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EVALUATION OF CARCASS TRAITS OF LAGUNAIRE, BORGOU AND ZEBU FULANI BULLS RAISED ON NATURAL PASTURE IN BENIN

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ABSTRACT

In Benin, there is no assessment related to the body composition of native bovine breeds in spite of the requirements of butchers and consumers. This study aimed at evaluating Benin indigenous cattle carcass characteristics raised on pasture and slaughtered in the abattoir of Cotonou-Porto-Novo at 5 years old. Carcass characteristics, carcass conformation, carcass degree of fat cover and rib segment composition were collected on 40 Lagunaire, 71 Borgou and 110 Zebu Fulani bulls. The carcass traits of the Zebu bulls were significantly higher than those of the Borgou bulls ($P<0.001$) while the lowest performance was obtained in Lagunaire bulls ($P<0.001$). Heavier carcass, a higher dressing percentage and empty dressing percentage were recorded in bulls slaughtered in the rainy season than those in the dry season ($P<0.05$). Zebu Fulani carcasses were characterized by their higher dressing percentage, an important rib muscle thickness, a low fat cover and a weak carcass fat percentage while Borgou carcasses were characterized by a high carcass fat percentage and a good carcass conformation. However, Lagunaire carcasses were characterized by a low fat cover and a weak carcass fat percentage, a poor carcass conformation and a high proportion of bone.

Key words: Carcass, conformation, fat cover, season, breed, bull, Benin.

INTRODUCTION

In Benin, the national meat production in 2011 was 61,646 tons of carcass weight equivalent and beef was the most important (56.75%), followed by chickens (18.94%), sheep and goats (7.46%), pork (7.46%) and finally, rabbits and grasscutter (4.05%) (CountryStat, 2012). The beef production is mainly provided by the national cattle composed of a genetic diversity of breeds including the Lagunaire, the Somba, the Borgou and the Zebu cattle, primarily, the Zebu Fulani, the White Fulani and the Red M'Bororo. Benin horned cattle population was estimated at 2,058,000 heads in 2011, including 51% of Borgou breed, 26% of Zebu cattle, 5% of Lagunaire and 3% of Somba breeds, the remainder being constituted by crossbred obtained from various crossings (DE, 2011). Borgou and Zebu Fulani breeds are the most slaughtered in Benin's main slaughterhouses while Lagunaire breed is more slaughtered in the butcheries of Southern Benin, especially during of ceremonies. The Somba breed, however, is threatened with extinction and localized in Boukoumbé area in the Northeast of Benin (Moazami-Goudarzi *et al.*, 2001). In Benin, development projects focused their activities on the control of major diseases, fodder availability and concentrate feed (Djenontin *et al.,* 2009, Zoffoun *et al.*, 2011a), the creation of waterholes (dams), transhumance management, veterinary prophylaxis and animal genetic improvement (Koudandé *et al.,* 2008, MAEP, 2011). At the same time, much research was carried out on disease control, including tick eradication and tick-borne diseases (Farougou *et al.,* 2006a, Farougou *et al.,* 2007, Zoffoun *et al.,* 2011b, Farougou *et al.,* 2012), bovine tuberculosis (Farougou *et al.,* 2006b), foot and mouth disease (Houndjê *et al.,* 2010), bovine trypanosomiasis (Doko Allou *et al.,* 2010), and bovine brucellosis (Koutinhouin *et al.,* 2003).

Much research was also carried out in order to improve the reproduction and the production performance of Benin's native cattle (Youssao *et al.,* 2007, Koudandé *et al.,* 2008, Youssao *et al.,* 2009, Koutinhouin *et al.,* 2009, Koutinhouin *et al.,* 2010). The results of these research and development actions have boosted the national horned cattle population to 1,540,647 heads in 2000. The increase in the cattle population did not reduce their sale price. For example, in 1993, Borgou cows were sold at 35,000 F CFA, the bulls at 50,000 F CFA and the steers at 20,000 F CFA in Northern Benin (Dehoux et Housounvê, 1993). Currently, the Borgou bull is sold between 201,667 and 285,798 F CFA and the cow between 125,416 and 197,955 F CFA in the same area (Youssao *et al.,* 2012).

If breeders take advantage of this system, the other actors of the meat sector, including butchers and consumers would not be favored. Thus, in Benin the meat sector must be organized because slaughtered animals are

sold on the basis of visual assessments of body conformation which are subjective, and slaughter animals are not weighed before selling. Moreover, at slaughter, price per kilogram of meat varies from area to area and is not related to the carcass quality, the carcass cuts value, the meat quality, etc. For example, there is no difference in price between a culled cow carcass and that of a young fattened steer just as viscera and *Longissimus dorsi* muscle do not differ in terms of price. These practices don't favor butchers and consumers because many variable factors could affect the body composition of slaughtered animals. For example, carcass composition and quality are influenced by several factors such as the breed, the weight at slaughter, the average daily gain during the fattening period, the slaughter season, the carcass conformation and the level of fat cover (Renand *et al.,* 2002, Cartier and Moevi, 2007). In Benin, there is no assessment related to the body composition of native bovine breeds in spite of a demand from butchers and consumers. Therefore, this study aimed at providing data on the carcass characteristics of Benin indigenous horned cattle (Lagunaire, Borgou and Zebu Fulani) raised on natural pasture. The specific objectives were to: a) evaluate the bull carcass characteristics according to the breed and the slaughter season; (b) evaluate their conformation and their degree of fat cover by using the international standards; (c) establish the relationship between the carcass characteristics of each breed and all breeds combined.

MATERIALS AND METHODS

Areas of study: The slaughterhouse of Cotonou-Porto-Novo is located in Akpakpa (Commune of Cotonou) and covers 3.5 ha (between latitude 6°21' North and longitude 2°25' East). Slaughtering begins at 4:00 am and ends at 12:00 pm. The average number of cattle slaughtered is about 50 heads per day. The animals slaughtered in the slaughterhouse of Cotonou-Porto-Novo come from Alibori and Borgou Departments for Zebu Fulani and Borgou breeds. Lagunaire are rarely slaughtered in the abattoir of Cotonou-Porto-Novo. Those, which have been slaughtered for this survey, came from the Department of Zou.

The Alibori Department is located in the extreme north of Benin between 10°49' and 11.86°0' North latitude and 2°25' and 3°41' East longitude. It has 26242 km² with Sudano-Sahelian climate and vegetation types. The rainy season extends from May to September and the dry season, from November to April. The mean yearly rainfall varies between 700 and 1000 mm (Adam and Boko, 1993).

The Department of Borgou is located to the northeast of Benin between latitude 8°52' and 10°25' North and longitude 2°36' and 3°41' East and covers 25,856 km². This Department has a Sudanese type climate characterized by one dry season (November to May) and one rainy season (June to October) with a yearly rainfall varying from 900 to 1200 mm (Adam and Boko, 1993). As in the Department of Alibori, the harmattan blows from December to February.

The Department of Zou is located in the center of Benin and covers 5,243 km². The climate is of sub-equatorial type characterized by two rainy seasons: the great, from April to July, and the small, from September to November. These two seasons are slipped in between dry seasons. The average rainfall is about 1200 mm per year (Adam and Boko, 1993). Slaughtered animals come from this Department between latitude 6.65°26' and 7°10' North and longitude 2.25 ° 14' and 2°4' East.

Choice of animals: The animals were transported from their native Departments at least 48 h before slaughtering. Upon arrival, the animals were approved and rested and it was during this period that they were identified for this study. The selection criteria were based on the breed (Borgou, Zebu Fulani or Lagunaire), the age (5 years old and determined from their dental formula) and the livestock system (sedentary or transhumant, natural pasture-fed without supplementation). Data on livestock practices were also obtained from animals' owners. They were interviewed about the origin of their animals, the breed, the age at slaughter, the method of grazing practiced (natural or artificial) and dietary supplement used during fattening, the livestock system (transhumance or sedentary), etc. This interview permitted to confirm the type of breed and the age at slaughter of the previously selected animals. All of the bulls slaughtered in this study, were raised on natural pasture. In all, 71 Borgou bulls, 110 Zebu Fulani bulls and 40 Lagunaire bulls were slaughtered.

Slaughtering process: The selected animals were submitted to the *ante-mortem* inspection by a veterinary inspector before slaughtering. The slaughtering process was according to the methodology described by Salifou *et al.* (2012). The killing procedure involved the section of the jugular vein without stunning or anesthesia according to the Halal requirements. After complete bleeding, slaughtered animals were manually skinned. The head and feet were not skinned but chopped off and singed afterwards. After evisceration, the empty carcasses were split along the backbone into halves. The digestive tract was emptied of its contents and carefully cleaned. The head, the legs, the leather, the thoracic and abdominal viscera and the two half-carcasses were finally submitted to the *post-mortem* inspection. The slaughtering was carried out from September to October in the rainy season and from February to March in the dry season.

