta.int/Agriculture/Regions/ACP/Central-Africa>

AOAC, 2000. Official methods of analysis. 17th ed., Association of Official Analytical Chemists, Gaithersburg, MD, USA.

Alawa, C.B.I., Etukudo-Joseph, I., Alawa, J.N., 2011. A 6-year survey of pathological conditions of slaughtered animals at Zango abattoir in Zaria, Kaduna State, Nigeria. Trop. Anim. Health Pro. 43:127-131.

Awah-Ndukum, J., Kudi, A.C., Bradley, G., Ane-Anyangwe, I.N., Fon-Tebung, S., Tchoumboue, J., 2010. Prevalence of bovine tuberculosis in abattoirs of the Littoral and Western Highland regions of Cameroon: a cause for public health concern. Vet. Med. Int. 2010:495015.

Bressan, M.C., Rodrigues, E.C., Rossato, L.V., Ramos, E.M., Da Gama, L.T., 2011. Physicochemical properties of meat from *Bos taurus* and *Bos indicus*. Rev. Bras. Zootecn. 40:1250-1259.

Bureš, D., Barto, L., Zahrádková, R., Teslík, V.,

- Krejová, M., 2006. Chemical composition, sensory characteristics, and fatty acid profile of muscle from Aberdeen Angus, Charolais, Simmental, and Hereford bulls. *Czech J. Anim. Sci.* 51:279-284.
- Christensen, M., Erbjerg, P., Failla, S., Sañudo, C., Richardson, R.I., Nute, G.R., Olleta, J.L., Panea, B., Albertí, P., Juárez, M., Hocquette, J.F., Williams, J.L., 2011. Relationship between collagen characteristics, lipid content and raw and cooked texture of meat from young bulls of fifteen European breeds. *Meat Sci.* 87:61-65.
- Corazzin, M., Bovolenta, S., Sepulcri, A., Piasentier, E., 2012. Effect of whole linseed addition on meat production and quality of Italian Simmental and Holstein young bulls. *Meat Sci.* 90:99-105.
- Cuvelier, C., Clingquart, A., Hocquette, J.F., Cabaraux, J.F., DufRASne, I., Istasse, L., Hornick, J.L., 2006. Comparison of composition and quality traits of meat from young finishing bulls from Belgian Blue, Limousin, and Aberdeen Angus breeds. *Meat Sci.* 74:522-531.
- Deffo, V., Pamo, E.T., Tchotsoua, M., Lieugong, M., Arene, C.J., Nwagbo, E.C., 2011. Determination of the critical period for cattle farming in Cameroon. Available from: http://academicjournals.org/article/article1379432605_Deffo%20et%20al.pdf
- Do Prado, I.N., De Oliveira, A.N., Rotta, P.R., Perotto, D., Do Prado, R.M., Silva, R.R., De Souza, N.E., Moletta, J.L., 2009. Chemical and fatty acid composition of Longissimus Muscle of crossbred bulls finished in feedlot. *Asian Austral. J. Anim.* 22:1054-1059.
- Eley, R.M., Thatcher, W.W., Bazer, F.W., Wilcox, C.J., Becker, R.B., Head, H.H., Adkinson, R.W., 1978. Development of the conceptus in the bovine. *J. Dairy Sci.* 61:467-473.
- European Commission, 1981. Council Regulation of 28 April 1981 determining the Community scale for the classification of carcasses of adult bovine animals, 1208/81/EEC. In: *Official Journal*, L 214, 07/05/1981.
- European Commission, 1991. Council Regulation of 22 April 1991 amending Regulation (EEC) No 1208/81 determining the Community scale for the classification of carcasses of adult bovine animals, 1026/91/EEC. In: *Official Journal*, L 106, 26/04/1991.
- Fakolade, P.O., 2012. Proximate composition of "Kundi", a Nigeria meat product from camel meat compared with "Kundi", made from 3 breed of cattle. Available from: [http://www.inacj.com/attachments/section/17/Temp%20October%202011-437%20Fakolade%20%20C%20P%20\(923-927\).pdf](http://www.inacj.com/attachments/section/17/Temp%20October%202011-437%20Fakolade%20%20C%20P%20(923-927).pdf)
- Ferguson, D.M., Warner, R.D., 2008. Have we underestimated the impact of pre-slaughter stress on meat quality in ruminants? *Meat Sci.* 80:12-19.
- Gallo, C.B., 2008. Using scientific evidence to inform public policy on the long distance transportation of animals in South America. *Vet. Ital.* 44:113-120.
- Ibeagha-Awemu, M.E., Erhardt, G., 2006. An evaluation of genetic diversity indices of the Red Bororo and White Fulani cattle breeds with different molecular markers and their implications for current and future options. *Trop. Anim. Health Pro.* 38:431-441.
