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Relationships between carcass characteristics and offal components of Lagunaire, Borgou and Zebu Fulani bulls raised on natural pasture

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Abstract

The correlations and Principal Components Analysis allow appreciating the relationship between several variables. Therefore, this study aims to establish the relationships between the offal components and the carcass characteristics of Lagunaire, Borgou and Zebu Fulani bulls raised on natural pasture and slaughtered in abattoir of Cotonou-Porto-Novo at 5 years old. Carcass characteristics, carcass conformation, carcass degree of fat cover and offal component traits were collected on 40 Lagunaire, 71 Borgou and 110 Zebu Fulani bulls. In Zebu bulls, except spleen weight, slaughter weight was moderately and positively correlated with heart weight ($P<0.01$, $r=0.299$), highly and negatively correlated with offal percentage ($P<0.001$, $r=-0.369$) and highly and positively correlated with offal weight and the others offal component ($P<0.001$, $0.324<r<0,824$). Unlike Zebu bulls, the correlations between hot carcass weight and head percentage ($r=-429$, $P<0.001$) on the one hand and between hot carcass weight and offal percentage ($r=-0.338$, $P<0.05$) in the second hand were significant and negative and no relationship was observed between hot carcass weight and liver weight. In Lagunaire bulls, slaughter weight and hot carcass weight were less correlated with offal components traits than those in Borgou and Zebu bulls. The Zebu bulls were characterized by higher dressing percentage, rib fat percentage and carcass length, heavier hot carcass weight, carcass fat weight, offal and offal component weight, a good and very good carcass conformation (R and U) with slighter carcass fat cover. Whereas Lagunaire bulls were characterized by higher head percentage, offal percentage, rib segment waste percentage, rib bone percentage on the one hand and a poor carcass conformation and a low carcass fat cover in the second hand. The butcher aptitude of Borgou bulls was in the middle of those of Lagunaire and Zebu bulls, whatever the season.

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Introduction

The carcass is the whole body of the slaughtered animal as it's presented after bleeding, evisceration and skinning operations. For the purpose of establishing market prices, the carcass is presented with external fat, the neck being cut accordingly to veterinary requirements: without kidneys, kidney fat, pelvic fat, thin skirt, thick skirt, tail, the spinal cord, cod fat, fat on the inside of topside, jugular vein and the adjacent fat in the European Union countries (Council Regulation N°1249/2008). The carcass qualities were assessed on the criteria that determine the beef traits. Those characteristics were the carcass weight, the carcass length, the carcass fat, the round weight, the back weight, the shoulder weight, the thigh thickness, the dressing percentage, etc. (Salifou *et al.,* 2010). This assessment can be classified in two major criteria including the carcass conformation and the carcass degree of fat cover accordingly to the Council Regulation N°1249/2008 of European Union. The bovine body composition takes into account the carcass characteristics and the offal components (head, legs, tail, spleen, liver, heart, lungs and intestines). In Europe, America, Asia and Australia countries, many works were related to bovine body composition (Renand *et al.,* 2002, Cabaraux *et al.,* 2003, Bartoň *et al.,* 2006, Cartier and Moevi, 2007, Kamieniecki *et al.,* 2009, Jaturasitha *et al.,* 2009). On the over hand, in Sub-Saharan Africa countries, there is few assessment related to the body composition of native bovine breeds in spite of a demand from butchers and consumers. Recently, Taye and Sunkwa (2010) evaluated the carcass characteristics of tropical beef cattle breeds (West African Shorthorn, Sanga and Zebu) in Ghana. These studies reported the carcass components such as empty carcass, fore-and hind-quarters and filet, internal offal (heart, liver, lungs, spleen, kidney and the rumen) and external offal (head, tail, legs and skin). These researches provided information on the carcass characteristics of beef cattle in Ghana and means of estimating their carcass and live weights. In Benin, Borgou, Zebu Fulani and Lagunaire are frequently slaughtered (Assogba and Youssao, 2002). To investigate slaughter performance of these breeds, Salifou *et al.* (2012a) assessed their carcass characteristics including the bulls raised solely on natural pasture. This livestock system is practiced by almost the cattle breeder in Benin (Balogoun, 2010). Salifou *et al.* (2012b) also assess the bull offal components traits according to the breed and the slaughter season and establish the relationships between the offal components of each breed and all breeds combined. Unlike the research carried out by Teye and Sunkwa (2010) in West African Shorthorn, Sanga and Zebu bull of Ghana, the relationship between carcass characteristic traits and offal components were not taking into account by Salifou *et al.* (2012a, 2012b). The motivation of the present study was to determine the degrees of linking between each carcass characteristic traits and respectively offal components traits in the one hand and to determine groups of highly correlated carcass and offal traits and carcass and offal groups that oppose in the second hand in order to improve butcher aptitude.