Data collection

Carcass characteristics: The slaughter weight was taken the day before slaughter using a mechanical balance of

1,500 kg capacity with a precision of 1.5 kg. After slaughtering, an electronic balance of 1,500 kg of capacity with a precision of 0.5 kg was used to weigh the hot carcass. Digestive tract (full and empty esophagus, stomach and intestines), offals (spleen, liver, lungs, kidneys, heart, head, leather, tail and legs), kidney fat, internal fat of carcass and offal fat were also weighed. The dressing percentage was then obtained by multiplying the ratio of the carcass weight and the slaughter weight by hundred while the empty dressing percentage was calculated by multiplying the ratio of the carcass weight and the slaughter weights without the stomach content by hundred (Ito *et al.,* 2012). The carcass fat was taken as the sum of kidneys fat weight and the carcass internal fat and offal fat weights. The percentage of the total carcass fat was the ratio of the carcass total fat weight and the hot carcass weight multiplied by hundred. Carcass length was measured from the centre of the first dorsal rib to the centre of the pubic symphysis. The thigh thickness was taken with a pelvimeter from inner side to the outer side of the thigh and from the top of an equilateral triangle whose base is the pubic symphysis. The same pelvimeter was used to measure the rib muscle thickness between the 7th and 8th rib in the middle of the distance between the backbone and the sternum. This measure represents the distance between internal and external rib faces.

Carcass quality: The carcass quality was determined at the end of the slaughter chain by determining two parameters such as the carcass conformation and its degree of fat cover accordingly to the Council Regulation N°1249/2008 of 10 December 2008 concerning the Community scale for the classification of carcasses of adult bovine. For the conformation, six classes (S, E, U, R, O and P) were considered on the basis of the development of carcass profiles, in particular the essential parts (round, back, shoulder). The classification was based on a scale varying from Excellent for S carcasses, to Poor for P carcasses. For the S class, all profiles were extremely convex (exceptional muscle development), while profiles of P class carcasses were extremely concave (poor muscle development). Regarding the carcass degree of fat cover, 5 classes (1, 2, 3, 4 and 5) were considered according to the amount of fat on the outside of the carcass and in the thoracic cavity. Carcasses classified as1 had low fat cover (no fat to low fat cover) and carcasses classified as 5 had very high fat cover (entire carcass covered with fat; heavy fat deposits in the thoracic cavity).

Rib segment composition: The composition of the rib segment was determined on 20 Zebu Fulani, 20 Borgou and 20 Lagunaire according to the procedure describe by Michaux *et al*. (1983) and Clinquart *et al.* (1998). For each slaughtered animal, the 6th rib was collected and weighed. The *Longissimus thoracis* muscle area was measured at the level corresponding to the intersection between the 6th and the 7th rib. The 6th rib segment was then dissected into muscle, fat, bone and waste. Then, all rib components were weighed separately and their proportion in the rib segment was calculated.

Statistical analysis: The Statistical Analysis System software (SAS, 2006) was used for data analysis. The factors of variation considered were the breed of slaughtered bull (Zebu Fulani, Borgou and Lagunaire) and season of slaughter (rainy season and dry season). Interaction between the breed and the season was significant and was taken into account in the model. The fixed linear model was adjusted to the slaughter weight and the carcass traits data. The mathematical expression of this model is as follows:

$$Y_{ijk} = \mu + B_i + SS_j + B^*SS_{ij} + e_{ijk}$$

Where:

Y_{ijk} is the slaughter weight or the carcass characteristic of the k-th animal of the i-th breed in the j-th slaughter season;

- μ is the overall mean ;
- B_i is the fixed effect of the breed i (Zebu Fulani, Borgou and Lagunaire);
- SS_j is the fixed effect of the slaughter season j (dry season and rainy season);
- B^*SS_{ij} is the interaction between the breed i and the slaughter season j;
- $e_{ijk}$is the residual error.

The data were analyzed according to General Linear Model procedure (GLM) of SAS (2006). The F test was used to determine the significance of each effect of the model then, the least squares means were estimated and compared by the Student test. The correlations between the different variables were determined by breed using *Proc corr* procedure of SAS (SAS, 2006). The frequencies of the conformation classes and the carcass degree of fat cover were calculated by *Proc Freq* procedure of SAS (2006). Chi-square test was used to determine the significance of each factor. The comparison of carcass conformation classes and carcass degree of fat frequency were made two by two by the bilateral Z test. Principal Components Analysis (PCA) of the carcass characteristics was carried out by the *Proc princompt* procedure of SAS (2006).

RESULTS

The carcass characteristics expressed in terms of least squares mean and standard errors are presented in Table 1.

Breed effect on carcass traits: Carcass characteristics varied between breeds (P<0.01). The slaughter weight, the hot carcass weight, the carcass length, the thigh thickness, the carcass fat, the rib muscle thickness, the

Longissimus thoracis area, the rib weight, the rib muscle, the rib segment waste, the internal carcass fat, the kidney fat of the Zebu bulls were significantly higher than those of the Borgou bulls ($P<0.001$) while the lowest performance were recorded in Lagunaire bulls ($P<0.001$). However, the rib fat, the rib bone and the rib fat percentage of Zebu bull were similar to those of the Borgou but they were significantly higher than those of the Lagunaire bull. No rib fat was observed in the Lagunaire bull carcass. However, the percentage of rib muscle of the Zebu Fulani was higher than that of the Lagunaire bull ($P<0.001$) while the percentage of the rib muscle of the Borgou cattle was not different from that of the other two breeds ($P>0.05$). Compared to the Borgou bull, the percentage of rib bone was higher than that of the Lagunaire bull ($P<0.05$) while the Zebu had a low rib bone percentage ($P<0.01$).

Season effect on carcass traits: The bull slaughter average weight was 262.8 kg in the rainy season and 254.8 kg in the dry season and were not significantly different ($P>0.05$). However, slaughtered bulls in the rainy season had a heavier carcass, a higher dressing percentage and a higher empty dressing percentage than those slaughtered in the dry season ($P<0.05$). The bulls slaughtered in the rainy season had also more thigh thickness, a thicker rib muscle, a higher *Longissimus thoracis* area and a more abundant rib fat than the bulls slaughtered in the dry season ($P<0.01$). Finally, the carcass length, the kidney fat, the carcass fat and the rib traits other than the rib fat of the bulls slaughtered were not different between slaughter seasons.

Interaction between breed and season effect: The interaction between breed and season was not significant for the slaughter weight, the hot carcass weight, the rib fat percentage, the kidney fat, the carcass length, the thigh thickness, the *Longissimus thoracis* area, the rib weight, the rib muscle, the rib bone, the rib segment waste, the rib muscle percentage, the rib bone percentage and the rib segment waste percentage (Table 2). However, the empty dressing percentage of the zebu bull in the rainy season was significantly higher ($P<0.001$) than that obtained during the dry season (64.84% *vs* 57.30%). The Borgou cattle carcasses were more fattened in the rainy season than in the dry season ($P<0.05$), in particular for the internal carcass fat (1.39 *vs* 1.03 kg) and the carcass fat (1.91 *vs* 1.66 kg). In the same way, the rib muscle was thicker ($P<0.05$) in the rainy season than in the dry season in the Borgou bull carcass (2.65 *vs* 2.42 cm). In the Zebu as in the Borgou cattle carcass, the rib fat was more abundant in the rainy season than in the dry season ($P<0.05$). With respect to the rib fat percentage, the Zebu bull was fatter ($P<0.05$) in the rainy season than in the dry season (9.87% *vs* 5.39%), whereas no difference was observed in the Borgou cattle (Table 2).

Relationship between carcass traits: Simple linear correlations between carcass traits are given by breeds in Tables 3, 4 and 5, respectively for Borgou, Lagunaire and Zebu Fulani bulls. The slaughter weight was highly correlated with the carcass weight, the thigh thickness, the rib muscle thickness, the carcass fat in the three horned cattle breeds ($P<0.01$) and their correlation coefficients varied from 0.363 to 0.846. Unlike Zebu Fulani, the slaughter weight was positively correlated with kidney fat in Lagunaire ($P<0.001$ and $r = 0.646$) and Borgou ($P<0.001$ and $r = 0,565$) breeds. The slaughter weight was not correlated significantly with the rib traits. On the other hand, the *Longissimus thoracis* area, the rib weight, the rib muscle, the rib fat, the rib bone, were highly and positively correlated to the slaughter weight.

The hot carcass weight was proportional to the rib fat percentage, the carcass length, the thigh thickness, the rib muscle thickness and the empty dressing percentage in the three breeds ($P<0.001$) with a coefficient of correlation varying between 0.325 and 0,829. Significant and positive correlations were only observed between slaughter weight and respectively the rib weight and the rib muscle weight in Borgou and Zebu bulls carcasses ($P<0.05$ and $0.596 < r < 0.862$). The carcass fat was positively associated with the dressing percentage in Lagunaire breed while it was near zero in Borgou and Zebu Fulani breeds. However, no relationship was observed between the empty dressing percentage and the carcass fat in each breed. The correlation between the rib fat and the carcass fat was significant in Borgou ($r = 0.641$) and the Zebu Fulani bulls ($r = 0.562$).

