Meat Science 90 (2012) 99–105

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of whole linseed addition on meat production and quality of Italian Simmental and Holstein young bulls

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ARTICLE INFO

Article history:
Received 26 August 2010
Received in revised form 1 June 2011
Accepted 3 June 2011

Keywords:
Italian Simmental
Italian Holstein
Linseed
Fatty acid composition
Carcass traits

ABSTRACT

The effect of long term dietary linseed addition on performance, carcass characteristics and meat quality of Italian Simmental (IS) and Italian Holstein (HI) young bulls was investigated. Thirty-two animals were assigned to 4 groups following a factorial design: 2 breeds – IS and IH – ×2 diets – containing whole ground linseed (5–8% of DM) and control. IS had greater *in vivo* performance and carcass characteristics than IH. IS muscle had lower C14:0, C16:0, SFA, higher C18:2n-6 *cis*, PUFAn-6, PUFA and PUFA/SFA proportion than IH in phospholipids (PL) fraction. Linseed inclusion did not affect animal's performance and carcass characteristics. In muscle PL, linseed increased C20:0, C22:0, C23:0, C20:5n-3 and decreased C20:4n-6, PUFAn-6/n-3, PUFAn-6 concentration. Linseed decreased C14:0, C16:0 proportion in neutral lipids (NL) and increased total PUFAn-3, C18:3n-3 proportions both in NL and PL fraction. However, these differences were relatively low from a quantitative point of view.

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1. Introduction

Recently, consumers have become more aware of food/health issues. Particular attention has been given to the role of meat as a functional food (Resurreccion, 2003). Indeed as recently reviewed by McAfee et al. (2010) in several epidemiological studies meat consumption seems to be associated with two of the major chronic diseases in the Western world; cardiovascular disease and colon cancer probably because of the saturated fatty acids (SFA) content. In general, on the other hand, the monounsaturated fatty acids (MUFA) and the polyunsaturated fatty acids (PUFA) can have an important beneficial health effect such as hypocholesterolemic properties (Bonamone & Grundy, 1988), essential metabolic roles in the eicosanoid production (Wood et al., 2008), and in the prevention of chronic inflammatory disease (Belluzzi, 2002). In addition, several national and international organisations reviewed by EFSA (2005) show that a low PUFAn-6/n-3 ratio aid in the prevention of many chronic diseases.

Increasing the content of PUFA and reducing SFA with the net effect of increasing PUFA/SFA and reducing n-6/n-3 ratio are priorities (Scollan et al., 2006). There are three major factors that influence the FA composition of beef: age of animal, breed type and diet (Smith, Gill, Lunt, & Brooks, 2009).

There is a different partitioning of body fat between beef and dairy breed, in particular the first one deposit more subcutaneous and less intramuscular fat than the other (Williams, 1978). Moreover there are breed variation in MUFA and total fat content in beef cattle (Dance, Matthews, & Doran, 2009) due to genetic differences (Wood et al., 2008). On the other hand it is widely known that breed can influence animals' performance and carcass characteristics (Wheeler, Cundiff, Shackelford, & Koohmaraie, 2005). Another important tool for improving FA profile of meat is the animal diet. In general previous studies reported the effect of different linseed form and concentration on performance and on FA composition of muscle and adipose tissue in beef cattle (Mach et al., 2006; Raes et al., 2004; Scollan et al., 2001).

The objective of this study was to investigate the effect of whole ground linseed addition to Italian Simmental (IS) and Italian Holstein (HI) young bulls diet on performances, carcass characteristics, and meat quality.

2. Materials and methods

2.1. Animals and diets

After weaning at approximately 5 month of age, 32 young bulls [mean 175.8 kg (S.E. 4.56) of initial body weight] belonging to two breeds: Italian Simmental (IS) and Italian Holstein (IH) were randomly chosen from one commercial dairy farm. The animals were assigned to a 2×2 experimental design. The experimental factors were breed – IS *vs* IH – and diet – containing whole ground linseed (WL) *vs* control (CON), without linseed. Young bulls were offered a growth diet for the first 90 days, after which they were adapted to a finishing diet (Table 1). The animals were fed with an isocaloric and isonitrogenous totally mixed ration given once a day in

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doi:10.1016/j.meatsci.2011.06.008

Table 1
Ingredients and chemical composition of diet.

	Growing		Finishing	
	Control	Linseed	Control	Linseed
Ingredients (g/kg DM)				
Maize silage	184	182	181	188
Grass hay	251	248	247	257
Wheat straw	60	60	59	62
Maize meal	258	229	283	200
Barley meal	57	43	57	46
Whole soybean	175	174	147	144
Whole linseed	0	50	0	80
Mineral–vitamin premix[a]	15	14	27	25
Chemical composition (unit/kg DM)				
Crude protein (g)	143	147	135	140
Crude fibre (g)	182	176	164	182
Ether extract (g)	53	68	49	73
Ash (g)	82	82	81	82
NEF[b] (MJ)	7.23	7.30	7.21	7.22
Fatty acid composition (g/100 g fatty acids)				
C14:0	0.25	0.23	0.28	0.20
C16:0	15.49	14.45	15.75	13.83
C18:0	4.03	4.21	3.97	4.15
C18:1n-9	25.52	25.30	25.35	24.47
C18:2n-6	45.30	42.22	45.34	39.00
C18:3n-3	7.13	12.73	6.94	16.27

