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Research Article

Assessment of Offal Components of Lagunaire, Borgou and Zebu Fulani Bulls Raised on Natural Pasture and Analysis of Macroscopic Lesions Associated with Potential Hazards for the Consumer

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Abstract: The offal is well appreciated by consumers in sub-Saharan Africa and viscera are sold at the same price as the carcass meat. Therefore, the aim of this study was to assess on the offal components yield of Lagunaire, Borgou and Zebu Fulani bulls raised on natural pasture and to examine the macroscopic lesions associated with potential hazards for the consumer. Offal was collected from the slaughterhouse of Cotonou-Porto-Novo in 40 Lagunaire, 71 Borgou and 110 Zebu Fulani bulls. The Zebu bulls offal weight and offal components weight were significantly higher than those of the Borgou bulls ($p<0.001$), whereas the Lagunaire bulls level were the lowest ($p<0.001$). The Zebu Fulani offal percentage was heavier, followed by the Borgou bulls whereas the Lagunaire had a higher head percentage and a higher offal percentage in the carcass. During the rainy season, the viscera weights of Borgou and Zebu bulls were higher than during the dry season; they were characterized by a higher external offal weight. Nevertheless, the Lagunaire bulls were weakly discriminated whatever the season. The offal components were condemned for 20 affections or diseases at the post mortem inspection. The main causes of lungs seizure were tuberculosis (43.04%) and pulmonary emphysema (21.41%). The diaphragm was also affected by tuberculosis (93.3%) and scarcely by abscess (3.70%). Livers were affected by fascioliasis (41.43%), dicrocoeliasis (22.92%) and tuberculosis (15.77%). Spleen's seizure was mainly due to congestion (56.99%) and to tuberculosis (32.26%). Nephritis (49.79%), tuberculosis (33.75%) and hydronephrosis (13.81%) caused kidneys seizure. Tuberculosis (76.09%) and oesophagostomiasis (23.91%) were main causes of intestines seizure. Abscess (87.5%) and tuberculosis (12.5%) were the major responsible of tongue's seizure. Owing to affections or diseases frequency in slaughtered animals, it could be suggested a strengthening of the veterinary care during cattle breeding.

Keywords: Benin, breed, bull, inspection, offal, viscera

INTRODUCTION

In Benin, the beef consumption is mainly issued from the national production composed of genetic diversity including the Lagunaire, the Somba, the Borgou and the Zebu cattle, formally, the zebu Fulani, the White Fulani and the Red M'Bororo. Among these breeds, Borgou, Zebu Fulani and Lagunaire are frequently slaughtered (Assogba and Youssao, 2002). To know slaughter performance of these breeds, Salifou *et al*. (2012) assessed their carcass characteristics. The last study included the bulls raised solely on natural pasture, this livestock system being practiced by almost the cattle breeders in Benin. Zebu Fulani carcasses had a high dressing percentage, an important rib muscle thickness, a low fat cover and a less carcass fat percentage while Borgou carcasses were characterized by a high carcass fat percentage and a better carcass conformation. Moreover, 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. Unlike the research carried out by

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Teye and Sunkwa (2010) in West African Shorthorn, Sanga and zebu bull of Ghana, the offal characteristics were not taken into account by Salifou *et al*. (2012) despite their preference by consumers. The offal is composed by to groups: external offal and internal offal. The external offal is composed by the head, the legs, the tail and the skim while the internal offal correspond the thoracic and abdominal viscera (esophagus, stomach, intestines, spleen, liver, lungs, kidneys, heart). Sub-Saharan Africa consumers didn't make any distinction between the internal offal, the muscle *Longissimus dorsi* and the external offal in terms of price. The head, the legs and the tail are particularly consumed at major cultural or religious events or in restaurants. Despite their importance in African cooking, offal components are often partially or totally seized during the *post mortem* veterinary inspection because they are considered as unfit for human consumption on basis of lesions indicating affection or disease (Cabre *et al*., 2005; Fosse *et al*., 2006). These affections or diseases can be zoonotic diseases (Cabre *et al*., 2005; Fosse *et al*., 2006). To characterize the offal components and to ensure food safety, this study was planned to:

- Assess the bull offal characteristics according to the breed and the slaughter season
- Establish the relationships between the offal components of each breed and in overall breeds
- Examine the macroscopic lesions related to potential hazards for the consumer

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 began at 4 o'clock in the morning and finished at 12 o'clock. About, 50 cattle were slaughtered per day; Zebu Fulani and Borgou breeds were provided from Alibori and Borgou Departments. Lagunaire were scarcely slaughtered and came from Zou Department.

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 Borgou Department is located in the northeast of Benin between 8°52' and 10°25' North latitude and 2°36' and 3°41' East longitude and covers 25856 km². This Department is characterized by Sudanese climate type with one dry season (from November to May) and one rainy season (from June to October). The mean yearly rainfall varies from 900 to 1200 mm (Adam and Boko, 1993). The harmattan, a dry and dusty wind, blows from December to February.

The Zou Department is located between 6.65°26' and 7°10' North latitude and 2.25°14' and 2°4' East longitude, in the center of Benin and covers 5243 km². The climate is sub-equatorial type characterized by two rainy seasons: the great one, from April to July and the small one, from September to November. These two seasons are slipped in between dry seasons. The average rainfall is 1200 mm/year (Adam and Boko, 1993).

