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EFFECT OF TYPICAL PRODUCTION SYSTEM FROM SEVERAL COUNTRIES ON FATTY ACID COMPOSITION OF BEEF

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Introduction

There are many factors that can affect the fatty acid composition of intramuscular fat such as breed (Robelin, 1986), age (Link et al., 1970), diet (Rhee, 2000), as well as the level of carcass fatness (Nürnberg et al., 1998), all of them make up a production system. Fatty acid composition of meat affects its nutritive value besides its palatability. With regard to the nutritive value, consumption of saturated fatty acids (SFA) has been associated with an increase in plasma of low density lipoprotein and cholesterol, both of them related to a major risk of coronary heart disease. Another fatty acid important in the human diet is the conjugated linoleic acid (CLA), since it exhibits health benefits when is consumed at low levels (French et al., 2000). Moreover, meat flavor is influenced by saturation rate of fatty acids (Purchas et al., 1979). The susceptibility of meat to lipid oxidation increases with the polyunsaturated fatty acid proportion; it could affect the oxidative meat flavor and reduce the acceptability by consumer (Gatellier et al., 2001).

Objectives

The aim of this study was to analyze fatty acid composition in commercial beef types representing typical production system from Spain, United Kingdom, Germany and Uruguay to assess the extent of "natural" dissimilarity in their fatty acid composition.

Methodology

Five groups of 20 beef slaughtered at usual commercial weight were used from four countries: Spain, United Kingdom, Germany and two types of Uruguay, 2 and 3 years old beef, which are representative of their typical production system conditions. Spanish beef were non-castrated males from Frisian breed; they were early weaned and kept on concentrates and cereal straw *ad libitum* until slaughtering. The age of slaughter was between 10 and 11 months and the carcass weight was 228.9 ± 3.0 kg. The cattle from

United Kingdom were castrated males from commercial crossbreed (Simmental, Charolais and Limousine), they were mainly reared on a grass-based system, using strategic concentrate supplementation. The age of slaughter was between 18 and 22 months and the carcass weight was 313.3 ± 5.2 kg. German beef cattle were noncastrated males from Fleckvieh and Limousine crossbreed. They were reared extensively on pasture and finish the last six months with maize silage *ad libitum*, supplemented with soya and cereal meal. The age of slaughter was between 19 and 24 months and the carcass weight was 382.4 ± 9.2 kg. Beef cattle from Uruguay were from castrated males exclusively raised under extensive improved grazing conditions, producing two kinds of beef, one slaughtered at 2 and the other one at 3 years old, with carcasses weights of 224.8 ± 2.8 kg and 282.0 ± 3.4 kg respectively.

Intramuscular fat was extracted from longissimus lumborum muscle (Hanson & Olley, 1963). Methyl esters of the samples were formed according to Morrison and Smith (1964), using nonadecanoic acid (C19:0) prior to saponification as internal standard. Chromatographic analysis of methyl esters was performed using a Perkin-Elmer gas chromatograph (Perkin-Elmer, USA). Fatty acids were identified from standards and quantified using the internal standard.

One-way ANOVA was performed using GLM procedure of SAS version 8.2. (SAS Inst. Inc, Cary, NC) Differences between the means were determined using the Student-Newman-Keuls test. PRINCOMP procedure was used to principal component analysis, the variables were standardized.

Results & Discussion

The least square means of the fatty acid composition (expressed as proportion by weight of total fatty acids) of the beef and fatty acids ratios from typical production systems of the countries studied are showed in table 1. Spanish and Uruguayan 2 years beef showed the lowest intramuscular fat proportion (1.67 % and 1.74 %, respectively) related to the lowest carcasses weights in comparison with British and German beef that had the highest proportion (2.92% and 2.95%, respectively) with highest carcasses weights.

