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Research Article

Muscle Characteristics, Meat Tenderness and Nutritional Qualities Traits of Borgou, Lagunaire and Zebu Fulani Bulls Raised on Natural Pasture in Benin

[1]C.F.A. Salifou, [2]M. Dahouda, [1]I. Houaga, [4]B. Picard, [5]J.L. Hornick, [4]D. Micol, [1]S.K. Kassa, [1]S. Farougou, [3]G.A. Mensah, [6]A. Clinquart and [1]A.K.I. Youssao
[1]Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, 01 BP 2009, Cotonou,
[2]Department of Animal Production, Faculty of Agronomic Science, University of Abomey-Calavi, 01 BP 526,
[3]Agricultural Research Center of Agonkanmey, National Institute of Agricultural Research of Benin, 01 BP 884, Cotonou 01, Republic of Benin
[4]Department of Animal Production, Faculty of Veterinary Medicine University of Liege, Sart Tilman B43b, 4000 Liège, Belgium
[5]Department of Animal Production,
[6]Department of Food Science, Faculty of Veterinary Medicine, University of Liege, Sart Tilman B43b, 4000 Liège, Belgiun

Abstract: This study was carried out to evaluate muscle characteristics, meat ten derness and nutritional qualities of Benin indigenous cattle raised on natural pasture. Thus, 10 Zebu Fulani, 10 Borgou and 5 Lagunaire were slaughtered at 5 years old and their *Longissimus thoracis* muscle samples were collected for analyses. Lactate dehydrogenase activity of Zebu Fulani was higher ($p<0.05$) than that of Lagunaire (3494 *vs* 2813 µmol/min/g protein) while that of Borgou was not significantly different from those of the two other breeds ($p>0.05$). As for isocitrate dehydrogenase, citrate synthase, cytochrome oxidase and phosphofructokinase, no significant difference was observed between the three breeds ($p>0.05$). By contrast, the total collagen content of Borgou (5.2 mg OH-proline/mg dry matter) was higher ($p<0.01$) than those of Zebu Fulani (3.1 mg OH-proline/mg dry matter) and Lagunaire (3.2 mg OH-proline/mg dry matter). The myosin heavy chain isoforms I, IIa and IIx were not different between the three breeds. The dry matter, the crude protein and the ether extract percentage were not significantly varied from one breed to another. Branched-chain Fatty Acids and saturated fatty acids contents were identical in Lagunaire and Borgou ($p>0.05$) while the Zebu Fulani had the highest values ($p<0.05$). The ratio n-6 to n-3 fatty acids obtained in the Zebu was the lower. In general, according to the fatty acids profile, Borgou and Lagunaire bulls' meat is better than that of Zebu for heart disease.

Keywords: Beef, collagen, fatty acids, metabolic enzyme activities, mucle fibres, warner-bratzler shear force

INTRODUCTION

In Benin, the national meat production in 2011 was 61646 tons of carcass weight and beef production 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/Benin, 2012). The beef production is mainly provided by the national cattle composed of several breeds including Lagunaire, Somba, Borgou and Zebu cattle (Zebu Fulani, White Fulani and Red M'Bororo). Borgou, Zebu Fulani and Lagunaire are frequently slaughtered in the main abattoirs of Benin (Assogba and Youssao, 2002). Salifou *et al*. (2012a) assessed local breed slaughter carcass characteristics including the bulls raised solely on natural pasture. This livestock system is practiced by almost all the cattle breeders in Benin (Balogoun, 2010). Salifou *et al*. (2013) also assessed the bull offal components traits according to the breed and the slaughter season and established the relationships between the offal components of each breed and all breeds combined. The relationships between the offal components and the carcass characteristics of Lagunaire, Borgou and Zebu Fulani bulls were also established by Salifou *et al*. (2012b). It appears from these studies that the Zebu

Corresponding Author: Issaka Youssao Abdou Karim, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, 01 BP 2009, Cotonou, Republic of Benin, Tel.: 0022995285988 or 0022997912074; Fax: 0022921360199

bulls were characterized by higher dressing percentage, rib fat percentage and carcass length, heavier hot carcass 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 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.

If the difference between the three breeds is well known on the reproduction and the production performances (Youssao *et al*., 2007; Koudandé *et al*., 2009; Koutinhouin *et al*., 2009; Youssao *et al*., 2009; Koutinhouin *et al*., 2010) and on the carcass qualities (Teye and Sunkwa, 2010; Salifou *et al*., 2012a, b, 2013), scarce information is available on the muscle biological characteristics and on the meat qualities of the native breeds in sub-Saharan Africa in general.

In Europe, America, Asia and Australia, many works were related to bovine meat characteristics as well as muscle fiber types (Costa *et al*., 2008; Kadim *et al*., 2009; Vestergaard *et al*., 2000; Lefaucheur, 2010). Different isoforms of Myosin Heavy Chain (MyHC) in bovine muscle were described such as MyHC I, MyHC IIa and MyHC IIx (Picard *et al*., 1998). The MyHC IIb was reported in some cattle as Blonde d'Aquitaine French breed (Picard and Cassar-Malek, 2009). With regard to the muscle enzyme activities, anaerobic glycolytic enzyme activities was assessed throughout Lactate Dehydrogenase (LDH) and phosphor fructokinase (PFK) studies (Jurie *et al*., 2006) and aerobic oxidative metabolism was assessed by Isocitrate Dehydrogenase (ICDH), Citrate Synthase (CS) and Cytochrome-c Oxydase (COX) activities (Briand *et al*., 1981; Piot *et al*., 1998). All these muscle characteristics are implicated in meat sensory qualities mainly ten derness (Guillemin *et al*., 2009).

Meat qualities can be classified into four groups, i.e., organoleptic or sensory, nutritional or dietary, technological and safety qualities. Among these qualities, tenderness and nutritional qualities are the most important for consumer in developing countries. The meat nutritional qualities are related to its protein, lipid, fat, vitamin, macronutrients and micronutrients contents. But, the consumers are particularly interested by the fat qualities. Fat supplies energy and essential nutrients such as fat-soluble vitamins and essential fatty acids, but must be moderately consumed (Williamson *et al*., 2005). Fat also provides juiciness and flavor to meat. Fat contain different types of fatty acids including Saturated Fatty Acids (SFAs), Monounsaturated Fatty Acids (MUFAs) and Polyunsaturated Fatty Acids (PUFAs). The fatty acid profile of the meat is determined by the proportions in which each of the fatty acids is present. The effects of fatty acids on blood cholesterol levels is well recognized, some beneficial and some adverse and therefore it is important to consider the fatty acid profile of a food (Williamson *et al*., 2005).

The purpose of the present work was to evaluates muscle characteristics, meat tenderness and nutritional qualities of Lagunaire, Borgou and Zebu Fulani *Longissimus thoracis* muscle.