Choice of animals: Animals were transported from their native Departments at least 48 h before slaughtering. Just on 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, determined from the dental table) and the livestock practices (sedentary or transhumant, 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 grazing technique used during livestock (natural or artificial) and dietary supplement given during fattening, the livestock system (transhumance or sedentary), etc. This interview allows to confirm the type of breed and the age at slaughter. The slaughtered bulls were all raised on natural pasture. In all, 71 Borgou bulls, 110 zebu bulls and 40 Lagunaire bulls were selected for this study.

Slaughtering process: Selected animals were submitted to the ante-mortem inspection by an official veterinarian before slaughtering. Animals were slaughtered by the section of the jugular vein without stunning or anesthesia following the Halal procedure. After a complete bleeding, slaughtered animals were manually skinned. Head and feet were not skinned but chopped off and singed afterwards. After evisceration, empty carcasses were split along the backbone into halves. The digestive tract was emptied of its contents and carefully cleaned. Head, legs, leather, thoracic and abdominal viscera and two half-carcass were finally subjected to the post-mortem inspection. Slaughter was carried out in September and October for the rainy season and from February to March for the dry season.

Data collection: The weight before slaughtering was taken a day before 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 measure hot carcass weight. Full and empty digestive tract (esophagus, stomach and intestines), spleen, liver, lungs, kidneys, heart, head, skin, tail and legs, were also

weighed. The offal percentages were then calculated by multiplying the ratio between offal weights and live weights by hundred while the head percentage was calculated by multiplying the ratio between the head weight and the live weight by hundred.

Statistical analysis: The Statistical Analysis System software (SAS, 2006) was used for data analysis. Variation's factors considered were the breed of slaughtered bull (Zebu Fulani, Borgou and Lagunaire) and the season of slaughter (rainy season and dry season). Interaction between the breed and the season was significant and then 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} = The offal weight or the offal components characteristic of the animal k; breed i and slaughter season j
μ = The overall mean
B_i = The fixed effect of the breed i (Zebu Fulani, Borgou and Lagunaire)
SS_j = The fixed effect of the slaughter season j (dry season and rainy season)
$B*SS_{ij}$ = The interaction between the breed i and the slaughter season j
e_{ijk} = 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 (2006). The season effect and the breed effect on offal component condemnation were not significant and the overall frequencies of seizure of each organ were calculated by *Proc Freq* procedure of SAS (2006). The comparisons of frequencies 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

Breed effect on offal traits: The offal components traits expressed in terms of least squares means and standard errors are presented in Table 1. Offal components characteristics varied among breeds ($p<0.01$). The offal weight, the legs, the tail, the skin, the head, the esophagus, the stomach, the intestines and the heart of the Zebu bulls were significantly higher than those of the Borgou bulls ($p<0.001$) whereas Lagunaire bulls had the lowest performances ($p<0.001$). However, the spleen, the liver, the kidneys, the lungs, the head percentage and the offal percentage of Zebu bulls were similar to those of the Borgou and significantly higher ($p<0.001$) than those obtained in Lagunaire bulls.

Effect of season on offal traits: The skin weight, the head weight and the head percentage, the stomach and the intestines weight, the offal weight and the offal percentage and the lungs weight of bulls slaughtered in rainy season were not significantly different from those of bulls slaughtered in dry season. However, the legs, the tail, the esophagus, the spleen, the liver, the kidneys and the heart of bulls slaughtered in rainy season were heavier ($p<0.05$) than those of bulls slaughtered in dry season (Table 1).

Interaction between breed and season effect: The interaction between breed and season effects was not significant for the skin weight, the esophagus weight, the stomach weight, the intestines weight, the spleen weight, the kidneys weight, the lungs weight, the heart weight, the offal weight and the offal percentage. By contrast to the Lagunaire and the Borgou bulls, the liver weight, the head weight and the head percentage, the legs and the tail weights of the zebu bulls were affected by the season and they are significantly heavier ($p<0.05$) in rainy season than those obtained during dry season (Table 2).

Relationship between offal component traits: Simple linear correlations between carcass traits are given by breeds in Table 3, 4 and 5, respectively for Lagunaire, Borgou and Zebu Fulani bulls. Correlations between offal components were variously observed according to the breeds. Offal weight was highly and positively correlated with respectively legs weight, tail weight, skin weight in the three horned cattle breeds ($p<0.001$) and their correlation coefficients varied from 0.534 to 0.925. By contrast, the offal weight was highly significant and positively correlated with the rumen weight, spleen weight, kidneys weight and heart weight in Zebu and Lagunaire bulls ($p<0.01$) whereas no significant correlations were obtained between offal weight and those components. The correlation between offal weight and esophagus weight was negative and high in Lagunaire Bull ($r = -0.642$, $p<0.001$), positive and high in Zebu bulls ($r = 0.386$, $p<0.001$) and not significant in Borgou bulls. With respect to the percentage of offal weight, it was significantly correlated with most of the offal components traits in Lagunaire bulls and with only head percentage and lungs weight in Borgou bulls ($p<0.001$) and with respectively head percentage, offal weight, intestines weight and stomach weight in Zebu bulls ($p<0.05$).