Spanish beef showed the highest proportion of C18:2 and C20:4 and lowest of C16:0 and C18:1, while British and German beef had the highest proportion of C14:0, C16:0. The proportions of C15:0, C18:3 and long chain fatty acids (C20:5, C22:5 and C22:6) were higher in grass fed cattle (Uruguayan) compared with cattle reared intensively using concentrates (Spanish and German beef). The differences in fatty acid composition in beef could be mainly related to differences in the feeding production system (grass or concentrate). Thus, Varela et al. (2004) reported that steers fed on pasture showed higher percentage of C18:3 and C18:0 than steers fed with concentrate. This may be due to the fact that C18:3 is the major fatty acid present in grass (Garton, 1960), precursor of the long chain *n*-3 fatty acids series (C20:5, C22:5 and C22:6) while cereal grain used in concentrated diet had high levels of C18:2 (Barnes, 1983), precursor of *n*-6 fatty acids series (C20:4 mainly, Rhee, 2000). Levels of C15:0 were also higher on grass fed animals due to this fatty acid arise from digestion of ruminant microorganisms encouraged to feed cattle with grass (Smith et al., 1979).

The CLA isomer, *cis-9, trans-11* C18:2, was detected in all beef samples evaluated. However, Uruguayan 2 and 3 years beef had the highest proportions of this fatty acid, 0.57 % and 0.54 %, respectively. British and German groups had lower proportion (0.34 % and 0.33 %, respectively), showing Spanish beef lesser than twofold the proportion of Uruguayan beef (0.22 %). French et al. (2000) showed the linear increment of intramuscular CLA concentration when the proportion of concentrate in the diet decreased. The high concentrations of rapidly fermentable sugar and soluble fiber of forage creates a rumen conditions which promoted a greater production or decreased utilization of CLA by rumen (Kelly et al., 1998).

The highest PUFA/SFA ratio (P/S) was for Spanish beef, due to their lower proportion of SFA and higher proportion of PUFA (40.99% and 17.34 % respectively). It could be due to differences in feed, age and fatness level. Thus, forage stimulated ruminal activity promoting the biohydrogenation of the fatty acids, which in turn, increases the concentration of SFA (Choi et al., 1997). Link et al., (1970) showed in muscle that the proportion of PUFA decreased with increasing animal age and concomitant increases in intramuscular neutral lipid deposition. The increment of SFA with age and decrement of PUFA could be the reason why older animals (German, British and Uruguayan beef) showed low PUFA proportions and P/S ratio. With regard to fatness, Nürnberg et al. (1998) found a negative relationship between fat content and PUFA, and Marmer et al. (1984) found that triacylglycerols, which increased with fatness, are less unsaturated than phospholipids in muscle membranes. The ratio *n*-6/*n*-3 was very high in Spanish beef (14.84) related to the other beef (7.60, 2.62, 1.48 and 1.37 for German, British, Uruguayan 3 years and 2 years, respectively). According to Kemp et al. (1981), the use of concentrate resulted in raised concentrations of *n*-6 PUFA and grass diets increased *n*-3 PUFA.

Principal component (PC) analysis was performed to study the relationship between fatty acids and examine the relationships between the types of beef compared. Figure 1 displays the projection of the fatty acid data in the plane defined by the two first principal components (PCs). The first PC explained 37.6 % of the variability of the fatty acid composition. PC1 was mainly characterized by PUFA, P/S and C20:4, and in the opposite side by intramuscular fat proportion (fat). The second PC explained the 28.1 % of the total variability, it was defined by long chain *n*-3 fatty acids (C20:5 and C22:5), C18:3 and in the opposite direction by C18:2 and *n*-6/*n*-3 ratio. However, Bas and Morand-Fehr (2001), using PCs analysis to study fatty acid composition of lambs, found that the first two PC explained about 45% of the total variance in subcutaneous and intramuscular fat, and about 60% in perirenal adipose tissue. The projection of the fatty acid data in the plane defined by the two first principal components of the five groups studied is shown in figure 2. Spanish beef were clearly separated from rest of beef groups and were placed on the left hand down PC1 axis, close to PUFA, P/S ratio and *n*-6 fatty acid (C18:2 and C20:4). The Uruguayan 2 years beef were located up in the figure on the left side, close to long chain fatty acids (C20:5, C22:5 and C22:6), C18:3 and C15:0, whereas Uruguayan 3 years beef are slightly moved on the right, where C17:0, C18:0, and CLA lay. British and German beef were located on the right side of the figure, close MUFA, SFA and fat proportion, both of them clearly separated, British above and German down PC1 axis. This different location was mainly due to German beef had higher *n*-6/*n*-3 ratio than British beef, which is located down in the projection of the fatty acid data.