MATERIALS AND METHODS

Areas of study: The slaughterhouse of Cotonou-Porto-Novo is located in Cotonou area (between 6°21' North latitude and 2°25' East longitude) in Benin and covers 3.5 ha. Slaughtering begins at 4 o'clock in the morning and ends at 12 o'clock. The average number of cattle slaughtered is about 50 heads per day. The animals slaughtered were purchased from Alibori and Borgou Departments for Zebu Fulani and Borgou breeds. Lagunaire were scarcely slaughtered and those slaughtered for this study were collected from Zou Department.

Choice of animals: Animals were purchased from their native Departments at least 48 h before slaughtering. Just arrived, animals were approved and left to rest. During this period, they were chosen for this study. The selection criteria were based on the breed (Borgou, Zebu Fulani or Lagunaire), the sex (bull), 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 breed, the age at slaughter, the grazing used during livestock (natural or artificial) and feed supplement used during fattening and the livestock system (transhumance or sedentary). This interview allowed confirming the type of breed and the age at slaughter of the previously selected animals. The bulls slaughtered were raised on natural pasture. In all 10 Zebu Fulani, 10 Borgou and 5 Lagunaire were slaughtered. The bulls were slaughtered from September 2011 to March 2012 according to Salifou *et al*. (2012a) process.

Muscle sample collection: *Longissimus thoraci*s (LT) muscle samples were collected within the first hour after slaughter for the biochemical analyses. The samples used for collagen and the nutritional quality analyses were taken 24 h after slaughter in the left half carcass. LT muscle of the sixth rib was used for biochemical analyzes, that of the seventh for the collagen determination and finally, that of the eighth rib for the meat nutritional qualities. This muscle has been identified because it is the most referenced in the literature. For the tenderness assessment, the half right carcass was used for Warner-Bratzler shear force. The LT of the sixth rib was used to evaluate the tenderness

at the slaughter day (d0), that of the seventh rib for the second day of maturation (d2) and that of the eighth rib for the 8th day of maturation (d8). A sample of 200 g of LT was collected and stored at -20°C for nutritional qualities.

Cubes of 3 to 4 mm aside were directly immersed in liquid nitrogen for 10 to 20 seconds for freezing and used for biochemical analysis. When samples were completely frozen, they were collected and placed in cryotubes cooled. The cryotubes filled were then kept in a dewar containing liquid nitrogen, to storage in the freezer at -20°C.

Finally, for the analysis of total collagen content (soluble and insoluble collagen), each sample was cut into small pieces of 2-3 cm aside and placed in a plastic bag. The plastic bag containing the meat was well flattened and placed under vacuum. It was then frozen at -20°C. The samples were ground still frozen and lyophilized for 24 h before being ground into a very fine powder. The vials were then stored para-filmed.

Collagen characteristics: The collagen content was determined by placing the LT samples in hydrochloric acid, boiling for 16 h and measuring the hydroxyproline content (collagen = 7.5X hydroxyproline content), according to the method of Bergman and Loxley (1963). The insoluble part of collagen was determined according to a procedure described by Bonnet and Kopp (1992). Collagen solubility was expressed as the percentage of heat-soluble collagen to total collagen. The data (means of triplicates) were expressed in µg of hydroxyproline (OH-proline) per mg of dry matter for both total and insoluble collagen.

Metabolic enzyme activities: The metabolic type of the muscle was determined by measuring enzyme activities. Anaerobic glycolytic metabolism was assessed by Lactate Dehydrogenase (LDH) (Ansay, 1974) and Phosphofructokinase (PFK) activities according to the methods and the detailed protocols cited by Jurie *et al*. (2006). Aerobic oxidative metabolism was assessed by Isocitrate Dehydrogenase (ICDH), Citrate Synthase (CS) and Cytochrome-C Oxydase (COX) activities according to Briand *et al*. (1981) and Piot *et al*. (1998) methods. One unit of the enzyme was defined as the amount which catalyzes per min the disappearance of 1 µmol of NADH for PFK and LDH, the reduction of 1 µmol of NADP for ICDH and the oxidation of 1 µmol of cytochrome-c for COX. Enzyme activities (means of triplicate) were expressed in µmol/min per g protein.

Contractile characteristics of *Longissimus thoracis* muscle: The contractile muscle type was determined by quantifying the different Myosin Heavy Chain (MyHC) isoforms by electrophoresis SDS-PAGE according to the method of Talmadge and Roy (1993) and adapted for bovine muscle by Picard *et al*. (2011). Each gel was loaded with 4-5 µg of myofibrillar protein and electrophoresis was performed at a constant voltage of 70 V for 30 h at 4°C. The relative proportions of slow isoforms (MyHC% I) and fast isoforms (MyHC% IIa, IIx and IIb) were determined after staining of gels in a solution of Coomassie Blue R250 and quantifying using Image Quant TL v2003.

Warner-bratzler shear force: Shear forces were measured at different days of maturation (0, 2 and 8 days) on the LT muscle of each breed. At each days of measurement, the LT sample was first thawed for 12 hours and then cooked at 70°C during 1 hour at the bath marie. Ten cores of the LT sample were cut and sheared using a Universal testing machine equipped with a Warner-Bratzler attachment (LLYOD Instruments). The shear force was expressed in Newton and its value reported for each sample was the average value for the ten evaluated cores of this sample (Salé, 1971).

Nutritional qualities: Dry matter and ether extract were analyzed according to AOAC (1990) procedures. Crude protein was determined by the Kjedahl method, as nitrogen (N)x 6.25. The fatty acid profile of meat was performed using Gas Chromatography (GC) after extraction and trans-esterification of fatty acids according to the method of Sukhija and Palmquist (1988). A combined one-step extraction and esterification method was carried out using a mixture of solvents containing methanol, benzene and acetyl chloride, to produce the different fatty acids methylesters. The internal standard was nonadecylic acid (C19:0). A1µ laliquot was injected into a ChrompackCP9001 chromatograph (Middelburg, The Netherlands) fitted with a CP-9010 automatic liquid sampler, asplit-splitless injector and a 901 Aflame ionization detector (Chrompack, Middelburg, The Netherlands). The GC system was fitted with an Omegawax 320 fused silica capillary column (30 m×32 mm i.d) with a stationary polyethyleneglycol phase (Supelco, Bellefonte, United States of America) coated with a 0.25µm filmthickness. Hydrogen was used as carrier gas at a pressure on the top of the column of 50 kPa. The column temperature was programmed from 120 to 240°C at a rate of 5°C/min. The temperatures of the injection port and detector were 250°C and 260°C, respectively. The injection was performed in the split mode with as plitratio of 1:25. The soft ware Alltech Allchrome Plus Chromatography DataSystemVersion1.4.2.1, Alltech Associates Inc., Lokeren, Belgium) was used for data processing. Fatty acids were identified by comparison of their retention times with that of the corresponding standard mix (Supelco 37 Component FAMEMix, Sigma-Aldrich, Bornem, Belgium).