The carcass characteristics and the offal components are very numerous. Thus, the relationships between carcass characteristics and the offal components will be based on phenotypic correlations that determine the degrees of linking between two variables and the principal components analysis that presents groups of highly correlated variables and variable groups that oppose. The least squares means of carcass characteristics of Lagunaire, Borgou and Zebu bulls by slaughter season and the relationship between those carcass traits are firstly presented by Salifou *et al.* (2012a). Those of offal components traits are secondly given by Salifou *et al.* (2012b). Therefore, this study aims to establish the relationships between the offal components and the carcass characteristics of Lagunaire, Borgou and Zebu Fulani bulls raised on natural pasture and slaughtered in abattoir of Cotonou-Porto-Novo.

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 6°21' North latitude and 2°25'

East longitude). Slaughtering begins at 4 o'clock in the morning and finished at 12 o'clock. 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 scarcely slaughtered in the abattoir of Cotonou-Porto-Novo. 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 1,000 mm (Adam and Boko, 1993).

The Department of Borgou is located to the northeast of Benin between 8°52' and 10°25' North latitude and 2°36' and 3°41' East longitude and covers 25,856 km². This Department is characterized by Sudanese climate type that composed of one dry season (November to May) and one rainy season (June to October) with a yearly rainfall varying from 900 to 1,200 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 1,200 mm per year (Adam and Boko, 1993). Slaughtered animals were collected from this Department between 6.65°26' and 7°10' North latitude and 2.25 ° 14' and 2°4' East longitude.

Choice of animals

Animals were transported from their natives Department at least 48 h before slaughtering. Just arrival, animals were approved and put to rest 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 the dental table) 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 race, the age at slaughter, the pasture used during livestock (natural or artificial) and feed supplementation used during fattening, the livestock system (transhumance or sedentary), etc. This interview allowed confirming the type of breed and the age at slaughter of the previously selected animals. All of the slaughtered bulls in this study were raised on natural pasture. The number of slaughtered animals was 71 for Borgou bulls, 110 for Zebu Fulani bulls and 40 for Lagunaire bulls.

Slaughtering process

The selected animals were submitted to the *ante-mortem* inspection by a veterinary inspector before slaughtering. The killing was done by 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-carcass were finally submitted to the *post-mortem* inspection. The slaughter was carried out from September to October for the rainy season and from February to March for the dry season.

Data collection

Carcass characteristics

The slaughter weight was taken the day before slaughter using a mechanical balance of 1,500 kg of capacity with a precision of 1.5 kg. The day of

slaughter, an electronic balance of 1,500 kg of capacity with a precision of 0.5 kg was used to weigh hot carcass. Digestive tract (full and empty esophagus, stomach and intestines), offal (spleen, liver, lungs, kidneys, heart, head, leather, tail and legs), kidney fat, internal fat of carcass and offal fat were also weighed. Thus the dressing percentage was 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. The carcass fat is 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 assessed by determining 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. Six classes (S, E, U, R, O and P) were considered on the basis of the development of carcass profiles for the conformation, in particular the essential parts (round, back and shoulder). The classification was based on a scale varying from Excellent for S carcasses, to Poor for carcasses P. For the S class, all profiles being extremely convex (exceptional muscle development), while profiles of P class carcasses were concave even extremely concave (poor muscle development). Regarding to 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 in 1 were less fat covered (none up to low fat cover) and carcasses classified in 5 had a 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. The 6th rib was collected and weighed in each slaughtered animal. The *Longissimus thoracis* muscle was measured at the area corresponding to the intersection between the 6th and the 7th rib. The 6th rib segment was then dissected and the muscle, fat, bone and waste were separated. 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 correlations between the different variables were determined by breed using *Proc corr* procedure of SAS (SAS, 2006). Principal Components Analysis (PCA) of the carcass characteristics and offal components was carried out each breed and for all breeds by the *Proc princompt* procedure of SAS (2006). The slaughter season and the breed effect were taken into account in the principal components analysis procedure in order to appreciate the high variability in body composition.