- Ibironke, A.A., Fasina, F.O., 2010. Socio-economic implications of bovine liver rejection in a major abattoir in South-Western Nigeria. Available from: <http://www.scielo.oces.mctes.pt/pdf/rca/v33n2/v33n2a18.pdf>
- King, D.A., Shackelford, S.D., Kuehn, L.A., Kemp, C.M., Rodriguez, A.B., Thallman, R.M., Wheeler, T.L., 2010. Contribution of genetic influences to animal-to-animal variation in myoglobin content and beef lean colour stability. *J. Anim. Sci.* 88:1160-1167.
- Liotta, L., Nanni Costa, L., Chiofalo, B., Ravarotto, L., Chiofalo, V., 2007. Effects of lairage time on same blood constituents and on beef quality of bulls after long journey. *Ital. J. Anim. Sci.* 6:375-384.
- Livestock Data Innovation in Africa Project, 2013. Investing in African livestock: business opportunities in 2030-2050. Available from: <http://www.fao.org/docrep/018/al757e/al757e.pdf>
- Maher, S.C., Mullen, A.M., Keane, M.G., Buckley D.J., Kerry, J.P., Moloney, A.P., 2004. Variation in the eating quality of M. longissimus dorsi from Holstein-Friesian bulls and steers of New Zealand and European/American descent, and Belgian Blue x Holstein-Friesians, slaughtered at two weights. *Livest. Prod. Sci.* 90:271-277.
- Marenčić, D., Ivankovi, A., Pinti, V., Ugarkovi, N.K., Jakopovi, T., 2012. Effect of pre-slaughter rest period on some physicochemical properties of Simmental beef. Available from: http://www.agronomsko.hr/casopisi/stocarstvo/2012/Stocarstvo_4_2012_str_253_262.pdf
- Mellau, B.L., Nonga, H.E., Karimuribo, E., 2011. Slaughter stock abattoir survey of carcasses and organ/offal condemnations in Arusha region, northern Tanzania. *Trop. Anim. Health Pro.* 43:857-864.
- Muchenje, V., Dzama, K., Chimonyo, M., Strydom, P.E., Hugo, A., Raats, J.G., 2009. Some biochemical aspects pertaining to beef eating quality and consumer health: a review. *Food Chem.* 112:279-289.
- Mullen, A.M., Troy, D.J., 2005. Current and emerging technologies for the predictions of meat quality. In: J.F. Hocquette and S. Gigli (eds.) *Indicators of beef and milk quality*. Wageningen Academic Publ., Wageningen, The Netherlands, pp 179-190.
- Nicholson, M.J., Butterworth, M.H., 1986. A guide to condition scoring of Zebu cattle. Available from: <http://www.fao.org/wairdocs/ILRI/x5496E/x5496e00.htm>
- Page, J.K., Wulf, D.M., Schwotzer, T.R., 2001. A survey of beef muscle colour and pH. *J. Anim. Sci.* 79:678-687.
- Pamo, E.T., 2008. Country pasture/forage resource profiles: Cameroon. Available from: <http://www.fao.org/ag/AGP/AGPC/doc/counprof/PDF%20files/Cameroon.pdf>
- Park, G.B., Moon, S.S., Ko, Y.D., Ha, J.K., Lee, J.G., Chang, H.H., Joo, S.T., 2002. Influence of slaughter weight and sex on yield and quality grades of Hanwoo (Korean native cattle) carcasses. *J. Anim. Sci.* 80:129-136.
- Piasentier, E., Bovolenta, S., Moiola, B., Orrù, L., Valusso, R., Corazzin, M., 2009. Fatty acid composition and sensory properties of Italian Simmental beef as affected by genes frequency of Montbéliarde origin. *Meat Sci.* 83:543-550.
- Raji, M.A., Salami, S.O., Ameh, J.A., 2010. Pathological conditions and lesions observed in slaughtered cattle in Zaria abattoir. *J. Clin. Pathol.* 1:9-12.
- Röhrle, F.T., Moloney, A.P., Osorio, M.T., Luciano, G., Priolo, A., Caplan, P., Monahan, F.J., 2011. Carotenoid, color and reflectance measurements in bovine adipose tissue to discriminate between beef from different feeding systems. *Meat Sci.* 88:347-353.
- Savell, J.W., Cross, H.R., 1988. The role of fat in the palatability of beef, pork, and lamb. *Designing foods: animal product options in the marketplace*. National Academy Press, Washington, DC, USA.
- Spanghero, M., Gracco, L., Valusso, R., Piasentier, E., 2004. In vivo performance, slaughtering traits and meat quality of bovine (Italian Simmental) and buffalo (Italian Mediterranean) bulls. *Livest. Prod. Sci.* 91:129-141.
- Zorzi, K., Bonilha, S.F.M., Queiroz, A.C., Branco, R.H., Sobrinho, T.L., Duarte, M.S., 2013. Meat quality of young Nelore bulls with low and high residual feed intake. *Meat Sci.* 93:593-599.

Copyright of Italian Journal of Animal Science is the property of PAGEPress and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.