Statistical analysis: The Statistical Analysis System software (SAS, 2006) was used for data analysis. The

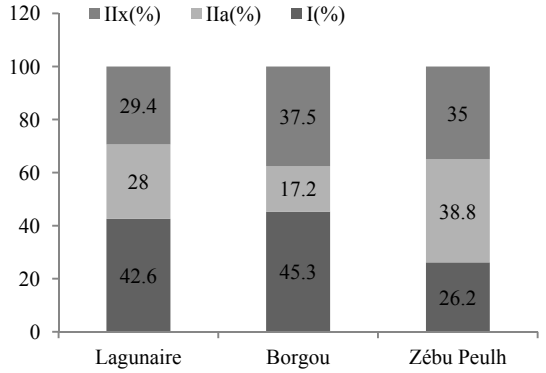

Fig. 1: Proportion (%) of various isoform myosin heavy Chain (MyHC) of Longissimus thoracis muscle in Lagunaire, Borgou and Zebu Peulh Fulani bulls of Benin. NS: p>0.05; I: slow oxidative; IIa: fast oxidative glycolytic; IIx: fast glycolytic

factors of variation considered were the breed (Zebu Fulani, Borgou and Lagunaire). The data were analyzed according to General Linear Model procedure (GLM) of SAS (2006). The F test was used to determine the significance of the breed effect. Then, the least squares means were estimated and compared by the Student test. The correlations between the different variables were determined by using Proccorr procedure of SAS (2006). Principal Components Analysis (PCA) was carried out by the Procprincompt procedure of SAS (2006).

RESULTS

Biological characteristics of muscle: Three types of MyHC were observed in LT muscle of Lagunaire, Borgou and Zebu Fulani bulls, i.e., type I (slow oxidative), type IIa (fast oxidative glycolytic) and type IIx (fast glycolytic) (Fig. 1). The proportion of MyHC was not significantly different within the three breeds. However, the proportion of I MyHC in Lagunaire (42.6%) and Borgou (45.3%) bulls was higher and Zebu Fulani had the greatest proportion of IIa My HC. As for the IIx MyHC, the Borgou and the Zebu Fulani had the highest proportions. Although differences are not significant, the Zebu Fulani breed appeared with specific MyHC composition characterized by a higher ratio of IIa/I MyHC.

Biological characteristics of LT muscle of Borgou, Lagunaire and Zebu Fulani bulls in Benin are presented in Table 1. The LDH activity of Zebu Fulani was higher ($p<0.05$) than that of Lagunaire (3494 *vs* 2813 µmol/ min/g protein) while that of Borgou was not significantly different from those of the two other breeds ($p>0.05$). As for ICDH, CS, COX and PFK, no significant difference was observed between the three breeds ($p>0.05$). The total collagen content of Borgou (5.2 mg OH-proline/mg dry matter) was higher ($p<0.01$) than those of Zebu Fulani (3.1 mg OH-proline/mg dry matter) and Lagunaire (3.2 mg OH-proline/mg dry matter). However, no significant difference was observed between total collagen content of Zebu Fulani and Lagunaire. The same trends were recorded in three breeds for the insoluble collagen with grades of 2.4, 4.1 and 2.4 mg OH-proline/mg dry matter, respectively for Lagunaire, Borgou and Zebu Fulani.

Relationships between muscle characteristics: The ICDH was positively correlated with the I MyHC proportion ($r = 0.80$, $p<0.001$). The Imyosin heavy chain proportion was inversely proportional to that of IIx myosin heavy chain ($r = -0.574$, $p<0.05$). Beside those correlations, the correlation between the others muscle traits were not significant.

The results of the Principal Component Analysis (PCA) are shown in Fig. 2. The circle of correlations shows that the PCA variability of muscle is mainly explained by two axes. The first explains 39.22% of the total variability and contrasts the enzymes LDH and ICDH, CS and LDH, IIx and I fibers and finally ICDH and IIx fibers. Thus, the first axis was rather indicative of muscle metabolism. Axis 2 explained 22.51% of the total variability and contrasts the ICDH and COX to collagen and opposed even the fibers IIa and IIx.

Warner-bratzler shear force: The shear force did not significantly vary from one breed to another for the

Table 1: Muscle biological characteristics and shear force of *Longissimus thoracis* muscle of lagunaire, borgou and zebu fulani bulls finished on natural pasture

Muscle characteristics and shear force	Lagunaire	Borgou	Zebu	SEM	Genotype effect
Lactate Dehydrogenase(µmol/mn/g protein)	2813[a]	3148.9[ab]	3493.7[b]	241.1	*
Isocitrate Dehydrogenase (µmol/mn/g protein)	6.400[a]	4.400[a]	3.1000[a]	1.900	NS
Citrate synthase (µmol/mn/g protein)	12.80[a]	26.60[a]	14.600[a]	10.3	NS
Cytochrome c-oxydase (µmol/mn/g protein)	61.30[a]	39.40[a]	56.100a	10.5	NS
Phosphofructokinase (µmol/mn/g protein)	8.300[a]	9.300[a]	5.3000[a]	1.70	NS
Total collagen contents (ig OH-proline per mg dry matter)	3.200[a]	5.200[b]	3.1000[a]	0.40	**
Insoluble collagen contents (ig OH-proline per mg dry matter)	2.400[a]	4.100[b]	2.4000[a]	0.30	**
Texture measurements at d0 (N)	90.70	121.8	101.60	13.1	NS
Texture measurements at d2 (N)	50.50	89.60	60.100	17.5	NS
Texture measurements at d8 (N)	36.80	65.90	38.00	14.7	NS

NS: p>0,05, *: p<0,05; **: p<0,01; The means of the same line followed by different letters, differ significantly at 5%; di: day i. SEM: standard Error of the Mean