Table 1: Effect of slaughter season and breed on the offal components of cattle raised on natural pasture in Benin

	Breed						Season					
	Borgou		Lagunaire		ZebuFulani		Rainy season		Dry season		Test of significance	
Variable	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Breed	Season
Slaughter weight (kg)	287.67b	6.33	142.30c	9.47	346.48a	4.74	262.80a	5.59	254.83a	6.03	***	NS
Legs (kg)	6.61b	0.14	3.27c	0.16	7.67a	0.10	6.03a	0.10	5.67b	0.12	***	*
Tail (kg)	2.70b	0.08	1.12c	0.10	3.09a	0.06	2.41a	0.06	2.20b	0.07	***	*
Skin (kg)	18.07b	0.60	9.13c	0.71	23.42a	0.48	17.35a	0.45	16.80a	0.50	***	NS
Head (kg)	17.26b	0.35	10.64c	0.42	20.46a	0.25	16.41a	0.27	15.83a	0.30	***	NS
Esophagus (kg)	0.46b	0.03	0.29c	0.04	0.65a	0.02	0.52a	0.03	0.41b	0.03	***	**
Rumen (kg)	9.79b	0.31	7.70c	0.36	11.53a	0.22	9.88a	2.23	9.47a	0.26	***	NS
Intestines (kg)	7.25b	0.27	4.95c	0.31	8.28a	0.19	7.01a	0.20	6.65a	0.22	***	NS
Spleen (kg)	1.01a	0.05	0.60b	0.06	1.12a	0.40	1.02a	0.04	0.80b	0.04	***	***
Liver (kg)	3.98a	0.13	2.01b	0.15	4.43c	0.09	3.89a	0.10	3.06b	0.11	***	***
Kidneys (kg)	0.83a	0.04	0.59b	0.05	0.91a	0.03	0.86a	0.03	0.69b	0.03	***	***
Lungs (kg)	2.17a	0.13	1.54b	0.16	2.22a	0.10	2.12a	0.10	1.83a	0.11	**	NS
Heart (kg)	1.25b	0.03	0.81c	0.04	1.33a	0.02	1.20a	0.02	1.06b	0.03	***	***
Offal (kg)	66.82b	1.64	44.61c	1.74	79.93a	1.11	61.77a	1.23	64.33a	1.25	***	NS
Head (%)	6.06a	0.09	7.49b	0.11	6.04a	0.07	6.59a	0.06	6.47a	0.05	***	NS
Offal (%)	23.70b	0.36	29.97a	0.39	23.38b	0.25	25.31a	0.27	26.06a	0.28	***	NS

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; S.E.: Standard error; The means between the classes of the same line followed by different letters differ significantly with the threshold of 5%; : % of live weight

Table 2: Effect of interaction between breeds and slaughter season on the offal components in cattle raised on natural pasture in Benin

	Lagunaire				Borgou				Zebu				
	Rainy season		Dry season		Rainy season		Dry season		Rainy season		Dry season		
Variable	Means	S.E.	Means	S.E.	Means	S.E.	Means	S.E.	Means	S.E.	Means	S.E.	Test of significance
Slaughter weight (kg)	145.00c	13.39	139.60c	13.39	292.59b	7.26	282.76b	10.37	350.81a	7.06	342.15a	6.33	NS
Legs (kg)	3.34a	0.23	3.20a	0.23	6.64b	0.15	6.60b	0.23	8.12c	0.14	7.22c	0.15	*
Tail (kg)	1.14a	0.13	1.10a	0.13	2.73b	0.09	2.66b	0.13	3.36a	0.08	2.92b	0.07	*
Skin (kg)	9.28a	1	8.98a	1.00	18.86b	0.67	18.49b	0.99	23.93c	0.63	22.84c	0.56	NS
Head (kg)	10.54a	0.59	10.74a	0.59	17.25b	0.39	17.27b	0.59	21.43c	0.37	19.49d	0.33	*
Esophagus (kg)	0.30a	0.05	0.28a	0.05	0.54b	0.04	0.38b	0.05	0.72c	0.03	0.58c	0.03	NS
Rumen (kg)	7.80a	0.50	7.60a	0.50	10.24b	0.34	9.33b	0.51	11.59c	0.32	11.47c	0.29	NS
Intestines (kg)	4.94a	0.44	4.96a	0.44	7.52b	0.29	6.98b	0.44	8.56c	0.28	8.01c	0.25	NS
Spleen (kg)	0.62a	0.09	0.58a	0.09	1.20b	0.06	0.81b	0.09	1.25c	0.05	1.00c	0.05	NS
Liver (kg)	2.04a	0.22	1.97a	0.22	4.60b	0.14	3.36c	0.22	5.02d	0.14	3.84e	0.12	**
Kidneys (kg)	0.62a	0.07	0.56a	0.07	0.97b	0.05	0.68b	0.07	0.99c	0.04	0.84c	0.04	NS
Lungs (kg)	1.56a	0.22	1.52a	0.22	2.45b	0.15	1.89b	0.22	2.36c	0.14	2.07c	0.13	NS
Heart (kg)	0.84a	0.05	0.78a	0.05	1.31b	0.04	1.19b	0.05	1.45c	0.03	1.20c	0.03	NS
Offal (kg)	42.94a	2.46	42.28a	2.46	63.99b	2.16	69.64b	2.46	78.38c	1.71	81.48c	1.38	NS
Head (%)	7.28a	0.15	7.70a	0.15	6.10b	0.10	6.02b	0.15	6.40c	0.10	5.67d	0.09	***
Offal (%)	29.66a	0.55	30.29a	0.55	23.10b	0.48	24.27b	0.55	23.18b	0.39	23.59b	0.31	NS