Results and discussion

Correlations between carcass characteristics and offal component

The correlations between carcass characteristics and offal component were presented in tables 1, 2 and 3, respectively for Zebu, Borgou and Lagunaire bulls.

In Zebu bulls, except spleen weight, slaughter weight was moderately and positively correlated with heart weight ($P<0.01$, $r=0.299$), highly and negatively correlated with offal percentage ($P<0.001$, $r=-0.369$) and highly and positively correlated with offal weight and the others offal component ($P<0.001$, $0.324<r<0,824$).

Table 1. Relationship between carcass characteristics and offal components trait of Zebu cattle rose on natural pasture in Benin.

	SWT	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP
Legs	0,697***	0,324***	0,130NS	0,347***	0,003NS	0,757***	0,249**	0,730***	0,501***	0,276**	0,192*
Tail	0,640***	0,333***	0,274**	0,391***	0,069NS	0,707***	0,260**	0,624***	0,498***	0,220*	0,200*
Leather	0,741***	0,369***	0,294**	0,419***	0,069NS	0,798***	0,249**	0,656***	0,451***	0,264**	0,161NS
Head	0,735***	0,382***	0,275**	0,424***	0,072NS	0,847***	0,332***	0,674***	0,573***	0,375***	0,271**
Esophagus	0,322***	0,230*	0,086NS	0,244*	0,082NS	0,413***	0,221*	0,279**	0,273**	0,053NS	0,148NS
Stomach	0,509***	0,394***	0,197*	0,403***	0,171NS	0,543***	0,184NS	0,523***	0,341***	0,049NS	0,108NS
Intestines	0,371***	0,445***	0,274**	0,470***	0,286**	0,500***	0,303**	0,354***	0,262**	0,096NS	0,183NS
Spleen	0,097NS	0,123NS	0,265**	0,235*	0,139NS	0,210*	0,208*	0,198*	0,116NS	0,053NS	0,120NS
Liver	0,419***	0,195*	0,200*	0,232*	-0,014NS	0,540***	0,321***	0,499***	0,313***	0,273**	0,240*
Kidneys	0,324***	0,285**	0,419***	0,354***	0,136NS	0,510***	0,397***	0,392***	0,246*	0,017NS	0,299**
Lungs	0,425***	0,159NS	0,123NS	0,170NS	-0,039NS	0,494***	0,227*	0,484***	0,341***	0,209*	0,147NS
Heart	0,299**	0,024NS	0,072NS	0,098NS	-0,065NS	0,316***	0,121NS	0,366***	0,240*	0,093NS	0,147NS
Offal	0,824***	0,494***	0,287**	0,512***	0,167NS	0,822***	0,168NS	0,685***	0,514***	0,276**	0,037NS
P_Head	-0,427***	-0,084NS	0,148NS	-0,06NS	-0,003NS	-0,044NS	0,597***	-0,158NS	-0,119NS	-0,154NS	0,626***
P_Offal	-0,369***	0,050NS	0,150NS	0,071NS	0,155NS	-0,106NS	0,408***	-0,156NS	-0,247*	-0,349***	0,330***

SWT: Slaughter weight, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, HCW: Hot carcass weight, DP: Dressing percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, EDP: Empty dressing percentage, P_Head: percentage of head ; P_Offal: percentage of offal. **:P<0.05;**:P<0.01;***:P<0.001, NS (non significant):P>0.05.*

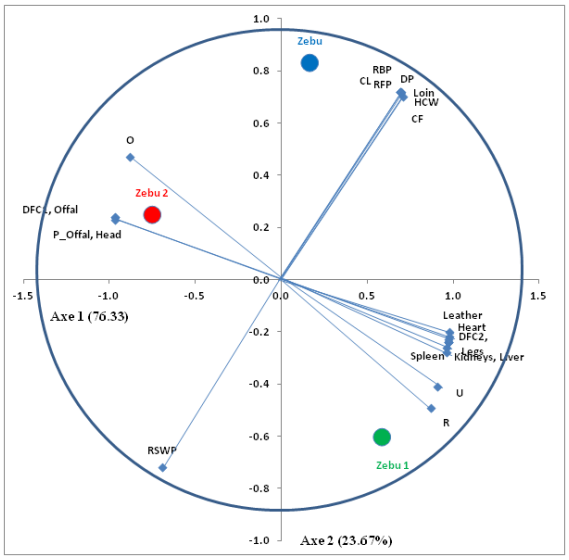
Table 2. Relationship between carcass characteristics and offal components trait of Borgou cattle rose on natural pasture in Benin.