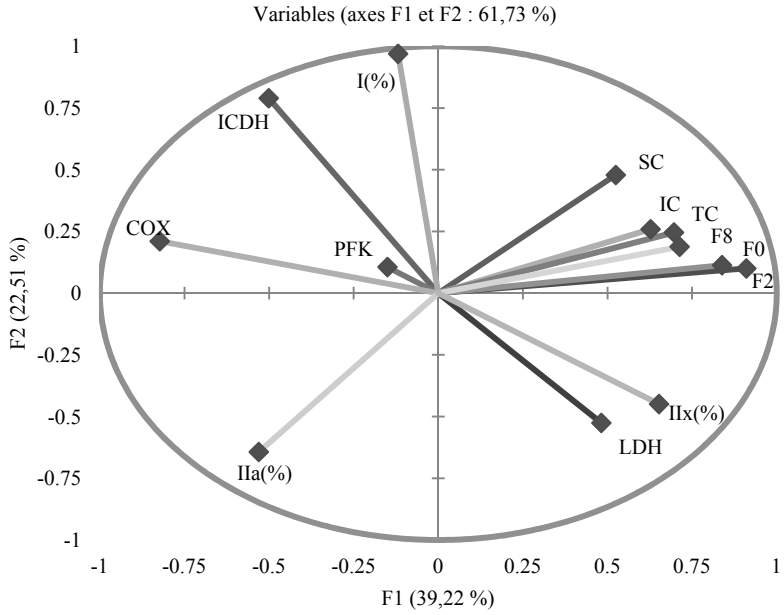

Fig. 2: Plot for muscle biological traits of Lagunaire, Borgou and Zebu bulls in the multivariate space following a Principal Component Analysis (PCA). TC: total collagen, IC: insoluble collagen, SC: Soluble Collagen; ICDH = Isocitrate dehydrogenase; LDH: Lactate Dehydrogenase; PFK: Phosphofructokinase; COX: Cytochrome oxydase; CS: Citrate Synthase; F0: shear force at day 0; F2: shear force at 2 days post mortem; F8: shear force at 8 days post mortem; I: slow oxidative; IIa: fast oxidative glycolytic; IIx: fast glycolytic

Table 2: Coefficients of correlations (Pearson) between muscle biological characteristics, shear force and various isoform myosin heavy chain of *longissimus thoracis* of Lagunaire, Borgou and Zebu Fulani bulls

Variables	ICDH	LDH	PFK	COX	CS	TC	IC	F0	F2	F8	I	IIa	IIx
Protéine	-0.557*	-0.065	-0.192	-0.269	-0.314	0.015	-0.100	0.003	0.290	0.472	-0.392	0.210	0.233
ICDH		-0.569*	0.093	0.658*	0.086	-0.216	-0.190	-0.388	-0.306	-0.177	0.796	-0.350	-0.545
LDH			-0.186	-0.320	0.244	0.148	0.265	0.490	0.238	0.085	-0.519	0.130	0.449
PFK				-0.009	-0.370	0.409	0.254	-0.210	-0.341	-0.108	0.095	0.081	-0.182
COX					-0.302	-0.436	-0.450	-0.795**	-0.605*	-0.468	0.261	0.306	-0.592*
CS						0.315	0.417	0.696**	0.442	0.155	0.447	-0.468	-0.041
TC							0.952***	0.475	0.414	0.383	0.128	-0.275	0.128
IC								0.528	0.494	0.399	0.092	-0.325	0.216
F0									0.745	0.514	0.047	-0.541	0.478
F2										0.783**	-0.005	-0.464	0.460
F8											0.080	-0.627*	0.526
I												-0.550	-0.574*
IIa													-0.368

*: p<0.05 ; **: p<0.01, ***: p<0.001; TC: Total Collagen, IC: Insoluble Collagen, SC: Soluble Collagen; ICDH = Isocitrate Dehydrogenase; LDH: Lactate Dehydrogenase; PFK: Phosphofructokinase; COX: Cytochrome Oxidase; CS : Citrate Synthase; F0: shear force at day 0; F2: shear force at 2 days post mortem; F8: shear force at 8 days post mortem; I: slow oxidative myosine; IIa: fast oxidative glycolytic; IIx: fast glycolytic

same day of measurement (d0, d2 or d8). However, the highest shear forces were obtained in Borgou and the lowest were recorded in Lagunaire, whatever the day of measurement. Texture measurements significantly decrease from d0 to d8 ($p<0.001$) in each breed. The COX content was negatively correlated to shear forces measured on the day of slaughter, the 2nd and 8th days after slaughter ($-0.795<r<0.468$) and to the IIx myosin heavy chain proportion ($r = -0.592$, $p<0.05$) (Table 2). Shear force on the day of slaughter was strongly correlated to the CS content ($r = 0.696$, $p<0.01$) and shear force at day 2 ($r = 0.745$, $p<0.01$). Shear force at day 8 was positively correlated with shear force at day 2 ($r = 0.783$, $p<0.01$) and negatively associated to the IIa myosin heavy chain proportion ($r = -0.627$, $p<0.05$). Likewise on the PCA, total collagen content and insoluble collagen content were positively correlated with shear forces.

Chemical composition of *Longissimus thoracis* muscle: Dry matter, crude protein and ether extract percentage did not significantly vary according to the breeds (Table 3). Throughout the three breeds, the dry matter, the crude protein and the ether extract percentage were on average respectively 21.88±2.55, 95.36±4.06 and 3.74±3.37%, respectively of DM.

Fatty acids profile in dry matter: The fatty acids profile in dry matter is given by breed in the Table 4. Whatever the breed, the highest quantities of fatty

Table 3: Dry matter, crude protein and ether extract of *longissimus* muscle of Borgou, Lagunaire and Zebu bulls finished on natural pasture

	Borgou (N = 10)		Lagunaire (N = 5)		Zébu (N = 10)		
Variables	Means	S.E.	Means	S.E.	Means	S.E[t].	Test of Significance
Dry matter (%)	21.46	0.80	20.66	1.14	22.91	0.80	NS
Crude protein (% DM)	96.37	1.28	94.34	1.81	94.87	1.28	NS
Ether extract (% DM)	2.82	1.07	2.12	1.51	5.47	1.07	NS

NS: p>0.05, SE: Standard error

Table 4: Fatty acids composition (mg/100g DM) of *longissimus thoracis* muscle of Borgou, Lagunaire and Zebu bulls finished on natural pasture