*: p<0.05; **: p<0.01; ***: <0.001; NS: p>0.05; S.E.: Standard error; The means between the classes of the same line followed by different letters differ significantly with the threshold of 5%. : % of live weight

Table 3: Relationship between on the offal components in lagunaire cattle raised on natural pasture in Benin

	Tail	Skin	Head	Esophagus	Rumen	Intestines	Spleen	Liver	Kidneys	Lungs	Heart	Offal	P_head	P_offal
Legs	0.697***	0.777***	0.813***	-0.603***	0.846***	-0.238NS	0.150NS	0.760***	0.024NS	-0.478**	0.647***	0.797***	0.215NS	0.277NS
Tail		0.507***	0.646***	-0.610***	0.897***	0.143NS	0.747***	0.521***	0.660***	0.116NS	0.952***	0.925***	0.353*	0.726***
Skin			0.437**	-0.733***	0.691***	-0.397*	0.040NS	0.997***	-0.154NS	-0.627***	0.441**	0.627***	-0.168NS	0.105NS
Head				-0.368*	0.753***	0.030NS	0.183NS	0.410**	0.160NS	-0.215NS	0.579***	0.766***	0.654***	0.458**
Esophagus					-0.811***	0.471**	-0.446**	-0.775***	-0.241NS	0.428**	-0.575***	-0.642***	-0.083NS	-0.426**
Rumen						-0.060NS	0.598***	0.705***	0.468**	-0.169NS	0.874***	0.956***	0.377*	0.664***
Intestines							0.414**	-0.412**	0.580***	0.843***	0.244NS	0.197NS	0.229NS	0.395*
Spleen								0.086NS	0.972***	0.598***	0.821***	0.649***	0.349*	0.869***
Liver									-0.115NS	-0.614***	0.461**	0.631***	-0.181NS	0.126NS
Kidneys										0.751***	0.749***	0.562***	0.413**	0.854***
Lungs											0.245NS	0.031NS	0.286NS	0.511***
Heart												0.921***	0.355*	0.786***
Offal													0.414**	0.732***
P_head														0.710***

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; All components are related in terms of weight except P_head: Percentage of head; P_offal: Percentage of offal

Liver weight was highly and positively correlated with spleen weight, kidneys weight and heart weight in Borgou bulls, whereas liver weight was highly linked with most of offal components traits. The liver weight was positively and highly correlated with esophagus weight (r = 0.386, p<0.001) in Zebu bulls and negatively and highly correlated in Lagunaire bulls and no significant in Borgou bulls. The correlations between head percentage and others offal components were weak especially in Zebu and Borgou bulls.

Principal components analysis: The Principal Components Analysis (PCA) of offal components characteristics showed that the high variability in offal

Table 4: Relationship between on the offal components in borgou cattle raised on natural pasture in Benin

	Tail	Skin	Head	Esophagus	Rumen	Intestines	Spleen	Liver	Kidneys	Lungs	Heart	Offal	P_head	P_offal
Legs	0.738***	0.503***	0.380**	0.349*	0.242NS	0.214NS	0.041NS	0.174NS	0.315*	-0.126NS	0.281*	0.534***	-0.321**	-0.138NS
Tail		0.597***	0.450***	0.420**	0.252*	0.295*	0.021NS	0.066NS	0.284*	-0.112NS	0.236NS	0.547***	-0.233NS	-0.140NS
Skin			0.535***	0.165NS	0.331**	0.290*	0.150NS	0.091NS	0.247NS	-0.287*	0.285*	0.728***	-0.293*	-0.137NS
Head				0.170NS	0.384**	0.371**	0.018NS	0.088NS	0.280*	-0.225NS	0.411***	0.732***	0.272 NS	-0.011NS
Esophagus					0.254NS	0.164NS	0.337*	0.268NS	0.354*	0.105NS	0.209NS	0.206NS	-0.101NS	-0.168NS
Rumen						0.416***	0.009NS	0.028NS	0.224NS	-0.215NS	0.215NS	0.272NS	-0.253*	-0.229NS
Intestines							-0.078NS	0.070NS	0.126NS	-0.178NS	0.205NS	0.414**	0.017NS	0.199NS
Spleen								0.701***	0.539***	0.217NS	0.368**	-0.036NS	-0.081NS	0.040NS
Liver									0.531***	0.015NS	0.451***	0.081NS	-0.090NS	-0.092NS
Kidneys										0.200NS	0.278*	0.129NS	-0.048NS	-0.115NS
Lungs											-0.031NS	-0.172NS	0.283*	0.613***
Heart												0.364*	-0.055NS	0.023NS
Offal													-0.014NS	0.250NS
P_head														0.650***

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; All components are related in terms of weight except P_head: Percentage of head; P_offal: Percentage of offal

Table 5: Relationship between the offal components in zebu fulani cattle raised on natural pasture in Benin