In Lagunaire breed, the correlation between rib muscle thickness and rib muscle quantity was significant ($P<0.01$ and $r = 0.564$) while it was near zero in other breeds. The correlations between rib muscle percentage and the carcass characteristics of the Lagunaire bull were very weak (table 2). However, the rib muscle percentage was negatively associated with the rib segment waste ($P<0.01$, $r =-0.840$) in Borgou breed and the rib weight in Zebu Fulani breed ($P<0.01$, $r = 0.751$). Overall, the rib fat percentage was not linked to the characteristics of the carcass.

Carcass conformation and carcass degree of fat cover: The classes of conformation observed were U, R, O and P. The frequency of carcasses conformation classes varied from breed to breed (Table 6). All Lagunaire carcasses were classified into P conformation, no carcass of Zebu was observed in this class and only 2.84% of the Borgou cattle carcasses were counted there. The frequency of U conformation was not significantly different ($P>0.05$) between Borgou (5.63%) and Zebu Fulani (13.64%) breeds. No significant difference was also observed between the frequency of R conformation ($P>0.05$) of the Borgou bull (5.63%) and Zebu Fulani

bull (13.64%) carcasses. The frequency of Zebu classified in R conformation (58.18%) was significantly higher than that of the Borgou (39.44%). Conversely, 52.11% of Borgou bulls were classified in O *versus* 28.18% for Zebu bulls (P<0.05).

Except the Lagunaire breed whose carcass was essentially classified in P conformation class whatever the year season, the carcass class conformation varied according to the year season for Zebu Fulani cattle (Figure 1) and Borgou (Figure 2). The frequency of U carcass conformation was higher (P<0.05) in rainy season (19.05%) than that of the dry season (6.38%), while more carcasses were classified in O conformation class during the dry season (P<0.05, 31.91% *vs* 15.40%). However, no significant difference was observed between the frequency of the R conformation carcass of the dry season (65.56%) and that of the rainy season (61.70%). The frequency of the U conformation carcass was low (5 to 5.88%) and didn't varied according to the season in Borgou bull. The Borgou were mostly classified into R conformation class during the rainy season (55.33% *vs* 33.00%) while during the dry season, the most dominant conformation class was O (P<0.05; 50% *vs* 34.86%). Finally, the frequency of the P carcass conformation was low and more observed (P<0.05) in dry season (12%) than in rainy season (3.92%) in the Borgou breed (Figure 2).

Regarding to the carcass degree of fat cover, all Lagunaire bulls carcasses were classified in low fat cover (group 1) while 91.55% of the Borgou bulls carcasses and 78.18% of zebu Fulani carcasses were classified in the same group. In this group, the difference between the frequencies of the Zebu Fulani and the Borgou or between the Zebu Fulani and the Lagunaire breeds was significant (P<0.05). The other carcasses had a slight fat cover and a visible flesh almost everywhere (group 2) in Borgou carcasses (8.45%) and in zebu Fulani carcasses (21.82%).

Table 1: Effect of slaughter season and breed on the carcass characteristics of cattle raised on natural pasture in Benin.

Variables	Breed						Season				Test of signifiance	
	Lagunaire		Borgou		Zebu Fulani		Rainy season		Dry season			
	Means	SE	Means	SE	Means	SE	Means	SE	Means	SE	Breed	Season
Slaughter weight (kg)	142.30^{c}	9.47	287.67^{b}	6.33	346.48^{a}	4.74	262.80^{a}	5.59	254.83^{a}	6.03	***	NS
Hot carcass weight (kg)	69.20^{c}	5.30	142.32^{b}	3.49	179.68^{a}	2.66	134.82^{a}	3.11	125.97^{b}	3.38	***	*
Dressing percentage (%)	48.59^{b}	0.93	49.35^{b}	0.62	51.95^{a}	0.46	50.73^{a}	0.55	49.16^{b}	0.59	***	*
Empty dressing percentage (%)	57.20^{b}	1.11	58.12^{b}	0.75	61.07^{a}	0.56	60.32^{a}	0.66	57.27^{b}	0.71	***	**
Internal fat of carcass (kg)	0.32^{c}	0.14	1.21^{b}	0.09	1.52^{a}	0.07	0.98^{a}	0.08	1.05^{a}	0.09	***	NS
Kidney fat (kg)	0.22^{c}	0.05	0.52^{b}	0.03	0.62^{a}	0.02	0.49^{a}	0.03	0.42^{a}	0.03	***	NS
Carcass fat (kg)	0.54^{c}	0.16	1.78^{b}	0.12	2.17^{a}	0.08	1.52^{a}	0.09	1.47^{a}	0.10	***	NS
Carcass fat (%)	0.78^{b}	0.09	1.25^{a}	0.07	1.22^{a}	0.05	1.06^{a}	0.05	1.10^{a}	0.06	***	NS
Carcass length (cm)	90.50^{c}	1.09	116.48^{b}	0.72	122.34^{a}	0.55	109.93^{a}	0.64	109.62^{a}	0.69	***	NS
Thigh thickness (cm)	12.90^{c}	0.38	17.61^{b}	0.25	19.54^{a}	0.19	17.15^{a}	0.22	16.21^{b}	0.24	***	**
Rib muscle thickness (cm)	2.34^{c}	0.09	2.54^{b}	0.06	2.85^{a}	0.05	2.71^{a}	0.06	2.44^{b}	0.06	***	**
Longissimus thoracis area (cm²)	33.57^{c}	2.71	47.13^{b}	2.71	56.07^{a}	2.76	47.18^{a}	2.15	44.01^{a}	2.30	***	NS
Rib weight (kg)	1.05^{c}	0.20	2.64^{b}	0.20	3.48^{a}	0.21	2.54^{a}	0.16	2.24^{a}	0.17	***	NS
Rib muscle (kg)	0.57^{c}	0.26	1.56^{b}	0.26	2.40^{a}	0.26	1.61^{a}	0.20	1.41^{a}	0.22	***	NS
Rib fat (kg)	0.0^{b}	0.03	0.19^{a}	0.03	0.27^{a}	0.03	0.19^{a}	0.02	0.11^{b}	0.03	***	*
Rib bone (kg)	0.27^{b}	0.03	0.57^{a}	0.03	0.57^{a}	0.03	0.49^{a}	0.02	0.45^{a}	0.02	***	NS
Rib segment waste (kg)	0.14^{c}	0.03	0.26^{b}	0.03	0.36^{a}	0.03	0.25^{a}	0.03	0.26^{a}	0.03	***	NS
Rib muscle (%)	54.04^{b}	3.93	57.44^{ab}	3.93	67.02^{a}	4.01	59.11^{a}	3.12	59.89^{a}	3.34	*	NS
Rib fat (%)	0^{b}	0.89	7.09^{a}	0.89	7.63^{a}	0.89	5.69^{a}	0.71	4.12^{a}	0.76	***	NS
Rib bone (%)	26.31^{a}	1.19	22.52^{b}	1.19	16.69^{c}	1.19	21.17^{a}	0.95	22.51^{a}	1.01	***	NS
Rib segment waste (%)	13.27^{a}	1.33	10.72^{a}	1.33	10.87^{a}	1.33	10.91^{a}	1.05	12.33a	1.13	NS	NS

*: P<0.05; **:P<0.01; ***:P<0.001, NS (non significant):P>0.05; S: standard error. The means between the classes of the same line followed by different letters differ significantly with the threshold of 5%.

Table 2: Effect of interaction between breeds and slaughter season on the carcass characteristics of cattle raised on natural pasture in Benin.