	Lagunaire (N = 5)		Borgou (N = 10)		Zébu (N = 10)		
Fatty acids (mg/100g DM)	Means	SE	Means	SE	Means	SE	Test of Significance
C15:0 iso	1.86a	2.53	3.24a	1.79	9.64b	1.79	*
C15:0 ant-iso	4.60a	2.49	4.54a	1.76	10.71b	1.76	*
C16:0 iso	4.19a	3.21	6.09a	2.27	12.42b	2.27	*
C17:0 iso	10.9900a	6.1100	13.84a	4.32	27.32a	4.32	NS
C18:0 anti-iso	1.74000a	2.1300	3.34a	1.51	8.00b	1.51	*
C12:0	0.41000a	0.9400	1.19a	0.67	3.08a	0.67	NS
C14:0	7.98000a	35.980	44.59a	25.44	117.96b	25.44	*
C15:0	7.09000a	5.7200	7.97a	4.05	19.92b	4.05	*
C16:0	296.040a	364.19	529.59a	257.52	1212.85b	257.52	*
C17:0	14.9600a	14.410	22.09a	10.19	51.66b	10.19	*
C18:0	402.060a	250.89	580.25a	177.41	1087.65b	177.41	*
C20:0	4.00000a	2.1900	6.12a	1.55	10.42b	1.55	*
C14:1 cis-9	0.33000a	4.5500	3.17a	3.22	11.52a	3.22	NS
C16:1cis9	75.6700a	29.150	64.43a	20.61	109.98a	20.62	NS
C17:1 cis-10	15.2800a	6.5200	13.79a	4.61	26.30a	4.61	NS
C18:1 *trans*-11	22.5300a	30.040	38.09a	21.24	112.67b	21.24	*
C18:1 cis-9	547.710a	444.78	714.35a	314.51	1462.92a	314.51	NS
C18:1cis11	30.100ab	9.5400	23.18a	6.75	43.06b	6.75	*
C20:1 cis-11	14.3200b	1.9300	3.11a	1.37	5.81a	1.37	***
C18:2n-6	299.660b	23.240	218.55a	16.43	231.61a	16.43	*
C20:2n-6	1.64000a	0.7400	2.87a	0.52	2.08a	0.52	NS
C20:3n-6	13.1500a	2.1000	15.42a	1.49	12.89a	1.49	NS
C20:4n-6	82.2700b	10.500	106.48a	7.42	81.92 b	7.42	*
C22:4n-6	6.06000b	0.8700	9.71a	0.61	7.41ab	0.61	**
C18:3n-3	75.28000	10.690	60.65	7.56	81.10	7.56	NS
C20:3n-3	1.08000a	1.4100	2.76a	0.99	1.74a	0.99	NS
C20:5n-3	22.8700a	3.4600	21.25a	2.45	20.45a	2.45	NS
C22:5n-3	50.5400a	5.7200	47.27a	4.05	51.38a	4.05	NS
C22:6n-3	1.58000a	0.4700	1.89a	0.33	2.62a	0.33	NS
C 18:2 *cis*-9 *trans*-11 CLA	5.38000a	6.0200	7.52a	4.25	20.87b	4.25	*
∑ FA	2021.34a	1224.78	2572.61a	866.05	4858.00a	866.05	NS
∑ BFA	23.3800a	16.3100	31.05a	11.53	68.10b	11.53	*
∑ SFA	755.920a	681.470	1222.84a	481.87	2571.65b	481.87	*
∑ MUFA	705.90a	523.08	860.12a	369.87	1772.28a	369.87	NS
∑ n-6	402.78a	30.83	353.03a	21.80	335.91a	21.80	NS
∑ n-3	151.34a	15.85	129.09a	11.21	157.29a	11.21	NS
∑ PUFA	559.50a	48.15	489.65a	34.04	514.08a	34.04	NS
PUFA / SFA	0.79a	0.25	0.84a	0.18	0.31a	0.18	NS
n-6/n-3	2.67a	0.13	2.81a	0.09	2.15b	0.09	***

*: 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%. FA: Fatty Acids, MUFA: Monounsaturated; PUFA: polyunsaturated, SFA: Saturated Fatty Acids, SFA: Saturated Fatty Acids; BFA: Branched-chain Fatty Acids

acids in dry matter were in decreasing importance: C18:1 cis-9 (547.7 to 1462.9 mg/100 g DM), C18:0 (402.1 to 1087.7 mg/100 g DM), C16:0 (296 to 1212.8 mg/100g DM) and C18:2n-6 (231.61 to 299.66 mg/100g DM). However the quantities of most of fatty acids identified differ according to the breed.

The content in C15:0 iso, C15:0 anti-iso, C16:0 iso, C18:0 anti-iso, C14:0, C15:0, C15:0, C16:0, C17:0, C18:0, C20:0, C18:1 *trans*-11 and C 18:2 *cis*-9 *trans*-11 CLA (Conjugated linoleic acid) was similar in Lagunaire and Borgou breeds (p>0.05) but higher in Zebu Fulani (p<0.05). The fatty acid C18:1cis11 content of Zebu Fulani was higher than that of Borgou (p<0.05) and the Lagunaire had a fatty acid C18:1cis11content which didn't differ from that of the others two breeds. The fatty acids C20:1 cis-11 and C18:2n-6 contents of Lagunaire were higher than those of Borgou and Zebu Fulani Cattle. However, the fatty acid C20:4n-6 content of the Borgou breed was higher than those of the other two breeds. The fatty acid C22:4n-6 was higher in Borgou than that of the Lagunaire one (p<0.05) while the Zebu had an intermediate content from that of the others. The fatty acids C17:0 iso, C12:0,C14:1 cis-9, C16:1cis9, C17:1

Table 5:Fatty acids composition (% of total of fatty acids) of *longissimus thoracis* muscle of Borgou, Lagunaire and Zebu bulls finished on natural pasture

	Lagunaire (N = 5)		Borgou (N = 10)		Zébu (N = 10)		Test of Significance
Fatty acids (% fat)	Means	SE	Means	SE	Means	SE	
C15:0 iso	0.09a	0.02	0.11a	0.02	0.20b	0.02	***
C15:0 ant-iso	0.22b	0.02	0.16a	0.02	0.24b	0.02	**
C16:0 iso	0.20a	0.03	0.22a	0.02	0.27a	0.02	NS
C17:0 iso	0.54a	0.05	0.55a	0.04	0.62a	0.04	NS
C18:0 anti-iso	0.08c	0.01	0.12b	0.01	0.16a	0.01	***
C12:0	0.02b	0.01	0.04a	0.01	0.05a	0.01	*
C14:0	0.37c	0.32	1.42a	0.22	2.08b	0.22	**
C15:0	0.34ab	0.03	0.28b	0.02	0.40a	0.02	**
C16:0	14.49b	1.61	19.32ab	1.14	22.40a	1.14	**
C17:0	0.72a	0.07	0.79a	0.05	1.03b	0.05	**
C18:0	19.53a	1.60	20.95a	1.13	23.48a	1.13	NS
C20:0	0.19a	0.02	0.22a	0.02	0.24a	0.02	NS
C14:1 cis-9	0.02b	0.04	0.10ab	0.03	0.17a	0.03	*
C16:1cis9	3.71a	0.27	2.50b	0.19	2.34b	0.19	**
C17:1 cis-10	0.77a	0.04	0.56b	0.03	0.56b	0.03	**
C18:1 *trans*-11	1.08a	0.26	1.26a	0.18	2.26b	0.18	***
C18:1 cis-9	27.21a	1.71	27.95a	1.21	27.20a	1.21	NS
C18:1cis11	1.50b	0.08	0.93a	0.05	0.97a	0.05	***
C20:1 cis-11	0.74b	0.06	0.13a	0.04	0.11a	0.04	***
C18:2n-6	15.11a	1.74	9.99ab	1.23	7.05b	1.23	**
C20:2n-6	0.08a	0.04	0.13a	0.03	0.06a	0.03	NS
C20:3n-6	0.67a	0.12	0.70a	0.08	0.37b	0.08	*
C20:4n-6	4.12ab	0.93	5.13a	0.65	2.49b	0.65	*
C22:4n-6	0.30ab	0.07	0.46a	0.05	0.21b	0.05	**
C18:3n-3	3.81a	0.50	2.60a	0.35	2.46a	0.35	NS
C20:3n-3	0.06a	0.01	0.05a	0.01	0.04a	0.01	NS
C20:5n-3	1.16b	0.15	0.82a	0.11	0.61a	0.11	*
C22:5n-3	2.55a	0.32	2.12ab	0.23	1.46b	0.23	*
C22:6n-3	0.08a	0.01	0.08a	0.01	0.07a	0.01	NS
C 18:2 *cis*-9 *trans*-11 CLA	0.27a	0.03	0.28a	0.02	0.40b	0.02	***
∑ BFA	1.13a	0.12	1.15a	0.08	1.50b	0.08	*
∑ SFA	35.65a	2.92	43.03a	2.06	49.68b	2.06	**
∑ MUFA	35.02a	1.73	33.43a	1.22	33.60a	1.22	NS
∑ n-6	20.27a	2.74	16.42a	1.94	10.18b	1.94	*
∑ n-3	7.65a	0.92	5.68ab	0.65	4.64b	0.65	*
∑ PUFA	28.19a	3.61	22.38ab	2.55	15.22b	2.55	*
PUFA / SFA	0.04b	0.11	0.57a	0.08	0.32ab	0.08	**
n-6/n-3	2.67a	0.13	2.81a	0.09	2.15b	0.09	***