	SWT	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP
Legs	0,580***	0,421***	0,315**	0,456**	0,295*	0,445***	-0,059NS	0,523***	0,247*	0,133NS	-0,095NS
Tail	0,570***	0,342**	0,226NS	0,316*	0,114NS	0,521***	0,088NS	0,377**	0,252*	0,217NS	0,021NS
Leather	0,668***	0,048NS	0,076NS	0,007NS	-0,190NS	0,628***	0,108NS	0,467***	0,282*	0,382**	0,017NS
Head	0,536***	0,082NS	0,261NS	0,120NS	-0,034NS	0,544***	0,169NS	0,519***	0,288*	0,388**	0,147NS
Esophagus	0,334*	0,403**	0,488**	0,501**	0,320*	0,321*	0,078NS	0,152NS	0,158NS	0,111NS	-0,015NS
Stomach	0,527***	-0,101NS	0,286*	-0,027NS	-0,189NS	0,494***	0,085NS	0,377**	0,217NS	0,309*	0,075NS
Intestines	0,262*	0,018NS	0,041NS	-0,026NS	-0,069NS	0,283*	0,102NS	0,272*	0,320**	0,230NS	0,061NS
Spleen	0,145NS	0,153NS	0,139NS	0,142NS	0,045NS	0,257*	0,212NS	-0,020NS	-0,075NS	-0,094NS	0,029NS
Liver	0,147NS	0,126NS	0,194NS	0,151NS	0,088NS	0,238NS	0,186NS	0,130NS	0,088NS	-0,171NS	0,004NS
Kidneys	0,308*	0,132NS	0,444**	0,227NS	0,073NS	0,401**	0,270*	0,248NS	0,137NS	-0,086NS	0,139NS
Lungs	-0,312*	-0,042NS	0,243NS	0,188NS	0,157NS	-0,232NS	0,052NS	-0,338**	-0,199NS	-0,366**	0,058NS
Heart	0,356**	0,069NS	0,097NS	0,049NS	-0,066NS	0,432***	0,202NS	0,373**	0,313*	0,301*	0,173NS
Offal	0,673***	0,285NS	0,376*	0,281NS	0,116NS	0,629***	0,125NS	0,611***	0,452**	0,308*	0,124NS
P_Head	-0,670***	-0,100NS	-0,246NS	-0,118NS	0,037NS	-0,429***	0,268*	-0,396**	-0,309*	-0,130NS	0,330**
P_Offal	-0,510***	0,046NS	-0,159NS	0,033NS	0,179NS	-0,338*	0,159NS	-0,273NS	-0,306*	-0,229NS	0,189NS

SWT: Slaughter weight, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, HCW: Hot carcass weight, DP: Dressing percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, EDP: Empty dressing percentage, P_Head: percentage of head ; P_Offal: percentage of offal. **:P<0.05;**:P<0.01;***:P<0.001, NS (non significant):P>0.05.*

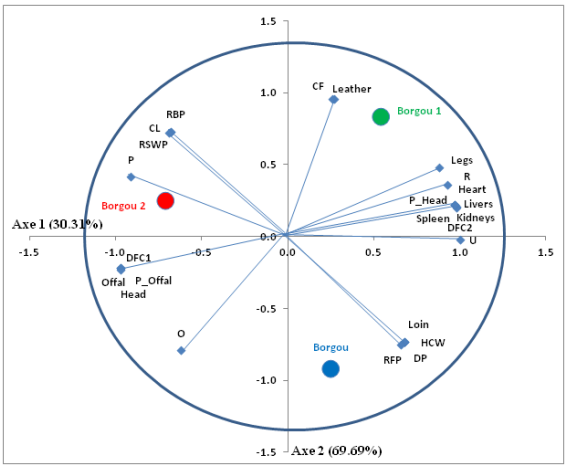
Hot carcass weight was not correlated with offal percentage and head percentage and weakly correlated with spleen weight (P<0.05, r=0.210) and highly and positively correlated with the others offal component weight (P<0.001, 0.316<r<0.847). The dressing percentage and the empty dressing percentage were positively correlated with the head

weight, the head percentage and the offal percentage (P<0.001). There was a high correlation between the dressing percentage and respectively liver weight or kidneys weight and those correlations were moderate between empty dressing percentage and kidney weight and weak between empty dressing percentage and liver weight. In general, the carcass length and the thigh thickness were positively correlated with offal weight and offal component weight. However, the carcass fat percentage was not correlated with offal weight and offal component weight, except intestines weight (Table 1). Finally, internal fat of carcass, kidney fat and carcass fat weight were variously correlated with offal component (Table 1).