	Tail	Skin	Head	Esophagus	Rumen	Intestines	Spleen	Liver	Kidneys	Lungs	Heart	Offal	P_head	P_offal
Legs	0.762***	0.755***	0.792***	0.469***	0.531***	0.466***	0.228*	0.623***	0.465***	0.578***	0.382***	0.758***	0.069NS	0.050NS
Tail		0.663***	0.680***	0.522***	0.496***	0.403***	0.200*	0.550***	0.468***	0.509***	0.388***	0.658***	0.005NS	-0.020NS
Skin			0.723***	0.376***	0.567***	0.493***	0.201*	0.497***	0.536***	0.408***	0.258**	0.904***	-0.075NS	0.170NS
Head				0.448***	0.502***	0.483***	0.117NS	0.592***	0.418***	0.511***	0.287***	0.755***	0.287**	-0.007NS
Esophagus					0.277**	0.172NS	0.348***	0.331***	0.282**	0.369***	0.256**	0.386***	0.124NS	0.057NS
Rumen						0.613***	-0.057NS	0.314***	0.424***	0.425***	0.161NS	0.683***	-0.000NS	0.289**
Intestines							0.028NS	0.357***	0.439***	0.319***	0.144NS	0.616***	0.126NS	0.385***
Spleen								0.538***	0.440***	0.429***	0.387***	0.272**	-0.013NS	0.105NS
Liver									0.481***	0.701***	0.438***	0.494***	0.191*	0.071NS
Kidneys										0.470***	0.186NS	0.481***	0.108NS	0.186NS
Lungs											0.333***	0.489***	0.086NS	0.066NS
Heart												0.218*	-0.038NS	-0.152NS
Offal													-0.130NS	0.211*
P_head														0.541***

*: p<0.05; **: p<0.01; ***: p<0.001; NS: p>0.05; All components are related in terms of weight except P_head: percentage of head; P_offal: Percentage of offal

Table 6: Visually detectable lesions observed at the post mortem inspection (the results are expressed in % of slaughtered animals)

Number of slaughtered animals	Lesion or disease	Lungs	Heart	Diaphragm	Liver	Spleen	Kidneys	Intestines	Ganglions	Tongue
25815	Abcess	0.51g	0.00d	3.70b	9.40d	8.60c	1.95d	0.00c	51.21a	87.50a
25815	Angioma	0.00k	0.00d	0.00b	6.73e	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Congestion	0.73f	2.50c	0.00b	0.24h	56.99a	0.56e	0.00c	2.13d	0.00c
25815	Pulmonary emphysema	21.41b	0.00d	0.00b	0.00h	0.00d	0.00e	0.00c	0.00e	0.00c
3830	Footandmouth diseases	0.00	0.00d	0.00b	0.00h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Fascioliasis	0.00	0.00d	0.00b	41.43a	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Hepatization	1.08f	0.00d	0.00b	0.00h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Hepatitis	0.00k	0.00d	0.00b	0.71g	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Hydronephosis	0.00k	0.00d	0.00b	0.00	0.00d	13.81	0.00c	0.00e	0.00c
25815	Jaundice (icterus)	0.03k	0.00d	0.00b	0.30h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Cyst	0.16j	0.00d	0.00b	1.55f	0.00d	0.14e	0.00c	0.00e	0.00c
25815	Nephritits	0.00k	0.00d	0.00b	0.00h	0.00d	49.79a	0.00c	0.08	0.00c
25815	Oesophagostomiasis	0.00k	0.00d	0.00b	0.00h	0.00d	0.00e	23.91b	0.00e	0.00c
25815	Dicrocoeliasis	0.00k	0.00d	0.00b	22.92b	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Pericaditis	0.00k	72.50a	0.00b	0.00h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Pleuritis	18.86c	0.00d	0.00b	0.00h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Pneumonia	9.00d	0.00d	0.00b	0.00h	0.00d	0.00e	0.00c	0.08	0.00c
25815	CBPP*	0.22h	0.00d	0.00b	0.12h	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Sclerosis	0.27j	0.00d	0.00b	0.83g	0.00d	0.00e	0.00c	0.00e	0.00c
25815	Splenitis	0.00	0.00d	0.00b	0.00	2.15	0.00e	0.00c	4.63b	0.00c
25815	Bovine tuberculosis	43.04a	25b	96.30a	15.77c	32.26	33.75	76.09a	41.86a	12.50b
Total		100	100	100	100	100	100	100	100	100

*CBPP: Contagious bovine pleuropnomoniae; The means between the classes of the same line followed by different letters differ significantly with the threshold of 5%

composition was mostly responsible for the first axis, which explains 93.53% of the variation. In this axis, the weight of each offal component weight opposed the percentage of offal in the slaughter weight and the percentage of head in the slaughter weight. The second axis explains 2.70% of the variation. In this axis, the viscera (kidney, lungs, spleen, liver, esophagus, heart, stomach and intestines) weight opposed the butchery byproducts weight (tail, head, legs, skin) and the offal weight. The projections of these variables on the first two main axes are reported in Fig. 1.

The Principal Components Analysis discriminated the three breeds in terms of offal components traits regarding the slaughter season. The Zebu Fulani offal was characterized by a heavier offal components, followed by the Borgou bulls whatever the season.On the other hand, Lagunaire offal components were characterized by a higher head percentage and a higher offal percentage in the carcass (Fig. 1). The offal components were greatly discriminated by season effect. During the rainy season, Borgou and Zebu bulls were characterized by a higher viscera weight while in the dry season, they were characterized by a higher butchery byproducts weight (Fig. 1). Finally, Lagunaire bulls were weakly discriminated whatever the season.