*: 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%. FA: Fatty Acids, MUFA: Monounsaturated; PUFA: Polyunsaturated, SFA: Saturated Fatty Acids

cis-10, C18:1 cis-9, C20:2n-6, C20:3n-6, C18:3n-3, C20:3n-3, C20:5n-3, C22:5n-3 and C22:6n-3 contents were not significantly different between breed.

Finally, Branched-chain Fatty Acids and saturated fatty acids contents were identical in Lagunaire and Borgou Bulls (p>0.05) while the Zebu Fulani had the highest values (p<0.05). On the other hand, the lower ratio n-6 to n-3 fattyacids was obtained in the Zebu bull. No significant difference was observed for the monounsaturated fatty acids, the total n-6 fatty acids, the total n-3 fatty acids, the polyunsaturated fatty acids and the ratio polyunsaturated to saturated fatty acids, according to the breeds.

Fatty acids profile in the total of fatty acids: The fatty acids profile by breed is given in the Table 5 according to the total fatty acids. As for the quantities of each fatty acids in dry matter, the highest proportions of fatty acids were indecreasing importance, C18:1 cis-9 (27.2 to 27.95%), C18:0 (19.5 to 23.5%), palmitic acid C16:0 (14.5 to 22.4%) and C18:2n-6 (7.05 to 15.11%) in the total Fatty acids, whatever the breed. However, the percentages of most of fatty acids identified differ significantly according to the breed. The fatty acids C15:0 iso, C18:1 *trans*-11 et C 18:2 *cis*-9 *trans*-11 CLA percentage in total fatty acids of LT muscle were identical in the Borgou and in the Lagunaire bulls while the highest percentage were recorded from the Zebu Fulani (p<0.01). The Zebu fatty acids C18:0 anti-iso and C14:0 percentage were higher than those of the Borgou and the lowest percentage were obtained in Lagunaire bulls (p<0.001). On the other hand, the Lagunaire were richer in C22:5 n-3 than the Zebu whereas the Borgou had an intermediate percentage which didn't differ from the proportion of other two breeds.

The proportions in fatty acids C16:1cis9, C17:1 cis-10, C18:1cis11, C20:1 cis-11 and C20:5n-3 were the highest in Lagunaire bulls while no difference between Borgou and Zebu bulls were observed for the same fatty acids. The opposite trend was observed for fatty acid C12:0.The proportions of fatty acids C20:4n-6 and C22:4n-6 in Borgou breed were higher than those of the Zebu ($p<0.05$), while those of the Lagunaire were not different from the other two breeds. On the other hand, the Borgou breeds had less fatty acid C15:0 ant-iso than the other two breeds ($p<0.01$).

The Zebu Fulani had the highest proportion of Branched-chain Fatty Acids and saturated fatty acids and the lowest proportion of total n-6 fatty acids and a weaker ratio n-6 to n-3 fatty acids than the Borgou and the Lagunaire bulls ($p<0.05$). On the other hand, the total n-3 fatty acids and the polyunsaturated fatty acids proportions in Zebu were lower than those of Lagunaire ($p<0.01$) while the Borgou had intermediate percentages which didn't differ from those of the others. The monounsaturated fatty acids proportions did not vary according to the breeds. Finally, the ratio of polyunsaturated to saturated fatty acids was higher in Borgou than in Lagunaire ($p<0.01$). In Zebu, this ratio was not significantly different from those of the others.

DISCUSSION

Biological characteristics and meat tenderness:

Biological characteristics: The results showed that the less glycolytic animals are the tenderest. This is in agreement with the literature indicating that the LT muscle is softer when it had more oxidative activity (Guillemin *et al*., 2009). The lack of significance of the breed effect on the biological characteristics of muscle can be explained by the smaller size of samples and the individual variability observed. The data obtained for the LT muscle were compared with those extracted from the database BIF beef of Jurie *et al.* (2011). Lagunaire, Borgou and Zebu Fulani bulls have a lower LDH activity than French bulls Aberdeen Angus, Limousin and Blonde d'Aquitaine (Jurie *et al*., 2011). As for the activity of ICDH, the Zebu Fulani (0.6) and Blonde d'Aquitaine (0.63 µmole/min/g), the Borgou (0.8 µmole/min/g) and Limousin (0.79 µmole/min/g), Lagunaire (1.1 µmole/min/g) and Aberdeen Angus (0.97 µmole/min/g) respectively have fairly similar enzymatic activity. Regarding the activity of CS, Borgou (5.1 µmole/min/g) are close enough to the three French breeds(Aberdeen Angus, Blonde d'Aquitaine, Limousin). The COX activity of Borgou (7.5 µmole/min/g) is low compared to Limousin, Angus and Blonde d'Aquitaine bulls. Lagunaire (11.4 µmole/min/g) and Zebu Fulani (10.7 µmole/min/g) had COX activity closer to those of Blonde d'Aquitaine (10.1 µmole/min/g) and Limousin (12.4 µmole/min/g). According to Chriki *et al*. (2012), Montbéliard and Salers had the highest ICDH activity, Charolais and Holstein had the lowest ICDH activity. The Limousin had the most glycolytic muscles based on LDH activity, unlike Holstein which had the lowest glycolytic muscle (Chriki *et al*., 2012).