CF : Carcass fat ; HCW: Hot carcass weight; DP: Dressing percentage; CL: Carcass length; Loin: *Longissismus thoracis* area; 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. P_Head: percentage of head; P_Offal: percentage of offal, Breed 1: rainy season; breed 2: dry season.

Fig. 1. Principal Components Analysis (PCA) of the cattle carcass characteristics and the offal components of Zebu Fulani bulls rose on natural pasture in Benin.

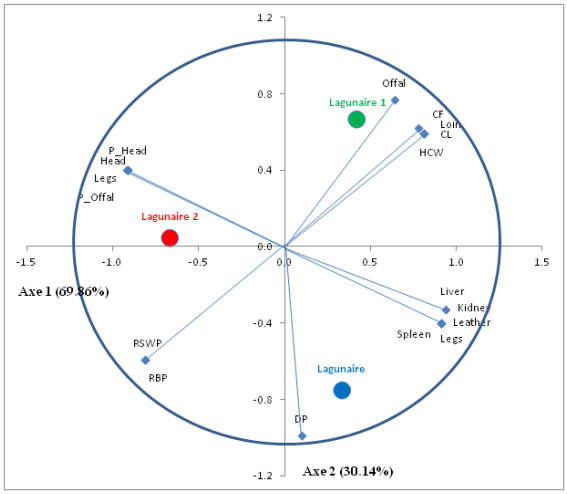


CF : Carcass fat ; HCW: Hot carcass weight; DP: Dressing percentage; CL: Carcass length; Loin: *Longissismus thoracis* area; RFP: Rib fat percentage; RBP: Rib bone percentage; RSWP: Rib segment waste percentage. U: Profiles on the whole convex; very good muscle development; R: Profiles on the whole straight; 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. P_Head: percentage of head; P_Offal: percentage of offal, Breed 1: rainy season; breed 2: dry season.

Fig. 2. Principal Components Analysis (PCA) of the cattle carcass characteristics and offal components of Borgou bulls rose on natural pasture in Benin.

Except liver weight, the correlations between slaughter weight and offal and offal components traits of Borgou bulls were similar to those of Zebu bulls. Whereas in Zebu bulls, the correlations between hot carcass weight and head percentage (r=-429, P<0.001) on the one hand and between hot carcass weight and offal percentage (r=-0.338, P<0.05) in the second hand were significant and negative and no relationship was observed between hot carcass weight and liver weight. Among offal components, the dressing percentage was only correlated with head percentage (r=0.268, P<0.05) and kidneys weight (r=0.270, P<0.05) and the empty dressing percentage was only linked to the head percentage (r=0.330, P<0.01) in Borgou bulls. Unlike Zebu bulls, no correlations were observed between carcass length and spleen weight, liver weight, kidneys weight, respectively whereas, the

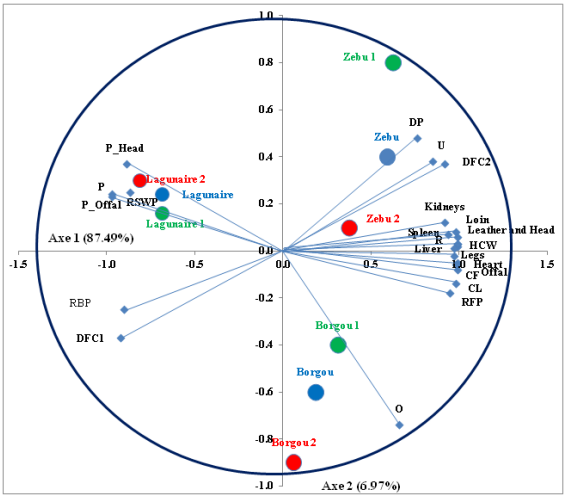
correlation between carcass length and head percentage was significant (r=-0.396, P<0.01) in Borgou bulls. Finally, low correlations were observed between offal components trait and internal fat of carcass, kidneys fat, carcass fat, thigh thickness, carcass fat percentage and rib muscle thickness in Borgou bulls (Table 2).