Variable	Lagunaire				Borgou				Zebu Fulani				Test of signifiance
	Rainy season		Dry season		Rainy season		Dry season		Rainy season		Dry season		
	Means	SE	Means	SE	Means	SE	Means	SE	Means	SE	Means	SE	
Slaughter weight (kg)	145.00^{c}	13.39	139.60^{c}	13.39	292.59^{b}	7.26	282.76^{b}	10.37	350.81^{a}	7.06	342.15^{a}	6.33	NS
Hot carcass weight (kg)	70.00^{c}	7.49	68.40^{c}	7.49	147.39^{b}	3.88	137.24^{b}	5.81	187.07^{a}	3.95	172.28^{a}	3.55	NS
Dressing percentage (%)	48.32^{b}	1.31	48.85^{b}	1.31	50.31^{b}	0.71	48.39^{b}	1.01	53.66^{a}	0.69	50.23b	0.62	NS
Empty dressing percentage (%)	57.01^{b}	1.57	57.41^{b}	1.57	59.13^{b}	0.86	57.11^{b}	1.22	64.84^{a}	0.83	57.30^{b}	0.74	***
Internal fat of carcass (kg)	0.36^{c}	0.19	0.28^{c}	0.19	1.03^{b}	0.12	1.39^{a}	0.15	1.56^{a}	0.10	1.48^{a}	0.09	*
Kidney fat (kg)	0.24^{a}	0.07	0.20^{a}	0.07	0.52^{b}	0.04	0.52^{b}	0.05	0.69^{b}	0.04	0.56^{b}	0.03	NS
Carcass fat (kg)	0.60^{d}	0.22	0.48^{d}	0.23	1.66^{c}	0.15	1.91^{b}	0.17	2.30^{a}	0.12	2.04^{b}	0.11	*
Carcass fat (%)	0.96^{bc}	0.13	0.71^{c}	0.13	1.09^{b}	0.09	1.40^{a}	0.10	1.24^{a}	0.07	1.19^{ab}	0.06	*
Carcass length (cm)	90.6^{c}	1.54	90.40^{c}	1.55	115.77^{b}	0.80	117.20^{b}	1.20	123.41^{a}	0.82	121.26^{a}	0.73	NS
Thigh thickness (cm)	13.30^{e}	0.54	12.50^{e}	0.54	18.04^{c}	0.28	17.18c^{d}	0.41	20.11^{a}	0.28	18.96^{b}	0.25	NS
Rib muscle thickness (cm)	2.58^{bc}	0.14	2.10^{c}	0.14	2.65^{b}	0.07	2.42^{c}	0.11	2.89^{a}	0.07	2.81^{a}	0.06	*
Longissimus thoracis area (cm²)	35.18^{a}	3.82	31.96^{a}	3.82	48.81^{b}	3.82	45.45^{b}	3.82	57.54^{c}	3.82	54.61^{c}	4.28	NS
Rib weight (kg)	1.15^{a}	0.29	0.96^{a}	0.29	2.83^{a}	0.29	2.44^{a}	0.29	3.63^{a}	0.29	3.32^{a}	0.32	NS
Rib muscle (kg)	0.60^{a}	0.34	0.53^{a}	0.34	1.66^{b}	0.34	1.46^{b}	0.34	2.57^{c}	0.34	2.23^{c}	0.41	NS
Rib fat (kg)	0,0^{d}	0.04	0.0^{d}	0.04	0.24^{b}	0.04	0.17^{c}	0.04	0.36^{a}	0.04	0.10	0.05	*
Rib bone(kg)	0.27	0.04	0.27	0.04	0.59	0.04	0.56	0.04	0.61	0.04	0.53	0.04	NS
Rib segment waste (kg)	0.14	0.05	0.14	0.05	0.27	0.05	0.26	0.05	0.35	0.05	0.38	0.05	NS
Rib muscle (%)	53.73	5.56	54.36	5.56	56.19	5.56	58.69	5.56	67.40	5.56	66.63	6.22	NS
Rib fat (%)	0,0^{d}	1.27	0,0d	1.27	7.22^{b}	1.27	6.97^{bc}	1.27	9.87^{a}	1.27	5.39^{c}	1.27	*
Rib bone (%)	24.35^{a}	1.68	28.26^{a}	1.68	21.91^{b}	1.68	23.14^{b}	1.68	17.26^{c}	1.68	16.12^{c}	1.88	NS
Rib segment waste (%)	12.27^{a}	1.88	14.27^{a}	1.88	10.49^{a}	1.88	10.95^{a}	1.88	9.96^{a}	1.88	11.78^{a}	2.10	NS

*:P<0.05;**: P<0.01; ***: P<0.001, NS (non significant):P>0.05; SE: standard error. The means between the classes of the same line followed by different letters differ significantly with the threshold of 5%.

Table 3: Relationship between carcass characteristics of Borgou cattle raised on natural pasture in Benin.

	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP	LTA	RW	RM	RF	RB	RSW	RMP	RFP	RBP	RSWP
SWT	0.257*	0.565***	0.363**	0.022	0.846***	-0.041	0.695***	0.527***	0.379***	-0.013	0.704**	0.862***	0.748***	0.789***	0.596 *	-0.044	0.318	0.487*	-0.75**	-0.374
IFC		0.389 **	0.957 ***	0.927 ***	0.181	-0.078	0.221 *	0.071	-0.054	-0.182	0.065	0.937 **	0.838 **	0.632*	0.508	-0.215	0.578	0.389	-0.78**	-0.464
KF			0.627 ***	0.441 ***	0.511 ***	0.093	0.456 ***	0.285 *	0.069	0.057	0.142	0.860 **	0.756 *	0.937***	0.752 *	-0.183	0.426	0.731*	-0.670*	-0.541
CF				0.918 ***	0.281 *	-0.021	0.303 *	0.087	-0.070	-0.078	0.109	0.853 **	0.863 **	0.641*	0.564 *	-0.263	0.615 *	0.399	-0.76 *	-0.511
CFP					-0.075	-0,176	0.108	-0.159	-0.217	-0.199	0.018	0.640 *	0.689 *	0.501	0.378	-0.255	0.587 *	0.402	-0.63 *	-0.433
HCW						0.491 ***	0.615 ***	0.556 ***	0.368 ***	0.325**	0.136	0.855**	0.739 *	0.783**	0.605 *	-0.095	0.327	0.468	-0.735*	-0.422
DP							0.006	0.155	0.132	0.832***	0.343	0.435	0.323	0.413	0.365	-0.107	0.077	0.173	-0.343	-0.302
CL								0.399 ***	0.302 **	0.018	0.010	0.580 *	0.595 *	0.478	0.191	-0.411	0.615 *	0.289	-0.83**	-0.631 *
TT									0.460 ***	0.049	0.318	0.763 *	0.732 *	0.658	0.419	-0.436	0.595	0.385	-0.857	-0.712 *
RMT										0.167	0.615**	0.243	0.255	0.162	0.013	-0.378	0.240	0.037	-0.353	-0.402
EDP											0.481	-0.184	-0.152	-0.282	0.003	-0.272	-0.025	-0.327	0.297	-0.153
LTA												0.059	0.174	-0.047	0.091	-0.64 *	0.354	-0.052	0.024	-0.520
RW													0.957	0.712*	0.790**	-0.276	0.647 *	0.319	-0.81 **	-0.626 *
RM														0.522	0.705 *	-0.489	0.827 **	0.121	-0.81**	-0.753
RF															0.696*	0 ?113	0.107	0.877***	-0.515	-0.275
RB																-0.144	0.391	0.434	-0.308	-0.466
RSW																	-0.840**	0.283	0.307	0.901***
RMP																		-0.207	-0.647	-.0.91***
RFP																			-0.164	0.008
RBP																				0.581

SWT: Slaughter weight, HCW: Hot carcass weight, DP: Dressing percentage, EDP: Empty dressing percentage, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, LTA: *Longissismus thoracis* area, RW: Rib weight, RM: Rib muscle content, RF: Rib fat content, RB: Rib bone content, RSW: Rib segment waste content, RMP: Rib muscle percentage, RFP: Rib fat percentage, RBP: Rib bone percentage, RSWP: Rib segment waste percentage, **:P<0.05;**:P<0.01;***:P<0.001, NS (non significant):P>0.05.*

Table 4: Relationship between carcass characteristics of Lagunaire cattle raised on natural pasture in Benin.

	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP	LTA	RW	RM	RB	RSW	RMP	RBP	RSWP
SWT	0.221	0.646***	0.732***	0.461*	0.674***	0.184	0.552**	0.788***	0.570**	-235	0.463*	0.272	0.430*	0.262	0.294	0.419*	-0.305	0.200
IFC		-0.268	0.554**	0.883***	-0.117	-0.322	-0.028	-0.201	0.299	-0.129	0.332	0.242	0.238	0.018	0.176	0.008	-0.487	-0.123
KF			0.652***	0.114	0.921***	0.739***	0.714***	0.932***	0.732***	0.364	0.124	0.148	0.398	0.170	0.103	0.485	-0.056	0.001
CF				0.793***	0.703***	0.385*	0.595***	0.648***	0.868***	0.213	0.368	0.319	0.445	0.161	0.227	0.425	-0.431	-0.096
CFP					0.131	-0.171	0.074	0.128	0.635***	-0.126	0.275	0.258	0.278	0.017	0.087	0.117	-0.484	-0.312
HCW						0.829	0.902***	0.898***	0.665***	0.489**	0.305	0.263	0.435	0.257	0.303	0.517	-0.205	0.195
DP							0.794***	0.599***	0.452*	0.842***	0.061	0.252	0.256	0.132	0.181	0.352	-0.068	0.092
CL								0.752***	0.535**	0.542**	0.605*	0.504	0.622*	0.498	0.616*	0.326	-0.424	0.452
TT									0.633***	0.224	0.354	0.137	0.309	0.216	0.207	0.533	-0.053	0.279
RMT										0.198	0.269	0.447	0.564**	0.329	0.272	0.412	-0.462	-0.202
EDP											-0.025	-0.04	-0.040	-0.146	-0.014	0.116	0.026	-0.09
LTA												0.696	0.693	0.699*	0.845**	-0.065	-0.661*	0.669*
RW													0.945	0.901***	0.904***	-0.268	-0.91***	0.195
RM														0.904***	0.915***	0.052	-0.85**	0.306
RB															0.929***	-0.129	-0.671	0.468
RSW																-0.095	-0.78**	0.587*
RMP																	0.267	0.251
RBP																		-0.030

SWT: Slaughter weight, HCW: Hot carcass weight, DP: Dressing percentage, EDP: Empty dressing percentage, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, LTA: *Longissismus thoracis* area, RW: Rib weight, RM: Rib muscle content, RF: Rib fat content, RB: Rib bone content, RSW: Rib segment waste content, RMP: Rib muscle percentage, RFP: Rib fat percentage, RBP: Rib bone percentage, RSWP: Rib segment waste percentage, **:P<0.05;**:P<0.01;***:P<0.001, NS (non significant):P>0.05.*

Table 5: Relationship between carcass characteristics of Zebu Fulani cattle raised on natural pasture in Benin.

