Muscle characteristics from young bulls of different beef breeds

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Abstract— **In the framework of the EU ProSafeBeef project, the aim was to determine (1) the contractile and metabolic properties and (2) the total and insoluble collagen contents of two muscles *Longissimus thoracis* (LT) and *Semitendinosus* (ST) of 74 young bulls from three breeds: Aberdeen Angus (AA), Limousine (Li), Blonde d'Aquitaine (BA) slaughtered at 17 months of age. Activities of glycolytic (Lactate dehydrogenase, LDH) and oxidative enzymes (Isocitrate dehydrogenase, ICDH; Citrate synthase, CS; Cytochrome-*c* oxidase, COX) were measured. Contractile properties were determined by electrophoretic separation and densitometric quantification of the proportions of the different myosin heavy chain (MyHC) isoforms. All the data were analyzed by using GLM procedure of SAS. The results demonstrated that muscles from AA bulls have a higher oxidative metabolism (ICDH and COX) associated with a higher proportion of MyHC I and IIa (P<0.001). On the contrary, muscles from Li and BA bulls have a higher LDH activity (P<0.001). The proportion of fast MyHC isoforms (IIx and IIb) was the highest in BA muscles. In addition, both total and insoluble collagen contents were higher in muscles from AA than in those from Li and BA bulls (P < 0.001). These data illustrated some particularities of AA muscles opposite to those of Li and BA in accordance with the fact that Angus is an early maturing breed producing marbled beef.**

Keywords— **muscle characteristics, young bulls, breeds**

I. INTRODUCTION

This study is part of the EU ProSafeBeef project on advancing beef safety, and beef products with enhanced quality characteristics. The aim of this study was to compare the characteristics of muscles from young bulls of three beef breeds differing in earliness and lipogenic capacity: Aberdeen Angus (AA) > Limousine (Li) > Blonde d'Aquitaine (BA).

II. METHODS

The experiment was performed with 74 young bulls of three breeds (24 AA, 25 Li, 25 BA). Animals (12 month-old), selected for their live weight and age, were assigned for a 100 day-feeding study at random to four rations (n=18 for each diet). Diets consisted in straw (25%) and concentrate (75%) based i) without lipid and antioxidant supplements, ii) with a lipid supplement from extruded linseed, iii) with the lipid and vitamin E supplements, iv) with the lipid and vitamin E + plant antioxidants rich in polyphenols supplements. Animals were slaughtered at 16 months of age. Samples of *Longissimus thoracis* (LT) and *Semitendinosus* (ST) muscles were collected (1) just after slaughter, frozen in liquid nitrogen and conserved at -80°C for determination of contractile and metabolic characteristics or (2) 24 hours after slaughter, stored under vacuum and conserved at -20°C for determination of total and insoluble collagen (Listrat et al., 1999).

Activities of glycolytic (Lactate dehydrogenase, LDH) and oxidative enzymes (Isocitrate dehydrogenase, ICDH; Citrate synthase, CS; Cytochrome-*c* oxidase, COX) were measured spectrophotometrically (Jurie et al., 2006). Contractile properties were determined by electrophoretic separation and densitometric quantification of the proportions of the different myosin heavy chain (MyHC) isoforms (Picard et al., 2011).

Data were analyzed by using GLM procedure of SAS. The model included fixed effects: breed, diet, animal nested within breed and diet, muscle and interactions. No significant diet, breed x diet and diet x muscle interactions were observed, so only breed and muscle effects were described in text.

III. RESULTS AND DISCUSSION

Metabolic characteristics. Whereas LDH activity was not different between LT and ST muscles, ICDH, CS and COX activities, enzymes representative of oxidative metabolism, were significantly higher in LT than in ST muscle. So LT muscle presents a higher oxidative metabolism than ST muscle. ICDH and COX activities were higher and LDH activity was lower in muscles from AA than in those of Li and BA bulls. Moreover ICDH and COX activities were significantly different between Li and BA bulls (Table 1). So muscles from AA bulls present the highest oxidative metabolism, those from BA bulls the lowest, and those from Li bulls were intermediate.