CF : Carcass fat ; HCW: Hot carcass weight; DP: Dressing percentage; CL: Carcass length; Loin: *Longissismus thoracis* area; RFP: Rib fat percentage; RBP: Rib bone percentage; RSWP: Rib segment waste percentage. 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. P_Head: percentage of head; P_Offal: percentage of offal, Breed 1: rainy season; breed 2: dry season.

Fig. 3. Principal Components Analysis (PCA) of the cattle carcass characteristics and the offal components of Lagunaire bulls rose on natural pasture in Benin.

Slaughter weight and hot carcass weight in Lagunaire bulls were less correlated with offal components traits than those in Borgou and Zebu bulls. The slaughter weight of Lagunaire bulls was correlated with offal components, except intestines weight, spleen weight, kidneys weight, head and offal percentages. Hot carcass weight was negatively correlated with esophagus weight, intestine weight and lungs weight whereas those correlations were positives in Borgou and Zebu bulls. The hot carcass weight and the liver weight were highly and significantly correlated (r=919, P<0.001) in Lagunaire. Unlike Zebu and Borgou bulls, the dressing percentage of Lagunaire bulls was negatively correlated with esophagus weight, intestines weight and lungs weight. In the same time, empty dressing percentage was also linked negatively with esophagus weight and spleen weight in Lagunaire bulls. Unlike Zebu cattle, the carcass length and the thigh thickness were inversely proportional with esophagus weight, intestines weight and lungs weight. Finally, internal fat of carcass, kidney fat and carcass fat weight were variously correlated with offal component in Lagunaire bulls (Table 3).



CF : Carcass fat ; HCW: Hot carcass weight; DP: Dressing percentage; CL: Carcass length; Loin: *Longissismus thoracis* area; 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. P_Head: percentage of head; P_Offal: percentage of offal, Breed 1: rainy season; breed 2: dry season.

Fig. 4. Principal Components Analysis (PCA) of the cattle carcass characteristics and the offal components of Zebu Fulani, Borgou and Lagunaire bulls raised on natural pasture in Benin.

In general, the carcass characteristics were better correlated with most of offal and offal component in Zebu bulls than in Borgou bulls while few carcass components were correlated with offal component in

Lagunaire bulls. The Borgou breed being a cross-breed between the Zebu White Fulani bull and the breed taurus cow, principally Somba cow and secondly, Lagunaire cow (Youssao *et al.,* 2007, Youssao *et al.,* 2009) in Benin while the Sanga breed being a cross-breed between the Zebu and the breed taurus cow, principally the West African Shorthorn breeds in Ghana (Sottie *et al.*, 2009, Darfour-Oduro *et al.,* 2010). However, other tendency were recorded by Teye and Sunkwa (2010) in Ghana, where slaughter weight, carcass weight, forequarter and hindquarter were highly correlated with internal and external offal component in Sanga bulls, very strong positive correlations were established between the carcass weight and the weights of heart, head and in Zebu bulls and only the liver and spleen had significant positive correlations with the live weights on the one hand and the legs and skin recorded negative correlations with live weights on the second hand, in the West African Shorthorn breeds.

The slaughter weight, the carcass weight and the carcass components weight which are highly correlated with offal components are good predictors that can be used to estimate the live weight and carcass weight where suitable weighing scales are not available for live weight and whole carcass weight. For example, Teye and Sunkwa (2010) predicted carcass weight by the regression equation using liver weight, spleen weight and heart weight in the West African Shorthorn breeds, Sanga breeds and Zebu breeds. In our study, the correlations between carcass weight and respectively liver, spleen, heart weights were highly significant in Zebu and Lagunaire bulls, thus, those offal components can be used to predict carcass weight by simple or multiple regression. By the contrast, the kidneys weight, the heart weight and the spleen weight were the best variables to predict carcass weight in Borgou bulls by simple or multiple regressions. The estimated carcass weight could then facilitate the estimation of the live weight and the pricing of the animal and meat.

Principal components analysis of carcass characteristics and offal component

In Zebu bulls, the Principal Components Analysis of the carcass characteristics and the offal component traits in Zebu showed that the high variability in body composition was mostly responsible for the first axis, which explains 76.65% of the variation and discriminated the Zebu bulls in terms of carcass traits and offal components regardless of the slaughter season. During the rainy season, the Zebu Fulani were characterized by their high internal offal (heart, spleen, kidneys and liver), their heavy head and leather, a good and very good carcass conformation (R and U) with slighter carcass fat cover while in the dry season, they were characterized by a carcass average muscle development conformation (O), a higher offal weight and offal percentage and a low carcass fat cover (figure 1). The second axis explains 23.67% of the variation and discriminated the Zebu in terms of carcass traits. In this axis, higher rib segment waste percentage opposed carcass traits including rib bone percentage, rib fat percentage, dressing percentage, carcass fat, hot carcass weight, carcass length.