	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP	LTA	RW	RM	RF	RB	RSW	RMP	RFP	RBP	RSWP
SWT	0.339	0.168	0.355**	-0.077	0.845***	-0.066	0.783***	0.628***	0.477***	-0.108	0.773**	0.676*	-0.046	0.377	0.788**	0.154	0.161	0.385*	0.655**	0.098
IFC		0.412**	0.968***	0.831***	0.362***	0.093	0.244**	0.369***	0.242**	-0.028	0.572	0.477	0.428	0.433	0.189	0.304	0.316	0.346	-0.248	0.038
KF			0.626***	0.515***	0.281**	0.269**	0.078	0.138	0.063	0.181	0.151	0.461	0.409	0.678	0.454	0.227	0.243	0.594	0.077	-0.011
CF				0.852***	0.404***	0.162	0.260**	0.360***	0.213*	0.082	0.508	0.529	0.473	0.562	0.295	0.317	0.332	0.465	-0.176	0.028
CFP					-0.084	-0.047	-0.147	0.029	-0.027	-0.142	0.013	0.408	0.377	0.333	-0.225	0.407	0.302	0.261	-0.568	0.142
HCW						0.472***	0.777***	0.667***	0.429***	0.371***	0.673*	0.100	0.628*	0.153	0.626*	-0.03	-0.063	0.135	0.501	-0.043
DP							0.175	0.212*	0.032	0.889***	-0.095	0.092	0.134	-0.28	-0.166	-0.35	0.144	-0.344	-0.212	-0.293
CL								0.569***	0.344***	0.165	0.549	-0.128	-0.183	0.188	0.620*	-0.19	-0.226	0.229	0.682*	-0.103
TT									0.529***	0.175	0.570	0.174	0.177	0.234	0.502	-0.17	0.161	0.173	0.290	-0.257
RMT										-0.017	0.698*	-0.089	-0.206	0.198	0.659*	0.217	-0.291	0.285	0.668*	0.220
EDP											-0.272	-0.027	-0.049	-0.03	-0.038	-0.43	-0.085	-0.008	0.014	-0.295
LTA												0.064	-0.082	0.400	0.546	0.413	-0.203	0.425	0.425	0.345
RW													0.898***	0.420	0.352	-0.13	0.751**	0.065	-0.535	-0.533
RM														0.150	0.031	-0.08	0.958***	-0.192	-0.709*	-0.464
RF															0.657	0.092	-0.076	0.925***	0.226	-0.071
RB																-0.03	-0.198	0.571	0.593	-0.141
RSW																	-0.124	0.211	0.149	0.898***
RMP																		-0.390	-0.78**	-0.456
RFP																			0.455	0.185
RBP																				0.377

SWT: Slaughter weight, HCW: Hot carcass weight, DP: Dressing percentage, EDP: Empty dressing percentage, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, LTA: *Longissismus thoracis* area, RW: Rib weight, RM: Rib muscle content, RF: Rib fat content, RB: Rib bone content, RSW: Rib segment waste content, RMP: Rib muscle percentage, RFP: Rib fat percentage, RBP: Rib bone percentage, RSWP: Rib segment waste percentage, **:P<0.05;****:P<0.01;*****:P<0.001, NS (non significant):P>0.05.*

Table 6: Frequency of carcass conformation and degree of fat cover classes as a function of breed

Carcass quality component	Class	Borgou			Lagunaire			Zebu Fulani		
		Frequency	Frequency (%)	IC	Frequency	Frequency (%)	IC	Frequency	Frequency (%)	IC
Conformation	U	4	5.63a	5.36	0	0.0b	0	15	13.64a	6.41
	R	28	39.44a	11.37	0	0.0c	0	64	58.18b	9.22
	O	37	52.11a	11.62	0	0.0c	0	31	28.18b	8.41
	P	2	2.82a	3.85	30	100b	0	0	0.0a	0
	Total	71	100		30	100		110	100	
Degree of fat cover	1	65	91.55a	6.47	30	100a	0.0	86	78.18b	7.72
	2	6	8.45a	6.47	0	0,0a	0.0	24	21.82b	7.72
	Total	71	100		30	100		110	100	

U: Profiles on the whole convex; very good muscle development; R: Profiles on the whole straight; good muscle development; O: Profiles straight to concave; average muscle development; P: All profiles concave to very concave; poor muscle development.

1: None up to low fat cover ; 2 : slight fat cover, flesh visible almost everywhere. The frequency between the classes of the same line followed by different letters differs significantly with the threshold of 5%.

Principal Components Analysis: The Principal Components Analysis (PCA) of the carcass characteristics showed that the high variability in carcass composition was mostly responsible for the first axis, which explains 86.65% of the variation. In this axis, heavy carcass, good and very good carcass conformation (R and U), and longer carcass with thicker thighs opposed the poor carcass conformation (P), the carcass bone percentage and the high proportion of carcass waste. The second axis explains 7.76% of the variation and highlights the variability in the carcass components proportions and a low carcass fat cover. Animals with a higher dressing percentage, a higher empty dressing percentage, a higher rib muscle percentage and a slight carcass fat cover opposed the animals with a low carcass fat cover and a weak carcass fat percentage. The projections of these variables on the first two main axes are reported in Figure 3.

The Principal Components Analysis discriminated the three breeds in terms of carcass traits regardless of the slaughter season. The Zebu Fulani carcasses were characterized by their high dressing percentage, an important rib muscle thickness, a low fat cover and a weak carcass fat percentage while the Borgou carcasses were characterized by a high carcass fat percentage, a R carcass conformation and secondly by a higher muscle content. On the other hand, the Lagunaire carcass had a low fat cover and a weak carcass fat percentage, a P carcass conformation and a high proportion of bone. Despite the low variability of the slaughter performance between slaughters seasons in the same breed, the carcasses of each breed were discriminated (Figure 3).

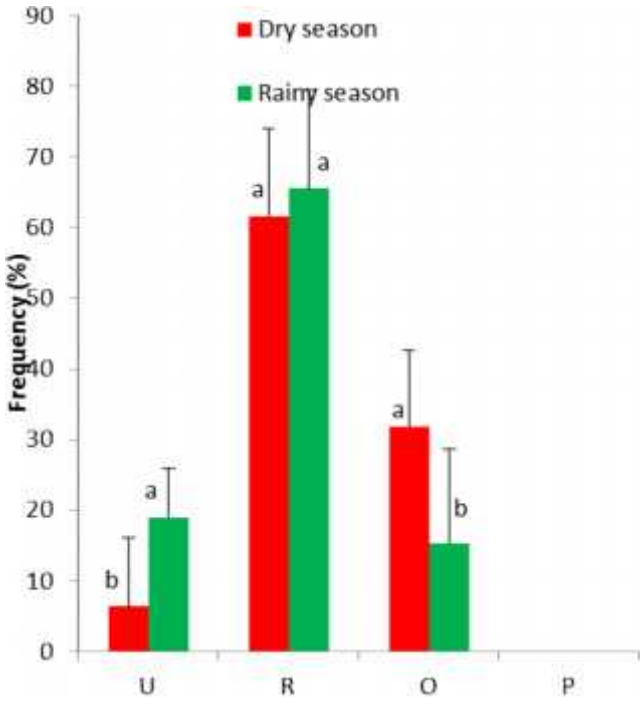

Figure 1: Distribution of Zebu Fulani cattle carcass conformation classes as a function of season

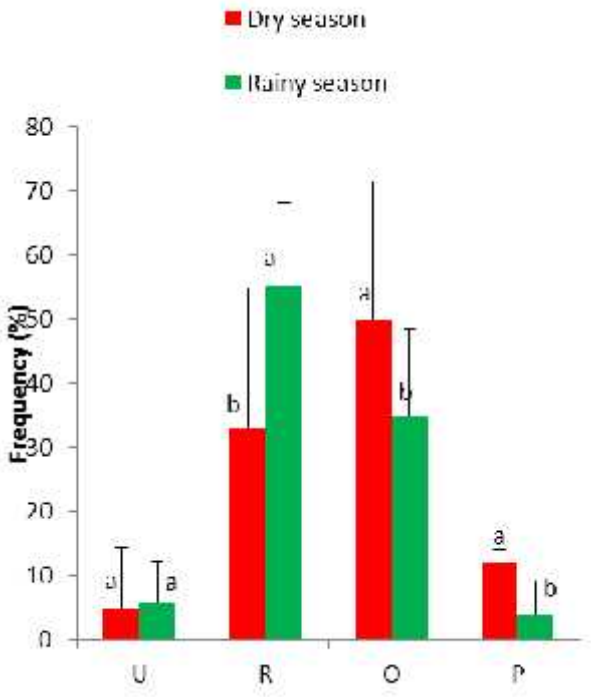

Figure 2 : Distribution of Borgou cattle carcass conformation classes as a function of season

U: Profiles on the whole convex; very good muscle development; R: Profiles on the whole straight; good muscle development; O: Profiles straight to concave; average muscle development; P: All profiles concave to very concave; poor muscle development.