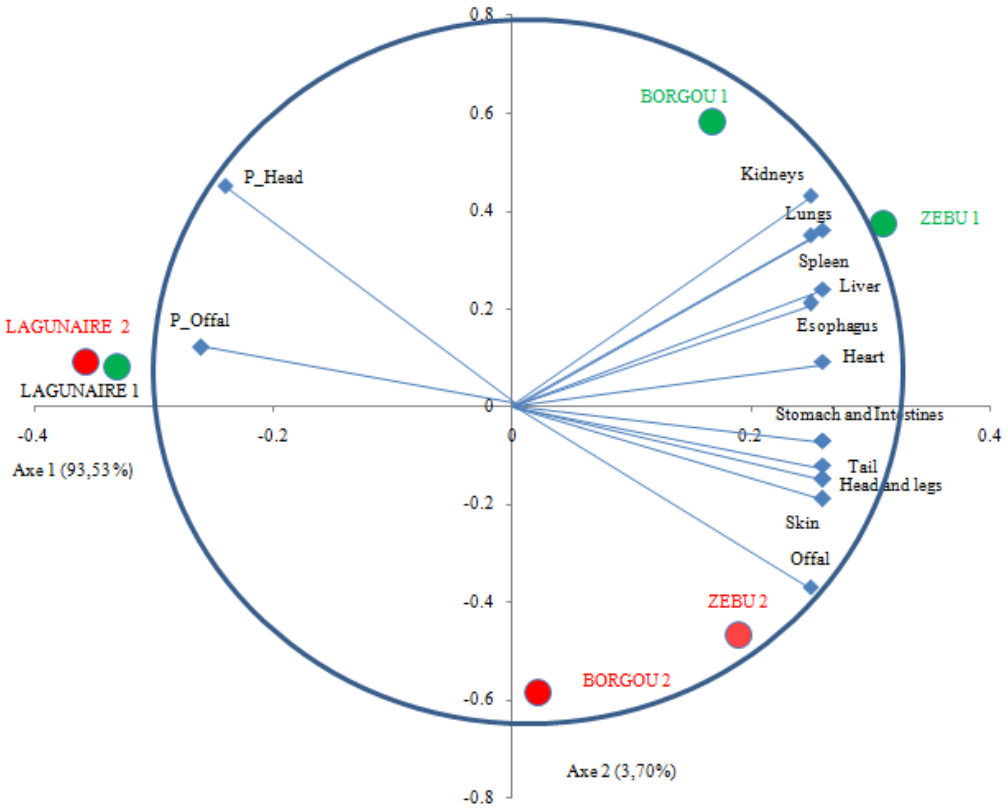

Fig. 1: Principal Components Analysis (PCA) of the offal traits in zebu fulani, borgou and lagunaire bulls raised on natural pasture in Benin
Breed 1: Rainy season; Breed 2: Dry season

Macroscopic lesions related to potential hazards for consumer: The number of cattle slaughtered from September 2007 to August 2009 was 25815. In total, 20 affections and diseases were identified on basis of lesions observed on 9 organs (Table 6). Among those diseases and affections, pulmonary tuberculosis prevalence was the highest (6.15% and $p<0.001$).

Except the ganglion seized due to abscess, pulmonary emphysema was the main frequent cause of seizures after tuberculosis with a prevalence of 3.06%. The prevalence of pleurisy, fascioliasis, dicrocoeliose and nephritis were respectively 2.7, 2.7, 1.49 and 1.38%. Pneumonia was also reported with a frequency of 1.29%. Other diseases such as contagious bovine pleuropneumoniae and the oesophagostomiasis were less observed (<1%). Likewise, lesions of splenite, of sclerosis, putrefaction, pericarditis, nephritis, cyst, jaundice, of hydronephrosis, hepatitis and lung's hepatisation, congestion and Angioma, were also observed.

Offal components seized at the slaughterhouse of Cotonou -Porto-Novo included lungs, heart, diaphragm, liver, spleen, kidney, intestines and tongue. Lungs were frequently seized than the others organs ($p<0.001$). On 3690 seized lungs, the frequency of lungs seized for the tuberculosis (43%) was significantly greater ($p<0.01$) than that of the pulmonary emphysema (21.4%). Pleurisy and pneumonia came in 3rd and 4th positions with respective prevalence of 19 and 9%. Abscess, congestion, hepatization, cyst, putrefaction, contagious bovine pleuropneumoniae and sclerosis were other causes of lungs seizures in slaughtered animals. The first cause of seizure of the heart was pericarditis (72.5%), followed by tuberculosis (25%) and finally, congestion (2.5%). The difference between the frequencies of these three causes of liver seizure was highly significant ($p<0.001$).

The main cause of the diaphragm seizure was tuberculosis (93.3%) and abscess was scarce (3.70%). Livers were seized for various parasitic causes such as fascioliasis (41.4%) and dicrocoeliasis (22.9%). Livers were also seized for tuberculosis (15.8%). Lesions of abscesses, angioma, congestion, hepatitis, cyst and sclerosis were also observed in liver affections (Table 6).

Congestion was the main cause of spleen's seizure at the slaughterhouse of Cotonou-Porto-Novo with a frequency of 57% followed by tuberculosis (32%). Spleen's abscesses and inflammations were obtained respectively with the frequencies of 8.6 and 2.15%. Nephritis was the seizure cause of the half of total kidney affections and a third was attributed to

tuberculosis. Hydronephrosis was responsible of 14% of kidney seizures and abscesses contribute to 2%. Tuberculosis and oesophagostomiasis were the main causes of intestines seizure with respective frequencies of 76 and 24%. The abscess was 87.5% of the causes of seizure of the tongue.