The Principal Components Analysis of the carcass characteristics and the offal component traits in Borgou bulls showed that the high variability in body composition was mostly responsible for the first axis, which explains 69.69 % of the variation and discriminated the Borgou bulls in terms of carcass conformation, carcass degree of fat cover and offal components regardless of the slaughter season. During the rainy season, the Borgou bulls were characterized by their heavier internal offal weight (liver, spleen, kidneys and heart), a higher head percentage, a heavier legs and a good and very good carcass conformation (R and U) with slighter carcass fat cover while in the dry season the Borgou bull was characterized by a heavier head, a heavier offal, a higher offal percentage and a low carcass fat cover. As for Zebu bulls, the second axis explains 23.67% of the variation and discriminated the Borgou bulls in terms of carcass traits. In this axis, higher rib segment waste percentage, carcass length, rib bone

percentage and heavier leather weight opposed carcass traits including *longissimus thoracis* muscle areas, hot carcass weight, rib fat percentage, dressing percentage, carcass fat and hot carcass weight (Fig. 2).

With respect to the Principal Components Analysis of the carcass characteristics and the offal component traits in Lagunaire bulls, the first axis explains 69.86% of the variation and discriminated the Lagunaire in terms of carcass traits and offal components according to the slaughter season. The rainy season was characterized by heavier liver, kidneys, spleen, legs and leather whereas the dry season was characterized by higher head percentage and offal percentage, heavier head. The second axis explains 30.14 % of the variation and opposed rib bone percentage, rib segment waste percentage and dressing percentage to hot carcass weight, carcass length, carcass fat and *longissimus thoracis* muscle areas (Fig. 3).

Table 3. Relationship between carcass characteristics and offal components trait of Lagunaire cattle rose on natural pasture in Benin.

	SWT	IFC	KF	CF	CFP	HCW	DP	CL	TT	RMT	EDP
Legs	0,811***	0,130NS	0,600***	0,630***	0,327*	0,663***	0,265NS	0,724***	0,800***	0,548***	-0,036NS
Tail	0,432**	0,421**	0,271NS	0,568***	0,402*	0,528***	0,392*	0,775***	0,424**	0,382*	0,378*
Leather	0,755***	-0,044NS	0,875***	0,735***	0,262NS	0,895***	0,617***	0,762***	0,963***	0,614***	0,335*
Head	0,545***	0,003NS	0,154NS	0,138NS	-0,005NS	0,287NS	-0,029NS	0,489**	0,468**	0,011NS	-0,215NS
Esophagus	-0,382*	0,224NS	-0,734***	-0,471**	0,100NS	-0,850***	-0,845***	-0,934***	-0,734***	-0,460**	-0,631***
Stomach	0,549***	0,159NS	0,467**	0,535***	0,196NS	0,664***	0,473**	0,873***	0,650***	0,389*	0,338*
Intestines	-0,211NS	0,690***	-0,758***	-0,126NS	0,362*	-0,580***	-0,611***	-0,406**	-0,571***	-0,432**	-0,204NS
Spleen	-0,149NS	0,444**	-0,132NS	0,232NS	0,234NS	0,141NS	0,315*	0,475**	-0,096NS	0,061NS	0,592***
Liver	0,734***	-0,055NS	0,887***	0,738***	0,243NS	0,919***	0,667***	0,796***	0,959***	0,617***	0,392*
Kidneys	-0,251NS	0,504NS	-0,355*	0,082NS	0,222NS	-0,077NS	0,103NS	0,282NS	-0,292NS	-0,103NS	0,447**
Lungs	-0,588***	0,547***	-0,803***	-0,278NS	0,212NS	-0,647***	-0,405*	-0,399*	-0,779***	-0,451**	0,105NS
Heart	0,352*	0,462**	0,195NS	0,533***	0,447**	0,422**	0,314*	0,688***	0,349*	0,349*	0,398*
Offal	0,527***	0,343*	0,296NS	0,529***	0,333*	0,523***	0,303NS	0,743***	0,532***	0,284NS	0,278NS
P_Head	-0,275NS	-0,181NS	-0,368*	-0,466**	-0,378*	-0,277NS	-0,169NS	0,065NS	-0,167NS	-0,483**	-0,032NS
P_Offal	-0,193NS	0,223NS	-0,159NS	0,035NS	0,038NS	0,054NS	0,219NS	0,414**	-0,027NS	-0,129NS	0,495**