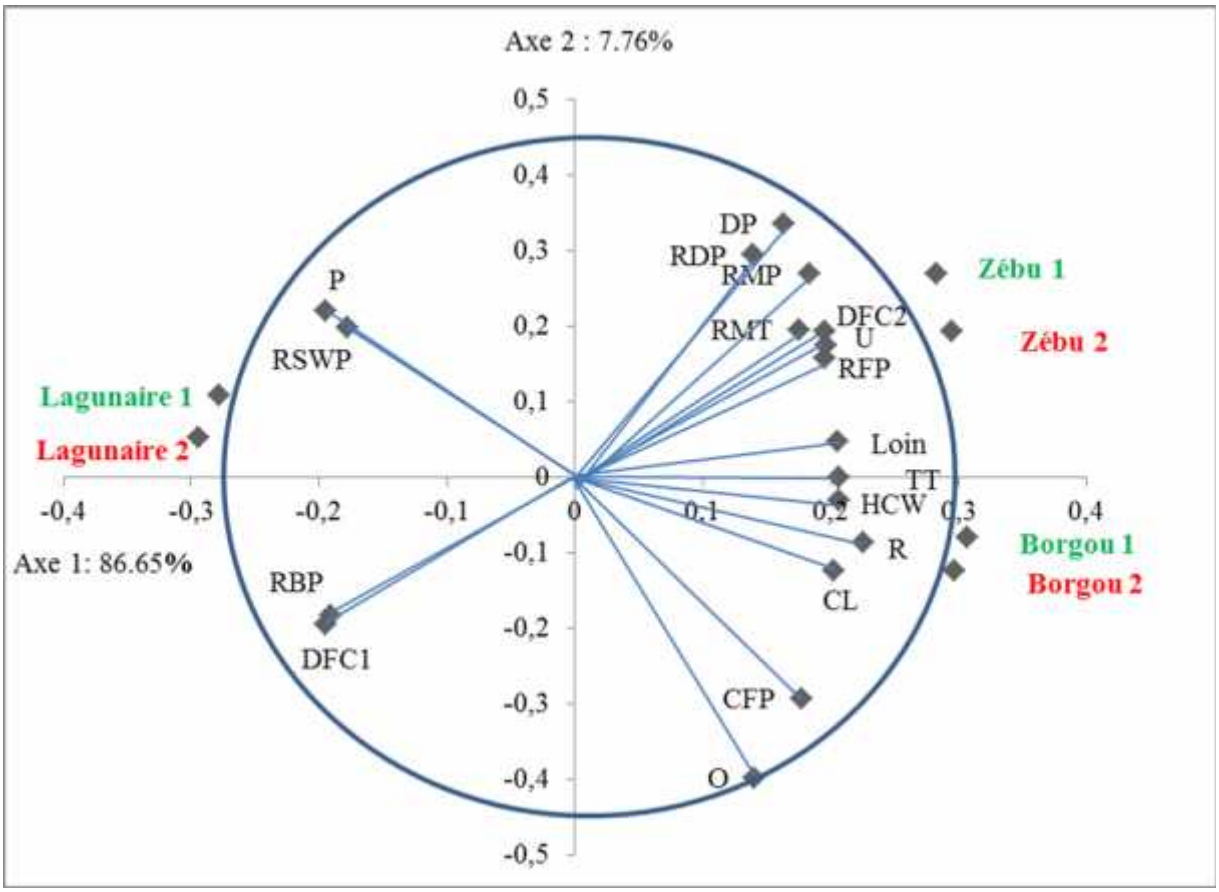

Figure 3: Principal Components Analysis (PCA) of the cattle carcass characteristics raised on natural pasture in Benin

CF : Carcass fat ; CFP : Carcass percentage; HCW: Hot carcass weight; DP: Dressing percentage; CL: Carcass length; TT: Thigh thickness; RMT: Rib muscle thickness; EDP: Empty dressing percentage; Loin: *Longissismus thoracis* area; RMP: Rib muscle percentage; RFP: Rib fat percentage; RBP: Rib bone percentage; RSWP: Rib segment waste percentage. U: Profiles on the whole convex; very good muscle development; R: Profiles on the whole straight; good muscle development; O: Profiles straight to concave; average muscle development; P: All profiles concave to very concave; poor muscle development. DFC 1: None up to low fat cover; DFC2: slight fat cover, flesh visible almost everywhere. Breed 1: rainy season; breed 2: dry season.

DISCUSSION

Carcass characteristics by breeds: The carcass traits of the Zebu Fulani bulls were significantly higher than those of the Borgou bulls while Lagunaire bulls had the lowest performance. Similar result are reported by Teye and Sunkwa (2010) in Ghana where there are significant differences (P< 0.001) in terms of live weight with the Zebu being the heaviest, followed by the Sanga and the West African Shorthorn breeds. Similar results are also reported by Sottie *et al.* (2009) in comparative studies on growth traits of Sanga and Friesian-Sanga crossbred calves raised on natural pasture on the Accra plains of Ghana. The Borgou breed is a cross-breed between the White Fulani bull and the Taurus breed cow, principally Somba cow and secondly, Lagunaire cow (Youssao *et al.,* 2009). Generally, the crosses (Borgou) are normally heavier at maturity than their humpless parental stock, but lighter than their humped parental stock, which was explicitly depicted in their carcass characteristics in this study. As for Somba breed, Lagunaire breed has the same conformation and they are trypanotolerant. Contrary to the Borgou and the Zebu bulls, the carcass of the Lagunaire bull contained little carcass fat and no rib fat was observed. Thus, the Lagunaire carcass was leaner than the other two breeds and a comparative study on nutritional and organoleptic qualities of the meat of these three breeds could help better characterize them. The bulls are raised on natural pasture, thus, additional supplementation would increase slaughter weight and carcass traits (Moreira *et al.,* 2005, Aricetti *et al.,* 2008). In another study, the average final live weight (467.1 kg)

and hot carcass weight (250.7 kg) of Purunã bulls (crossbred between zebu Nellore specimens and Charolaise cattle) slaughtered at 18 or 24 months of age (Ito *et al.,* 2010) are higher than those of Zebu bull slaughtered at 5 years old. Thus, the carcass traits could be improved with the meat breed as Girolando breed which is adapted to the Benin climate (DE, 2011).

The dressing percentage varied according to the breed in our study. The higher dressing percentage obtained in Zebu bull could be explained by the highest offal weight, particularly, the head and the legs proportion (Kassa, 2011). The dressing percentage of Thai native cattle fattened on Guinea grass (*Panicum maxima*) or Guinea grass-legume (*Stylosanthes guianensis*) pastures is 55% (Jaturasitha *et al.,* 2009). This dressing percentage is higher than those obtained in our study. On the other hand, the dressing percentage of the Sanga, the West African Shorthorn and the zebu Bull reported in Ghanaian beef cattle (Teye and Sunkwa, 2010) are respectively similar to those obtained in Borgou, Lagunaire and Zebu bull in this study. Similar results were reported in four genetic groups finished in feedlot, where hot carcass dressing was higher ($P<0.05$) than Canchin (55.2%) genetic group in comparison with the Caracu (50.4%) Aberdeen Angus × Canchin (53.8%) and Charolais × Caracu (52.4%) (Ito *et al.,* 2012).

The effects of breed on carcass performance were reported in feedlot conditions on bull calves in Hereford, Simmental and Charolais breeds (Bartoň *et al.,* 2006, Kamieniecki *et al.,* 2009) and on Nellore, Caracu and Holstein-friesian Bulls finished (Rotta *et al.,* 2009). Another result is observed in Criollo Argentino and Braford steers raised on forage in a semi-tropical region of Argentina (Orellana *et al.,* 2009). Breed effect on live weight and carcass traits were also reported in Simmentaler cross, Bonsmara cross and Nguni steers raised on natural sweet veld pastures and slaughtered at 18 or 30 months of age in the arid subtropics of South Africa (du Plessis and Hoffman, 2007).

There are varying reports on the slaughter or mature and carcass weights in Africa. It was reported that the slaughter and carcass weights of Sudan Baggara Zebu cattle were, respectively, 319 kg and 168 kg (Fadol and Babiker, 2010). In Ghana, the slaughter weight and the carcass weight are respectively, 162 kg and 74.1 kg in West African Shorthorn while those of Sanga bull are 202 kg and 95.3 kg and 309 kg and 155.9 kg for zebu cattle (Teye and Sunkwa, 2010). This is in agreement with the results of the present study.