DISCUSSION

Offal components performances: In view of these results, most of the offal components weights of Zebu bulls were significantly higher than those of Borgou bulls while Lagunaire bulls had the lowest level. The livestock practices and breed affected the offal components and tend to follow the trend of the weights of the major carcass components in the same breeds. In a similar study (Salifou *et al*., 2012), the carcass traits of the Zebu Fulani bulls were significantly higher than those of the Borgou bulls whereas Lagunaire bulls had the lowest performance. These results are in line with Teye and Sunkwa (2010) study in Ghana. He found significant differences ($p<0.001$) in Zebu offal components weight, being the heaviest, followed by Sanga and West African Shorthorn breeds. The Borgou breed is a cross-breed between the White Fulani bull and 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 offal components characteristics.

Legs, tail, esophagus, spleen, liver, kidneys and heart of the bulls slaughtered in rainy season were heavier than those slaughtered in dry season. The results are in agreement with those of Salifou *et al*. (2012) on carcass characteristics of the same breeds. These authors recorded that carcasses of bulls slaughtered in rainy season were heavier. Their dressing percentage and empty dressing percentage were also higher. Those carcasses had also more thigh thickness, a thicker rib muscle, a higher longissimus thoracis area and more rib fat than the bulls slaughtered in dry season. These differences in offal components might be due to many factors including the season effect, the forages availability on pasture in the livestock areas and the breeds (Balogoun, 2010). The bulls slaughtered were exclusively fed on natural pasture that explains better offal performance at slaughter in the rainy season. However, during the dry season, forages become scarce and poor and farmers are obliged to go to transhumance for the survival of the herd. Animals are thus less fed and their legs, tail, esophagus, spleen, liver, kidneys and heart weights decrease at slaughter.

The offal weight was highly and positively correlated with respectively legs weight, tail weight, skin weight in the three horned cattle breeds. By the contrast, the offal weight was strongly significant and positively correlated with the stomach weight, spleen weight, kidneys weight and heart weight in Zebu and Lagunaire bulls while no significant correlations were obtained between offal weight and those components in Borgou bulls. The correlations obtained are consistent with those in a recent study reported by Teye and Sunkwa (2010) in West African Shorthorn, Sanga and zebu bull in Ghana.

The Principal Components Analysis has discriminated the three breeds in terms of offal components traits regardless of the slaughter season. In this study, the results are in line with those obtained by Salifou *et al.* (2012) on carcass characteristics of the same breeds. Similar results were observed in Aubrac, Salers and Aubrac systems in terms of slaughter performance (Renand *et al*., 2002).

Macroscopic hazards related to the offal consummation: In total, 20 affections and diseases were identified and 9 internal and external offals were seized. The same affections and lesions were reported by Kora (2002) and Akpata (2005) respectively in the slaughterhouses of Cotonou-Porto Novo and Malanville, in Benin. Among those organs, the lungs were the most frequently seized. The causes of lungs seizing, from the highest to the lowest frequencies, were tuberculosis, pulmonary emphysema, pleurisy and pneumonia, abscess, congestion, hepatization, cyst, putrefaction, contagious bovine pleuropnomoniae and sclerosis. The prevalence of tuberculosis was 6.15% in this study. A similar prevalence (6.45%) was obtained on 4510 slaughtered cattle by Gamavo (2004) at the slaughterhouse of Savalou (Benin). Similarly, the results of the cervical tuberculin testing on 13 cattle herds by intradermal test revealed a tuberculosis prevalence of 14.91% in the Commune of Savalou (Gamavo, 2004). The results of tuberculin tests revealed a prevalence of 8.25% at Samiondji farm and 2.64% at Betecoucou farm (Adoligbé, 2005). The prevalence of tuberculosis is 10.64% in slaughterhouse of Parakou (North Benin) and 16% in the milk (Lègba Gbénou, 2011) and 5.32% in the herds of cattle (Farougou *et al*., 2006). The permanent presence of this disease in slaughterhouses might be due to lack of hygiene and non-determination of Benin government to eradicate definitely this dangerous enzootic and zoonotic disease. The high cost of control of this disease and the duration of treatment come further complicate its eradication from Benin. This disease is also frequently reported in other countries of Africa. Bovine tuberculosis is the main cause of lungs seizure at the slaughterhouse of Abidjan Port-Bouet (22.11%) in Côte d'Ivoire (Cisse *et al*., 2008) and in the slaughterhouses of the South of Tchad (11.8%) (Ngandolo *et al*., 2009). In Arusha slaughter house, a total of 15,245 (13.2%) lungs of cattle were seized (between 2005 and 2007) due to nine

diseases/affections including tuberculosis (Mellau *et al*., 2010). Pneumonia was the leading cause of seizing as it was responsible for 30.1% of all the lung seizures in cattle at Arusha, Tanzania (Mellau *et al*., 2010). Seizures of cattle lungs were also due to nine diseases/affections including tuberculosis namely pneumonia, hydatidosis, emphysema (Mellau *et al*., 2010).