SWT: Slaughter weight, ICF: Internal fat of carcass, KF: Kidney fat, CF: Carcass fat, CFP: Carcass fat percentage, HCW: Hot carcass weight, DP: Dressing percentage, CL: Carcass length, TT: Thigh thickness, RMT: Rib muscle thickness, EDP: Empty dressing percentage, P_Head: percentage of head; P_Offal: percentage of offal. **:P<0.05;**:P<0.01;***:P<0.001, NS (non significant):P>0.05.*

Principal Components Analysis of the carcass characteristics and the offal component traits discriminated the three breeds according to their butcher aptitude. The first axis explains 87.49% of the variation and opposed Lagunaire bull's body composition performances to those of Zebu bulls, while the Borgou bulls performances were in the middle whatever the season. The Zebu bulls were characterized by higher dressing percentage, rib fat percentage and carcass length, heavier hot carcass weight, carcass fat weight, offal and offal component weight, a good and very good carcass conformation (R and U) with slighter carcass fat cover while Lagunaire bulls were characterized by higher head percentage, offal percentage, rib segment waste percentage, rib bone percentage on the one hand and a poor carcass conformation and a low carcass fat cover in the second hand. The second axis characterized the body composition performances of Borgou bulls which were in the middle of those of Lagunaire and Zebu bulls, whatever the season. The Borgou bulls were characterized by a fair carcass conformation (O), which is located between P

conformation of Lagunaire bulls and R conformation of Zebu bulls.

Principal Components Analysis of the carcass characteristics and the offal component traits discriminated the three breeds according to their butcher aptitude regardless of the slaughter season. The body composition performances of Borgou bulls were in the middle of those of Lagunaire and Zebu bulls, whatever the season. The differences in carcass and offal traits between breeds could be accounted for by the differences in live weights due to their genetic differences. These results are in accordance with Moazami-Goudarzi *et al.* (2001) who reported that the frequency of the alleles in the Borgou is located between Zebu and that of the Lagunaire using 51 markers microsatellite. Similar results were observed in Aubrac, Salers and Aubrac systems in terms of slaughter performance (Renand *et al.,* 2002). The carcasses are heavier and leaner in Aubrac system; they have a lesser conformation in Salers system and a better dressing percentage in Gascon system (Renand *et al.,* 2002).

Carcass qualities take into account carcass conformation and degree of carcass fat cover (Council Regulation N°1249/2008). Thus, principal components analysis of carcass characteristics and offal component traits showed high correlations between U and R conformations, slight carcass fat cover and most of carcass characteristics and offal components trait in Zebu bulls and in Borgou bulls. Therefore, the improvement of carcass conformation increases internal offal components and decrease offal percentage and poor carcass conformation and carcass low fat degree of cover, with an inconvenient to improve head and legs weights. With respect to Lagunaire bulls, the carcass qualities improvement will be due by fattening in order to improve at least the carcass degree of fat cover, and if possible, the carcass conformation.

Conclusion

The relationship between carcass characteristics and offal component shows that the carcass characteristics are better correlated with most of offal and offal component in Zebu bulls than in Borgou bulls while few carcass components are correlated with offal component in Lagunaire bulls. The season influenced the carcass characteristics and the offal component. During the rainy season, the Zebu Fulani are characterized by their high internal offal, their heavy head and leather, a good and very good carcass conformation with slighter carcass fat cover while in the dry season; they are characterized by a carcass average muscle development conformation, a higher offal weight and offal percentage and a low carcass fat cover. The Borgou bulls are characterized by their heavier internal offal weight, a higher head percentage, a heavier legs and a good and very good carcass conformation with slighter carcass fat cover in the rainy season, while they are characterized by a heavier head, a heavier offal, a higher offal percentage and a low carcass fat cover in the dry season. The rainy season is characterized by heavier liver, kidneys, spleen, legs and leather in Lagunaire bulls, whereas the dry season is characterized by higher head percentage and offal percentage, heavier head. The butcher aptitude of Borgou bulls is in the middle of those of Lagunaire and Zebu bulls, whatever the season. Finally, further study on those three breed raised on natural pasture is required to achieve their meat qualities.

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