Season effect on carcass traits: Carcasses of bulls slaughtered in the rainy season were heavier, and their dressing percentage and empty dressing percentage were higher. They also had more thigh thickness, a thicker rib muscle, a wider *Longissimus thoracis* area and a rib fat more than the bulls slaughtered in the dry season. These differences were related to the season effect due to the good nutritional quality of the pasture in the livestock areas (Youssao *et al.,* 2012). The bulls slaughtered were exclusively fed on natural pasture that explains better carcass performance at slaughter in the rainy season. However, during the dry season, forages become scarce and poor and farmers are obliged to adopt transhumance for the survival of the herd. Animals are thus less fed and their slaughter performance decreases at slaughter.

Season effect is more expressed in Borgou and Zebu cattle because of the long duration of the rainy season and the dry season in this area. However, season effect is not observed in Lagunaire weight and the body composition because of the short duration of the four seasons of the year in their livestock area. The empty dressing percentage of the Zebu bull in the rainy season was significantly higher than that of the dry season because during the dry season, the carcass muscle content decreased. In Borgou and Zebu bull, the carcass fat was higher in the rainy season than in the dry season because of the abundance of fodder during the rainy season.

Relationship between carcass traits: The slaughter weight was highly correlated with the carcass weight, the thigh thickness, the rib muscle thickness, the carcass fat in the three cattle breeds. The correlations obtained were near to those of Teye and Sunkwa (2010) in West African Shorthorn, Sanga and Zebu bull in Ghana. According to those authors, there was a weak positive correlation ($r=0.52$) between the live and carcass weights of the West African Shorthorn. Unlike the West African Shorthorn, there was a great significant ($P<0.001$) positive correlation ($r=0.93$) between the live and carcass weights of the Sanga. There was also a good significant ($P<0.01$) positive correlation ($r = 0.78$) between the live and the carcass weights of the Zebu. Those carcass components or those rib components that had strong and significant positive correlations with the live and carcass weights are good predictors that can be used to estimate the live and carcass weights where suitable weighing scales are not available for live and whole carcass weight.

The Principal Components Analysis discriminated the three breeds in terms of carcass traits regardless of the slaughter season. Similar results are observed in Aubrac, Salers and Aubrac breeds in terms of slaughter performance (Renand *et al.,* 2002). The carcasses were heavier and leaner in Aubrac system; they had a lesser conformation in Salers system and a better dressing percentage in Gascon system (Renand *et al.,* 2002).

Carcass conformation and degree of carcass fat cover: The conformation of Zebu Fulani was firstly good and secondly fair whereas the carcass conformation of Borgou was firstly fair and secondly good. All Lagunaire carcasses had poor conformation. The conformation varied according to the age at slaughter and the breed

(Renand *et al.,* 2002, Cartier and Moevi*,* 2007). Compared to meat breeds, the conformation of Benin native breed is less developed. Thus, the Charolaise breed has a conformation that varies between "good" (R +) and "very good equal" (= U), the Limousine between "very good less" (U-) and very "good plus" (U +), the Blonde d'Aquitaine between U = and "excellent less" (E) (Cartier and Moevi*,* 2007). Thus, each breed has his own carcass conformation. However, the level of fattening can also influence the carcass conformation. Good conformations are obtained on the Blanc Bleu Belge cows double muscling fattening with corn silage: most have excellent (E) conformation (60.0%) followed by the superior conformation S (33.3%) and very good (U) conformation (6.7%) (Cabaraux *et al.,* 2003).

The Borgou, like the Fulani, has a similar fat cover mostly very low. The weakness of the level of the carcass fat cover of both breeds can be related to the breeding mode. During the transhumance, the animals walk a long distance to gain access to water and forage. Thus, the animals waste energy and the carcass muscle content decreases. The same phenomenon is observed in the sedentary breeding, where water and fodder are often restricted during the dry season.

According to the Council Regulation of European Union (EC No 1249/2008), a good carcass is classified in E3 classes (E for conformation and 3 for degree of fat cover), which means that all profiles are convex to super-convex; exceptional muscle development and flesh, with the exception of the round and shoulder, almost everywhere covered with fat, slight deposits of fat in the thoracic cavity. To be competitive on the international market, significant efforts must be made in order to improve the carcass conformation of Benin native breeds in general and those of the Zebu Fulani, the Borgou and the Lagunaire breeds in particular. Because of the difference between the shape of the West African breeds and those of European breeds, the Economic Community of West African States (ECOWAS) should set its own council regulation for its cattle breed.

Conclusion: The carcass traits of the Zebu bulls were significantly higher than those of the Borgou bulls while Lagunaire bulls had the lowest performance. The Lagunaire carcass was leaner than the other two breeds. The bulls slaughtered in the rainy season had a heavier carcass, a higher dressing percentage, a higher thigh thickness, a thicker rib muscle, a higher *longissimus thoracis* area and more rib fat than the bulls slaughtered in the dry season. The conformation of Zebu Fulani is principally good and secondly fair whereas the carcass conformation of Borgou is principally fair and secondly good. All Lagunaire carcasses have poor conformation whatever the year season. The best conformations were observed in the rainy season in Zebu and Borgou bulls. The degree of carcass fat cover is essentially low in Lagunaire bull, but slight carcass fat cover frequency increases from Borgou to Zebu bulls. Zebu Fulani carcasses were characterized by their higher dressing percentage, a high rib muscle thickness, a low fat cover and a weak carcass fat percentage while Borgou carcasses were characterized by a high carcass fat percentage, a good carcass conformation and secondly by a higher muscle content. The Lagunaire carcass had a low fat cover and a weak carcass fat percentage, a poor carcass conformation and a high proportion of bone. Finally, further research is required to evaluate the offal components and to establish the relationships between the offal components and the carcass characteristics. This work contributes to a better characterization of the carcasses, useful to objectively set the price that is paid to the producer.

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REFERENCES

Adam, S. K. et M. Boko (1993). Le climat du Bénin. In: Le Bénin, Ed. Sodimas-Edicef. Paris. 96 p.

Aricetti, J. A., P. P. Polyana Pizzi Rotta, R. M. do Prado, D. Perotto, J.L. Moletta, M. Matsushita, and I.N. do Prado (2008). Carcass Characteristics, Chemical Composition and Fatty Acid Profile of *Longissimus* Muscle of Bulls and Steers Finished in a Pasture System. Asian-Aust. J. Anim. Sci. 21, (10): 1441 – 1448.

Bartoň, L., D. Řehák, V. Teslík, D. Bureš, and R. Zahrádková (2006).Effect of breed on growth performance and carcass composition of Aberdeen Angus, Charolais, Hereford and immental bulls. Czech J. Anim. Sci. 51: 47–53.

Cabaraux J. F., J. L. Hornick, I. Dufrasne, A. Clinquart, et L. Istasse (2003). Engraissement de la femelle de réforme Blanc-Bleu Belge culard: performances zootechniques, caractéristiques de la carcasse et qualité de la viande. Ann. Méd. Vét. 147: 423-431.

Cartier, P. and I. Moevi (2007). La qualité des carcasses et des viandes de gros bovins. Compte rendu final n° 17 05 32 022, Département Techniques d'Elevage et Qualité, Service Qualité des Viandes, France. 2007, ISSN: 1773-4738, 70p. [en ligne] Adresse URL: www.agrireseau.qc.ca/.../qualite_carcasse_viande_bovin_2008 , consulté le 15/10/2011.

Clinquart, A., J-L. Hornick, C. Van Eenaeme, et L. Istasse (1998). Influence du caractère culard sur

la production et la qualité de la viande des bovins Blanc Bleu Belge. INRA Prod. Anim., 11: 285-297.

Council Regulation of European Union (EC No 1249/2008) of10 December 2008 concerning the Community scale for the classification of carcasses of adult bovine, pork and sheep. Official Journal of European Union, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:337:0003:0030:FR:PDF

Country Stat/Benin (2012). Base de données statistique, consulté à : http://countrystat.org/ben ou http://www.fao.org/economic/ess/countrystat/en/

D. E. (2011). Direction de l'Elevage, Rapport annuel d'activités, Bénin, 109p

Dehoux, J-P. et G. Hounsou-Vê (1993). Productibilité de la race bovine Borgou selon les systèmes d'élevage traditionnels au Nord-Est du Bénin. World Anim. Review.74, 75 : 36-48.

Djenontin, A. J., Houinato M., Toutain B. et Sinsin B. (2009). Pratiques et stratégies des éleveurs face à la réduction de l'offre fourragère au Nord-Est du Bénin. Sécheresse 2009, 20 (4): 346-53.

Doko Allou, S., S. Farougou, S. Salifou, E. Ehilé, and S. Geerts (2010). Dynamique des infections trypanosomiennes chez des bovins Borgou à la ferme de l'Okpara au Bénin. Tropicultura. 28, (1): 37-43.

Du Plessis,I., and L. C. Hoffman (2007). Effect of slaughter age and breed on the carcass traits and meat quality of beef steers finished on natural pastures in the arid subtropics of South Africa. South Afri. J. Anim. Sci. 37,(3): 143-153.