Lagunaire, Borgou and Zebu Fulani bulls have the particularity to contain more I fibers and less IIx fibers compared to Limousin, Angus and Blonde d'Aquitaine bulls. This difference can be explained in part by the absence of selection on the three breeds of Benin. However, their compositions of mixed fibers (IIa) are close enough. Significant differences were observed for the proportions of slow oxidative fibres, fast oxidative glycolytic fibres and fast glycolytic muscle fibres between, Montbéliard, Salers Charolais, Holstein, Limousin breeds (Chriki *et al*., 2012).

The results show that the LT muscle total collagen content (5.2 mg OH-proline/mg MS) of Borgou bulls is close to that of Angus (5.36 mg OH-proline/mg MS). By the contrast, Zebu (3.1 mg OH-proline/mg MS) and Lagunaire (3.2 mg OH-proline/mg MS) have total collagen content lower than that of Limousin and Blonde d'Aquitaine. The similar observation is made at the level of insoluble collagen. The results showed that the I fibers have exclusively oxidative metabolism, partially oxidative for IIa and exclusively glycolytic for IIx fibers. This is in agreement with the expected results according to bibliography (Jurie and Listrat, 2010).

The Imyosin heavy chain proportion was inversely proportional to that of IIx myosin heavy chain. Beside those correlations, the correlation between the others muscle traits were not significant. In general, the proportion of slow oxidative fibres was negatively correlated to the proportions of fast oxidative glycolytic fibres; that of slow oxidative fibres was also negatively correlated to the proportion of fast glycolytic fibres and the proportion of fast oxidative glycolytic fibres was negatively correlated to that of fast glycolytic fibres in LT (Chriki *et al*., 2012).

Meat tenderness: The shear force did not significantly vary from one breed to another for the same day of measurement (d0, d2 or d8). However, in the literature; many authors have reported the effect of breeds on beef tenderness. In semi-tropical region of Argentina, breeds effect on tenderness was observed between Criollo Argentino and Brasford steers raised on forage (Orellana *et al*., 2009). Breeds specialized for meat production (Limousin and blonde of Aquitaine) have a low value of shear force than other breeds (Holstein and Old Brown Swis) (Monsón *et al*., 2004). In indigenous African cattle breeds, the meat of Santa Gertrudis is less tender than those of Sanga, Afrikaner, Nguni, Brown Swiss, Pinzgauer and Bonsmara (Strydom *et al*., 2000). In the arid subtropics of South Africa, breeds effect on the tenderness and the shear force were not significant

beteween Simmental, Bonsmara and Nguni steers raised on natural pasture (Du Plessis and Hoffman, 2007). Texture measurements significantly decrease from d0 to d8 ($p<0,001$) in each breed. The high shear force at the days of slaughter is related to the *rigor mortis* that appeared a few hours after slaughter. The decrease of the tenderness from the day of slaughter to 8th day *post mortem* is related to the process of maturation.

Relationship between meat tenderness and biological characteristics: Shear force at day 8 was negatively correlated to the IIa myosin heavy chain proportion. However, tenderness scores were not correlated with the proportions of the myosin heavy chain isoforms (IIa and IIx) in Charolais heifers (Oury *et al*., 2009). The shear force values recorded were not correlated with the proportions of myosin heavy chain isoforms of Charolais heifers (Oury *et al*., 2009). The results of our study are similar to those of Abdelhadi *et al*. (2012) who reported that the proportions of types IIa and I muscle fibers were found logically negatively correlated ($p<0.01$) and ICDH activity was significantly correlated ($p<0.01$) with COX activity($r = 0.54$). PCA results are near from those of Renand *et al*. (2002) and Abdelhadi *et al*. (2012) in terms of enzyme activities and type of fibers. On average, this analyses indicates that type IIa muscle fibers have a higher metabolic activity (oxidative and glycolytic) than type I fibers.

Nutritional qualities:

Chemical composition of *Longissimus thoracis* muscle: Dry matter, crude protein percentage did not significantly vary within breeds. The results are in agreement with the conclusions of Ito *et al*. (2012) because they didn't find any difference between genetic groups for moisture and crude protein in LT muscle of Caracu, Canchin, Aberdeen Angus × Canchin and Charolais × Caracu slaughtered at 22 months old. By contrast to the results of this study, Orellana *et al*. (2009) found a slight effect ($p<0.05$) on the fat content of LT muscle between breeds. Meat from Braford steers had higher intramuscular fat content compared to that from Criollo Argentino steers (Orellana *et al*., 2009). In 100 g of *longissimus dorsi* muscle of Belgian Blue, Limousin and Aberdeen Angus bulls, Cuvelier *et al*. (2006) obtained 0.52, 1.11 and 1.50 g, respectively, of total lipid. The percentages obtained in our study are widely above those of European breeds. Thereby, the sensorial qualities of Borgou, Lagunaire and Zebu bulls' meat could be better than the European breed ones.

Fatty acids profile: As a whole, 30 fatty acids were recorded in the LT muscle of Lagunaire, Borgou and Zebu Fulani bulls. Fatty acids diversity in cattle is partly explained by the biohydrogenation that occurs in the rumen (Tamminga and Doreau, 1991). Some fatty acids were in similar proportions between Lagunaire and Borgou while the Zebu had higher level or lower level than the other two breeds. The breeds effect on the fatty acids profile were also observed in Criollo Argentino and Braford steers raised on forage in a semi-tropical region of Argentina (Orellana *et al*., 2009), in Nellore, Caracu and Holstein-Friesian bulls finished in a feedlot (Rotta *et al*., 2009a) and in Caracu, Canchin, Aberdeen Angus × Canchin and Charolais × Caracu bulls finished in feedlot (Ito *et al*., 2012). Apart from the genetic effect, the differences in fatty acids profile content can be related to the fatty acid composition of the forage consumed in natural pasture. Each of the three breeds lives in specific agro-ecological areas. The Zebu Fulani comes from Alibori Department in the extreme north of Benin, Borgou breed is originating of the Borgou Department in the North of Benin and the Lagunaire lives in the South of Benin (Salifou *et al*., 2012a). Nevertheless, the comparison of the results of this study is valid for each animal in its natural habitat because fatty acids profiles are affected by breed (Huerta-Leidenz *et al*., 1993), feeding (De Smet *et al*., 2004) and slaughter age (Chung *et al*., 2006). In our study, the bulls were slaughtered at the same age.