Among the diseases reported in abattoir of Cotonou, the frequencies of fascioliasis and dicrocoeliose were 2.7 and 1.49% respectively. The result in this study is lower than the findings of Assogba and Youssao (2001, 2002). They reported a prevalence of 6.3% for fasciolosis in the same slaughterhouse 10 years ago. Higher frequencies (24.84%) were obtained in slaughterhouses of Karimama and Malanville, in the north of Benin (Youssao and Assogba, 2002). Out of 641,224 cattle slaughtered in 12 Western Nigeria abattoirs in three years, 51,196 (7.98%) internal offal condemnations were attributed to 14 diseases/affections including fascioliasis, pimply gut, paramphistomosis, cysticercosis, dermatophilosis, tonsillitis, taeniasis, ascariosis, abscess, mange, mastitis and immature fetuses (Cadmus and Adesokan, 2009). In this study, livers were seized for various causes including fascioliasis (41.4%) and dicrocoeliasis (22.9%). Except pneumonia (21.38%), fascioliasis (20.28%) was the major reason for seizing; least being ascariosis (0.01%) causes and implications of bovine organs/offal condemnations in some abattoirs in Western Nigeria (Cadmus and Adesokan, 2009).

The liver (32.94%) accounted for most organ seizures while the heart (0.02%) was the least affected. In a similar study at Nsukka Urban slaughterhouse in Enugu State (Nigeria), analysis of the records of 168,104 cattle showed that 14,351 (8.54%) harbored *Fasciola gigantica* (Okoli *et al*., 2000). In Kenya, out of 5,421,188 cattle slaughtered, 8% were infected with *Fasciola* and the economic loss due to condemnation of infected liver from cattle was US$ 2.6 million (Njeruh *et al*., 2004*).* Livers were seized for various causes such as parasitic origin, in particular, fascioliasis (41.4%) and dicrocoeliasis (22.9%). In a five-year study (2033-2007) performed in Iran's slaughterhouses, the infection rate was 4.8% for fascioliasis and dicrocoeliasis and, since this period, those diseases are continuously increasing (Tavakoli *et al*., 2008). In Iran, the prevalence of *F. hepatica* and *D. dendriticum* was 8.5 and 20.0%, respectively (Ghazani *et al*., 2008). In another study in Iran, the prevalence of liver infections in livestock due to fascioliasis and dicrocoeliosis were respectively 24.4 and 41.9% of total livers seizures (Ghazaei, 2007). Out of 5,421,188 cattle slaughtered 8% were infected with Fasciola and the economic loss due to condemnation of infected liver from cattle was US$ 2.6 million in Kenya (Njeruh *et al*., 2004). Livers were seized for various causes such as parasitic origin, in particular, fascioliasis (41.4%) and dicrocoeliasis (22.9%).

In Iran, the prevalence of *F. hepatica* and *D. dendriticum* was 8.5 and 20.0%, respectively (Ghazani *et al*., 2008). In another study in Iran, the prevalence of liver infections in livestock due to fascioliasis and dicrocoeliosis were respectively 24.4 and 41.9% of total livers seizures, (Ghazaei, 2007). In Malet slaughtering of Malatya Province, Turkey, the prevalence rates of *Dicrocoelium dendriticum* was 4.67% and that of *Fasciola hepatica* was 4.42% on a total of 513 cattle in post-mortem examinations (Murat *et al*., 2009).

Most of these diseases are zoonosis. Thus, to protect consumers, the various lesions observed on offal components have to be associated with partial or total seizing of the concerned organs or carcass during the meat inspection (Cabre *et al.*, 2005; Fosse *et al*., 2006). When the meat consumption is authorized at the end of the inspection, preventive measures are to prevent its contamination. Cooking operations should begin as soon as possible after the acceptance of the meat and otherwise, the meat must be chilled quickly at + 7°C in core and be distributed in timely and the meat must be cooked also in core (Cabre *et al.*, 2005). Compliance with all of these good hygiene practices during the slaughter process and with meat inspection rules, will reduce the risk of transmission of pathogens by diet and limit the risks of epizootic.

CONCLUSION

This study revealed that the offal weight and most of the offal components of Zebu Fulani were significantly higher than those of the Borgou while Lagunaire had the lowest level. Among offal components, legs, tail, esophagus, spleen, liver, kidneys and heart of bulls slaughtered in rainy season were heavier than those of the bulls slaughtered in the dry season. Zebu Fulani offal was characterized by a heavier offal components, followed by Borgou bulls while Lagunaire offal components were characterized by a higher head percentage and a higher offal percentage in the carcass whatever the season. During the rainy season, the Borgou and the Zebu bulls were characterized by a higher viscera weight while in the dry season, they were characterized by a higher external offal weight. The Lagunaire bulls were few discriminated whatever the season for offal components. . Regarding the visually detectable hazards associated with offal consumption, lungs were the most frequently seized among offal components. The causes of lungs seizure, from the highest to the lowest frequencies, were tuberculosis, pulmonary emphysema, pleurisy and pneumonia, abscess, congestion, hepatization, cyst, putrefaction, contagious bovine pleuropneumoniae and sclerosis. The main cause of seizure of the diaphragm was also tuberculosis and in scarce cases, the abscess. Livers were affected by

fascioliasis, dicrocoeliasis and tuberculosis. Congestion was the main cause of seizure of the spleen and tuberculosis was the second cause. Nephritis, tuberculosis and hydronephrosis were the causes of kidneys seizure. Tuberculosis and oesophagostomiasis were the main causes of the intestines seizure. Abscesses were the major causes of tongue's seizure. To protect the consumer, various lesions observed on offal components have to associate with partial or total seizure of the concerned organ or carcass during the inspection. On basis of the frequency of these affections or diseases it has to be suggested a strengthening of the veterinary services activities during cattle breeding in order to improve the meat and offal safety and reduce the risk for the consumer.

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