Contractile characteristics. The electrophoretic separation of MyHC isoforms has revealed the MyHC IIb isoform, described in bovine muscle by Picard et Cassar-Malek (2009), in 9 of 74 young bulls (-1AA, 3 Li, 5 BA). When it was present, it was expressed both in ST and LT muscles of these animals, but in variable proportions, on average 33% in ST and 22% in LT. However, this isoform being only present for some animals, the MyHC IIx and IIb were pooled for the following analyses. The differences in metabolism between muscles and among breeds are in accordance with the differences observed in contractile characteristics. The LT muscle more oxidative than ST showed higher proportions of MyHC I (23%, low oxidative) and MyHC IIa (37%, fast oxido-glycolytic) isoforms and a lower proportion of MyHC IIx+IIb (40%, fast glycolytic) isoforms than ST (8, 24, 68%) respectively (P<0.001). Indeed, the muscles more oxidative from AA bulls presented higher proportions of MyHC I (19%) and MyHC IIa (43%) isoforms and a lower proportion of MyHC IIx+IIb (38%) isoforms than the muscles of Li (15, 27, 58%) and BA (12, 21, 67%) young bulls respectively (P<0.001). The proportions for each isoform between Li and BA bulls were significantly different (Figure 1).

Collagen characteristics. Both total and insoluble collagen contents were lower in LT than in ST muscle, and were higher in AA than in Li and BA young bulls (Table 2). The same differences were reported by Chambaz et al. (2006) between AA and Li steers in LT muscle.

Table 1. Enzyme activities (µmol per min per g) in *Longissimus thoracis* (LT) and *Semitendinosus* (ST) muscles of bulls of Aberdeen Angus (AA), Limousine (Li) and Blonde d'Aquitaine (BA) breeds.

	Muscle				Breed				
	LT	ST	SEM	Muscle effect	AA	Li	BA	SEM	Breed effect
LDH	934	909	11	0.11	820 [b]	961 [a]	984 [a]	17.7	<.0001
ICDH	0.95	0.64	0.028	<.0001	0.97 [a]	0.79 [b]	0.63 [c]	0.04	<.0001
CS	5.2	4.4	0.11	<.0001	5.0	4.6	4.8	0.15	0.17
COX	17.1	8.7	0.37	<.0001	16.3 [a]	12.4 [b]	10.1 [c]	0.76	<.0001

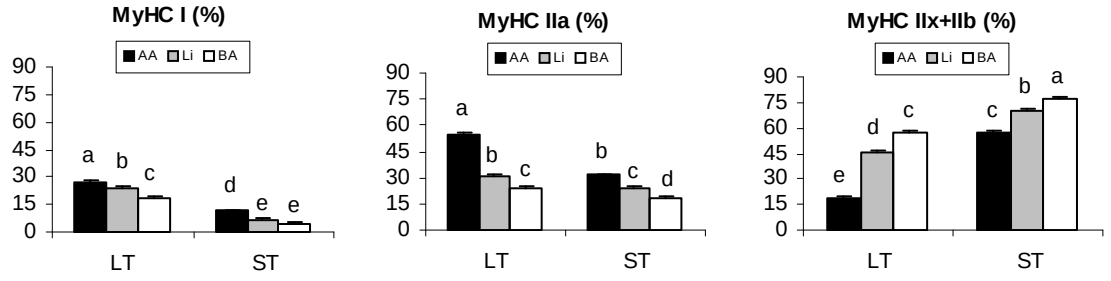

Figure 1. Proportions (%) of different MyHC isoforms in *Longissimus thoracis* (LT) and *Semitendinosus* (ST) muscles of Aberdeen Angus (AA), Limousine (Li) and Blonde d'Aquitaine (BA) breeds.

Table 2. Collagen contents (µg OH-proline per mg dry matter) in *Longissimus thoracis* (LT) and *Semitendinosus* (ST) muscles of bulls of Aberdeen Angus (AA), Limousine (Li) and Blonde d'Aquitaine (BA) breeds.

	Muscle				Breed				
	LT	ST	SEM	Muscle effect	AA	Li	BA	SEM	Breed effect
Total	3.63	5.34	0.07	<.0001	5.36 [a]	4.06 [b]	4.04 [b]	0.12	<.0001
Insoluble	2.78	3.78	0.08	<.0001	3.86 [a]	3.02 [b]	2.96 [b]	0.10	<.0001

IV. CONCLUSIONS

These data illustrated some particularities of muscles from AA young bulls. The AA breed is known as an early maturing breed producing marbled beef. So, slaughtered at the same age, muscles of AA bulls have a higher oxidative metabolism associated with higher proportions of MyHC I and IIa isoforms and both higher total and insoluble collagen contents, whereas muscles of BA bulls have a higher glycolytic metabolism associated with higher proportions of MyHC IIx + IIb isoforms and both lower total and insoluble collagen contents. Muscles of Li bulls have generally intermediate characteristics. Furthermore the different diets of finishing bulls, with or without linseed and antioxidants supplementations, had no effects on muscle characteristics.

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