The fatty acids C18:1 *trans*-11 and C18:2 *cis*-9 *trans*-11 CLA percentages in total fatty acids of LT muscle were identical in the Borgou and in the Lagunaire bulls while the highest percentage were recorded in Zebu Fulani. CLA is a collective term used to describe a mixture of positional and geometric isomers of linoleic acid. CLA isomers are intermediates in the bio-hydrogenation of linoleic acid and the majority of CLA is produced within the peripheral tissues from the rumen-derived fatty acid vaccenic acid (Williamson *et al*., 2005).The volume of the rumen is important, higher is the activity of rumen microorganisms, higher is the production of the CLA. The high CLA fatty acids in Zebu Fulani bull can be explained by the higher volume of its rumen compared to the two other breeds. The vaccenic acid (C18:1 t-11) is an important intermediate produced by microrganisms in the rumen and transformed into CLA (18:2 c-9, t-11 - rumenic acid) in the muscular tissue of ruminants (Bauman *et al*., 1999). CLA present in intramuscular fat was dependent on feeding system: CLA is higher for ruminants raised on pasture, particularly when they were not supplemented (Orellana *et al*., 2009).

Fatty acids C14:0 and C16:0 contents were identical in Lagunaire and Borgou breeds while the highest content was recorded in Zebu Fulani. Fatty acids C14:0 and C16:0 are considered to as

hypercholesterolemic; they are there by responsible for the increase in quantity of Lipoproteins of Low Density (LDL) that are responsible for heart disease (Prado *et al*., 2008b, 2009b; Rotta *et al*., 2009a). Some foods with low amounts of these fatty acids are required. Thus the meat of Borgou and Lagunaire bulls is better than that of Zebu for heart disease prevention.

In this study, α-linolenic acid (C 18:3 n-3) content varied from 2.46 to 3.81% of total fatty acids and didn't differ according to the breed. By contrast, fatty acid C18:3 n-3 was higher ($p<0.05$) for genetic groups Canchin (0.43%) and Charolais×Caracu (0.40%) than Caracu (0.26%), Aberdeen Angus×Canchin (0.28%) slaughtered at 22 months of age (Ito *et al*., 2012). Lower results of C18:3 n-3 were observed by Rotta *et al*. (2009a) for Caracu (0.18%). Prado *et al*. (2008a) observed inferior results for genetic group Aberdeen Angus×Canchin (0.12%). However, Prado *et al*. (2008c) observed values superior to C18:3 n-3 for genetic group Charolais×Caracu (0.73%). The fatty acid C18:3 n-3 content of Lagunaire, Borgou and Zebu Fulani bulls were higher than those of South American breeds. Thus, the meat of Lagunaire, Borgou and Zebu Fulani bulls can be recommended to consumers.

The Zebu had the highest content/proportion of Branched-chain Fatty Acids and saturated fatty acids and the lowest proportion of total n-6 fatty acids when compared to the Borgou and the Lagunaire bulls. The variability of saturated fatty acids among breeds is reported by Rotta *et al*. (2009b) who observed that Saturated Fatty Acids (SFA) content was similar ($p<0.10$) in Caracu and in Holstein-Friesian breeds and was lower ($p<0.10$) in Nellore than Holstein-Friesian breed. The average percentage for both groups varied from 35.65 to 49.68%. This value has been observed in bovines finished in feedlot and pasture systems (Moreira *et al*., 2003; Prado *et al*., 2003; Padre *et al*., 2006, 2007). These high Saturated Fatty Acid (SFA) estimates are caused by biohydrogenation in the rumen.

The high saturated fatty acids in Zebu Fulani bull can be explained by the higher volume of its rumen compared to the two other breeds or most acetic fermentation and poorer forage.

The predominant PUFAs in meat are linoleic (n-6) and α-linolenic acid (n-3), which are known as essential fatty acids because they cannot be synthesized in the body (Williamson *et al*., 2005). The n-6/n-3 ratio varied from 2.15 to 2.67 in our study and the Zebu had a weaker ratio. Breed effect on n-6/n-3 ratio is reported by Rotta *et al*. (2009b) and Raes *et al*. (2003) also suggested that these ratios are mainly influenced by genetic factors, because fat deposition differs between breeds. The n-6/n-3 ratio must be 4 to 10 according to the recommendation of British Department of Health (1994). In this manner, all the breeds showed good ratio for quality food to human health in our study. In Europe and United State, this ratio is greater than 10 (Willett, 2012).

No significant difference was observed for the monounsaturated fatty acids, the total n-6 fatty acids, the total n-3 fatty acids, the polyunsaturated fatty acids and the ratio polyunsaturated to saturated fatty acids content, according to the breeds. Similar results were observed in Caracu, Holstein-Friesian and Nellore breeds, where Monounsaturated Fatty Acids (MUFA), Polyunsaturated Fatty Acids (PUFA), n-6, n-3 and the PUFA/SFA ratio were similar ($p>0.05$) among breeds (Rotta *et al*., 2009b).

The ratio PUFA/SFA fatty acids varied from 0.04 to 0.57 in our study and was higher in Borgou than in Lagunaire ($p<0.01$). This ratio has important roles in reducing the risk of coronary heart disease; however, the optimal balance between these two classes of fatty acids is still a matter of debate (Willett, 2012). In general, it is accepted that increasing the level of n-3 fatty acids in the diet reduces the risk of heart problems and arteriosclerosis, while CLA isomers have anticarcinogenic and antiatherogenic properties (Belury, 2002). Therefore, a major challenge for cattle producing systems worldwide is to find ways to decrease the proportion of SFA and increase the amount of n-3 PUFA and CLA in meat (Wood *et al*., 2008).

CONCLUSION

This study is the first one showing particular characteristics and meat qualities of muscle from three breeds originating from Benin. The LT muscle of Lagunaire is characterized by the high proportions of MyHC I and IIa and low proportion of MyHC IIx. The Zebu bull is characterized by less I MyHC and more IIa and IIx MyHC. On the other hand, Borgou bulls are characterized by high proportion of IIx and I MyHC and a small proportion of IIa MyHC. The LT muscle of Lagunaire bulls has a slower contraction and oxidative metabolism than other breeds. On the other hand, the LT muscle of Zebu Fulani bulls has a faster contraction and glycolytic metabolism, whereas the Borgou have a muscle intermediate characteristic. The collagen content in LT muscle of Borgou bulls is more important than Lagunaire and Zebu Fulani which have neighboring collagen content. According to the shear force test, the meat of Lagunaire bulls is the tenderest. In Lagunaire, Borgou and Zebu Fulani bulls raised in natural pasture, dry matter, crude protein and ether extract percentages did not significantly vary from one breed to another. The meat of the three breeds is quite oily. The fatty acids profile is generally similar to that expected in intra-muscular lipids in cattle. This profile may reflect the diet. The dietary characteristics are good, especially report w6/w3. They may be also the anatomical trait of the Zebu that influences the profiles. As a whole, according to the fatty acids profile, the

meat of Borgou and Lagunaire bulls seem to be better than that of Zebu and it could prevent heart disease. This hypothesis can be verified through an experimental study.

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