Fadol S. R. and S. A. Babiker (2010). Effect of feedlot regimen on performance and carcass characteristics of Sudan Baggara Zebu cattle. LRRD, 22, (2): 2010

Farougou S., P. Agbadjè, M. Kpodekon, C. Adoligbe, and A. J. Akakpo (2006b).Prévalence de la tuberculose bovine dans les fermes d'Etat de Samiondji et de Bètècoucou au Bénin. RASPA. 4 : 27-31.

Farougou S., M. Kpodékon, and D. M. Tchabodé (2006a).Abondance saisonnière des tiques (Acari : Ixodidae) parasites des bovins dans la zone soudanienne du Bénin: cas des départements de l'Atacora et de la Donga. Ann. Méd. Vét. 150, (2): 145-152.

Farougou S, A. W. Tassou, D. M. Tchabodé, M. Kpodékon, C. Boko and A. K. I. Youssao (2007). Tiques et hémoparasites du bétail dans le nord-Bénin. Revue Méd. Vét. 158, (8-9): 463-467.

Farougou S., H. Adakal, A. S. Biguezoton, C. Boko (2012). Prévalence de l'infection d'*Amblyomma variegatum* par *Ehrlichia ruminantium* dans les élevages extensifs du Bénin. Revue Méd. Vét., 163, (5), 261-266

Houndjê E., D. Berkvens, and T. Gbaguidi (2010). Approche bayésienne spatiale et spatio-temporelle des cas cliniques de fièvre aphteuse au Benin de 2003-2006. Symposium International de Pathologie Animale et de Biotechnologie en Santé Animale en milieu tropical, Université d'Abomey-Calavi, 04 au 06 février 2008, Bénin, 5p.

Ito H. R., I. N. do Prado, P. P. Rotta, M. G. de Oliveira, R. M. do Prado, and J. L. Moletta (2012). Carcass characteristics, chemical composition and fatty acid profile of *longissimus* muscle of young bulls from four genetic groups finished in feedlot. R. Bras. Zootec. 41, (2): 384-391.

Ito H. R., I. N. do Prado, J. V. Visentainer, R. M. do Prado, C. A. Fugita, and de M. C. Oliveira Pires (2010). Carcass characteristics, chemical and fatty acid composition of *Longissimus* muscle of Purunã bulls slaughtered at 18 or 24 months of age. Acta. Sci. Anim. Sci., Maringá. 32, (3): 299-307.

Jaturasitha S., R. Norkeaw, T. Vearasilp, M. Wicke, and M. Kreuzer (2009). Carcass and meat quality of Thai native cattle fattened on Guinea grass (Panicum maxima) or Guinea grass–legume (*Stylosanthes guianensis*) pastures. Meat Sci. 81: 155–162

Kamieniecki H., J. Wójcik, R. Pilarczyk, K. Lachowicz, M. Sobczak, W. Grzesiak, and P. Błaszczyk (2009). Growth and carcass performance of bull calves born from Hereford, Simmental and Charolais cows sired by Charolais bulls. Czech J. Anim. Sci. 54, (2): 47–54.

Kassa K. S. (2011). Evaluation de la composition corporelle et de la qualité de la carcasse des bovins de races Borgou et zébu Peulh, élevés dans le système d'élevage traditionnel au Bénin. Mémoire de fin de formation pour l'obtention du Master en Production et Santé Animales, EPAC, Université d'Abomey-Calavi, Bénin, 72p.

Koudandé O. D., G. Dossou-Gbété, F. Mujibi, H. Kibogo, D. Mburu, G. A. Mensah, O. Hanotte and J. A. M. van Arendonk (2008). Genetic diversity and zebu genes introgression in cattle population along the coastal region of the Bight of Benin. AGRI 44: 33-43.

Koutinhouin B., A. K. I. Youssao, A. E. Houehou and P. M. Agbadje (2003). Prévalence de la brucellose bovine dans les élevages traditionnels encadrés par le Projet pour le Développement de l'Elevage (PDE) au Bénin. Revue Méd. Vét.154, (4): 271-276.

Koutinhouin G. B., A. K. I. Youassao, P. Tobada, T. M. Kpodekon, and V. Adimatin (2009). Influence

de l'indice de température et d'humidité relative de l'air sur la fécondité de la vache Borgou élevée selon deux modes d'élevage au Bénin.Int. J. Biol. Chem. Sci. 3,(6): 1336-1345.

Koutinhouin, G. B., A. K. I. Youssao, T. M. Kpodekon, and Y. G. Gantoli (2010). Influence de la traite précoce des vaches sur la croissance pondérale et l'état sanitaire des veaux en élevage traditionnel : cas de la zone périurbaine de Natitingou (Bénin). LRRD, 22 (02) 2010

M. A. E. P. (2011). Ministère de l'Agriculture, de l'Elevage et de la Pêche. Rapport annuel d'Activités, Bénin, 124p.

Michaux, C., A. Stasse, R. Sonnet, P. L. Leroy, et R. Hanset (1983). La composition de la carcasse de taureau culards Blanc Bleu Belge. Ann. Méd. Vét., 127: 349-375.

Moazami-Goudarzi K., D. M. A. Bélemsaga, G. Ceriotti, D. Laloë, F. Fagbohoun, N. T. Kouagou, I. Sidibé, V. Codjia, M. C. Crimella, F. Grosclaude and S. M. Touré (2001). Caractérisation de la race bovine Somba à l'aide de marqueurs moléculaires. Rev. Elev. Méd. Vét. Pays Trop. 54 (2):129-138.

Moreira F. B., I. N. Prado, N. E. Souza, M. Matsushita, I. Y. Mizubuti and L. M. Macedo (2005). Desempenho animale caracterísitcas da carcaça de novilhosterminadosempastagem de aveiapreta, com ou semsuplementação energética. Acta Sci. Anim. Sci. 27:469-473.

Orellana C., F. Peña, A. García, J. Perea, J. Martos, V. Domenech and R. Acero (2009). Carcass characteristics, fatty acid composition, and meat quality of CriolloArgentino and Braford steers raised on forage in a semi-tropical region of Argentina. MeatSci. 81 : 57–64

Renand G., A. Havy, and F. Turin (2002).Caractérisation des aptitudes bouchères et qualités de la viande de trois systèmes de production de viande bovine à partir des races rustiques françaises Salers, Aubrac et Gasconne. INRA Prod. Anim. 15, (3): 171-183.

Rotta, P. P., I. N. do Prado, R. M. do Prado, J. L. Moletta, R. R. Silva, and D. Perotto (2009). Carcass Characteristics and Chemical Composition of the *Longissimus* Muscle of Nellore, Caracu and Holstein-friesian Bulls Finished in a Feedlot. Asian-Aust. J. Anim. Sci. 22,(4): 598 – 604.

SAS (2006). SAS/STAT User's guide, vers, 6, 4thed, Cary, NC,USA, SAS Inst, 2006.

Sottie E. T., K. A. Darfour-Oduro, and O. S. A. Kantah (2009). Comparative studies on growth traits of Sanga and Friesian-Sanga crossbred calves raised on natural pasture on the Accra Plains of Ghana. Trop. Anim. Health Prod.,41: 321-328.

Teye, G. A. and W. K. Sunkwa (2010). Carcass characteristics of tropical beef cattle breeds (West African Shorthorn, Sanga and Zebu) in Ghana. Afri. J. Food Agri. Nutri. Dev., 10, (7), 2866-2883.

Youssao A. K. I., G.B. Koutinhouin, T. M. Kpodekon, H. Agnandjo, Z. Toure, A. Ahissou and G. Renand (2007). Variabilité génétique des performances de croissance et des mesures corporelles de jeunes bovins de race Borgou à la Ferme d'Elevage de l'Okpara. RASPA. 5, (3-4): 157-165.

Youssao A. K. I., G. B. Koutinhouin, T. M. Kpodekon, H. Agnandjo, Z. Toure, and A. Ahissou (2009). Influence d'une sélection phénotypique sur les performances de croissance et les caractères de développements musculaire et squelettique de jeunes bovins de race Borgou à la Ferme d'Elevage de l'Okpara (Bénin). Ann. Méd. Vét.153 :105-111.

Youssao A. K. I., G. S. Ahounou, G. B. Koutinhouin (2012). Typologie des élevages traditionnels de bovins de race Borgou dans la zone soudannienne du Bénin. Journées Scientifiques Internationales de l'Université de Lomé, 22 au 26 Octobre 2012, Campus Universitaire de Lomé, 45-46.

Zoffoun A. G., S. Babatounde, M. Houinato, G. A. Mensah et B. Sinsin (2011a). Comportement alimentaire des taurillons Girolando sur deux types de pâturages cultivés en zone subéquatoriale. Can. J. Anim. Sci. 91: 1-9. ISSN 0008-3984. Site web: http://www.journals@aic.ca

Zoffoun G. A., S. Salifou, M. Houinato and A .B. Sinsin (2011b). Interactions ticks, hosts and pastures: Case of the Girolando dairy cattle and the artificial pastures of Panicum maximum and Panicum maximum var. C1. J. Agri. Sci. Technol., 5, (4): 433-442.