[a] Contained per kg: Ca 150 g, P 50 g, Na 80 g, Mg 32 g, Fe 1.2 g, Zn 3.5 g, Mn 1.2 g, Cu 0.2 g, Co 25 mg, I 35 mg, Se 1 mg, vitamin A 500,000 UI, vitamin D3 50,000 UI, vitamin E 1000 mg, vitamin B1 400 mg and vitamin PP 2000 mg.
[b] Net energy for fattening calculated according to INRA standard.

the morning. Moreover, the daily rations were formulated to keep constant the proportion of whole soybean with the aim to avoid confounding effects between this ingredients and linseed. The linseed used in this trial had a cyanogenic potential of 0.116 g HCN/kg DM (data provided by supply company). Thus the level of inclusion of whole linseed in animals' ration (5% and 8% of DM) was chosen in order to respect the maximum total content of cyanogenic substances tolerated by ruminants, 0.25 mg HCN/kg body weight, recently proposed by EFSA (2007). Throughout the entire experimental period the young bulls were loose-housed in 4 pens (7.78 × 11.45 m, 8 bulls per pen) with straw bedding. The young bulls were slaughtered at an average weight of 577 kg (S.D. 24.5) for earlier maturing breeds IH and 619 kg (S.D. 19.3) for later maturing breeds IS, that corresponds to their usual commercial live weight according to the Italian market. The animals were slaughtered at an EU-licenced abattoir, 15 km far from the farm, within 30 min from their arrival and following standard handling procedures.

2.2. Measurements and sample collection

The young animals were individually weighed every month. DM intake was recorded and feed efficiency was calculated daily at group level.

Immediately after slaughter the hot carcass weight was recorded and the dressing percentage calculated. On the same day the carcasses were graded for carcass conformation and fatness according to the EU Regulation No 1208/81, 1026/91. After 45 min from the animals' slaughter the pH was measured, on the *longissimus thoracis* muscle (LT), between 5th and 7th ribs by a glass piercing electrode (Crison 52–32) connected to a pH-meter.

After chilling at 4 °C for 48 h from the right side of the carcass a sample joint was removed from the 8th rib position. The margins of the joint were the cranial edges of the 8th and 9th ribs. The sample joint was than dissected into lean, fat and bone. These values and the ether extract content of LT were included in linear regression equations with the aim to predict the percentage of lean, fat and bone of the carcass as proposed by Andrighetto, Rioni Volpato, Andreoli, and Cozzi (1996). At the same time and at the same side of the carcass, samples of the LT were collected from the 5th and 7th ribs, the pH was measured as described above, and colour was evaluated, according to CIE L*, a*, b* colour system, after a 1-hour blooming period at normal refrigeration temperatures, by a Minolta CM-2600d Spectrophotometer (Minolta Camera, Osaka, Japan) with D65 as light source.

The muscle was then divided into three parts. From the caudal end, on the first sample, vacuum-packed and aged at 4 °C for 10 days, cooking loss was measured in a 75 °C-water bath for 20 min (Spanghero, Gracco, Valusso, & Piasentier, 2004) and shear force was measured on the cooked sample, using a Warner-Bratzler device (WBSF), with a triangular hole in the shear blade, mounted on a Lloyd TAPlus texture analyser (ELIS, Electronic Instruments & Systems S.r.l., Roma, Italy). The measurement was recorded as the peak yield force in N, required to shear, at a 100 mm/min crosshead speed, perpendicular to the direction of the fibres, three cylindrical cross-section replicates, 10 mm diameter × 30 mm length, from each sample. The other samples were vacuum-packed, rapidly frozen and stored at −20 °C until analysis. Proximate analysis was carried out on the second part, whilst on the third part of muscle the FA assay were performed.

2.3. Chemical analysis

Feed samples, collected monthly and dried at 65 °C in a forced oven draught, were analysed for crude protein (CP), crude fibre and ether extract (EE) according to AOAC (2000). The nutritive value, expressed in net energy for fattening (NEF), was estimated in accordance with the INRA standards (Vermorel, 1988).

The proximate analysis of meat was performed following ASPA (1996) procedures on the freeze-dried samples.

The FA composition of feeds and meat was determinate after extraction of total lipids using chloroform:methanol (2:1, v/v; Folch, Lees, & Sloane Stanley, 1957). Considering the meat samples, the separation of neutral lipids and phospholipids was determinate on 20–30 mg of lipids using silicic acid column (Supelclean LC-NH2 SPE tube, Supelco) as suggested by Scollan et al. (2001). The FA from feed and neutral lipids and phospholipids from meat were methylated using acid methylation method (ISO, 5509:2000) and their composition determined by GC/MS (Saturn 2100T, Varian) on a SP-2380 column (60 m × 0.25 mm × 0.25 μm; Supelco). The following temperature programming was used: initial temperature 100 °C, ramp at 4 °C/min and hold 1 min at 160 °C, ramp 0.3 °C/min and hold 2 min at 180 °C, ramp at 30 °C/min and final temperature at 240 °C. Identification of compounds was based on the comparisons of the mass spectrum and their retention time, corresponding with the standard.

2.4. Statistical analyses

The statistical analysis was performed using SPSS version 17 software (SPSS Inc., Illinois).

Average daily gain (ADG) was estimated by fitting a linear regression through live weights during the experimental period for each individual. ADG and meat FA composition were analysed with a 2 (breeds) × 2 (diets) covariance model, using respectively the initial live weight and the intramuscular fat content (expressed as ether extract) as covariate factors. The same model, without covariate, was used for other animal performances, carcass and meat composition and characteristics with the exception of carcass conformation and fatness scores that were analysed by Scheirer-Ray-Hare test for non parametric data following Dytham (2003).

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