Conclusions

The Spanish beef fed with concentrate had lowest SFA proportion and higher PUFA proportion, therefore they had a better ratio P/S compared with the rest of the beef groups. The Uruguayan 2 and 3 years beef had the highest proportion of *n*-3 fatty acids (C18:3, C20:5, C22:5 and C22:6), CLA and odd fatty acids (C15:0 and C17:0) and the lowest *n*-6/*n*-3 ratio. British and German beef had the highest intramuscular fat proportion, SFA and MUFA.

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Tables and Figures

Table 1. Fatty acid composition of m. *longissimus lumborum* in percentage by weight of total fatty acids of beef from typical production system of several countries.

		United		Uruguay	Uruguay	
	Spain	Kingdom	Germany	2 years	3 years	RMSE
Fat (%)	1.67$_{a}$	2.92$_{c}$	2.95$_{c}$	1.74$_{a}$	2.35$_{b}$	0.73
C14:0	2.32$_{b}$	2.64$_{a}$	2.78$_{a}$	2.01$_{c}$	2.19$_{bc}$	0.39
C15:0	0.38$_{b}$	0.43$_{c}$	0.30$_{a}$	0.47$_{d}$	0.48$_{d}$	0.06
C16:0	22.57$_{a}$	27.29$_{d}$	26.53$_{cd}$	24.22$_{b}$	25.24$_{bc}$	2.44
C16:1	2.90$_{a}$	3.39$_{b}$	3.63$_{b}$	2.83$_{a}$	3.30$_{b}$	0.48
C17:0	1.05$_{b}$	1.05$_{b}$	0.74$_{a}$	1.11$_{b}$	1.11$_{b}$	0.12
C18:0	14.47$_{b}$	15.00$_{ab}$	15.02$_{ab}$	16.26$_{a}$	15.20$_{ab}$	1.69
C18:1	37.67$_{a}$	41.26$_{b}$	41.96$_{b}$	38.30$_{a}$	40.72$_{b}$	3.49
C18:2	12.22$_{a}$	3.34$_{b}$	4.76$_{b}$	4.68$_{b}$	3.77$_{b}$	1.85
C18:3	0.45$_{d}$	0.88$_{c}$	0.47$_{d}$	2.13$_{a}$	1.70$_{b}$	0.28
CLA	0.23$_{c}$	0.34$_{b}$	0.33$_{b}$	0.57$_{a}$	0.54$_{a}$	0.15
C20:4	3.11$_{a}$	1.16$_{c}$	1.25$_{c}$	2.10$_{b}$	1.54$_{c}$	0.62
C20:5	0.16$_{d}$	0.43$_{c}$	0.14$_{d}$	1.30$_{a}$	0.84$_{b}$	0.25
C22:5	0.45$_{d}$	0.71$_{c}$	0.29$_{d}$	1.73$_{a}$	1.19$_{b}$	0.30
C22:6	0.04$_{c}$	0.07$_{c}$	0.04$_{c}$	0.17$_{a}$	0.12$_{b}$	0.06
SFA	40.99$_{c}$	46.63$_{a}$	45.60$_{ab}$	44.27$_{b}$	44.45$_{b}$	2.84
MUFA	41.67$_{b}$	46.11$_{a}$	46.90$_{a}$	42.49$_{b}$	45.44$_{a}$	3.62
PUFA	17.34$_{a}$	7.26$_{d}$	7.50$_{d}$	13.24$_{b}$	10.11$_{c}$	3.02
P/S	0.43$_{a}$	0.16$_{d}$	0.17$_{d}$	0.30$_{b}$	0.23$_{c}$	0.08
n-6/*n*-3	14.84$_{a}$	2.63$_{c}$	7.60$_{b}$	1.37$_{d}$	1.48$_{d}$	1.29

$_{a, b, c, d}$: Means in the same row with different letter differ significantly (P<0.05)
RMSE: root of mean square error

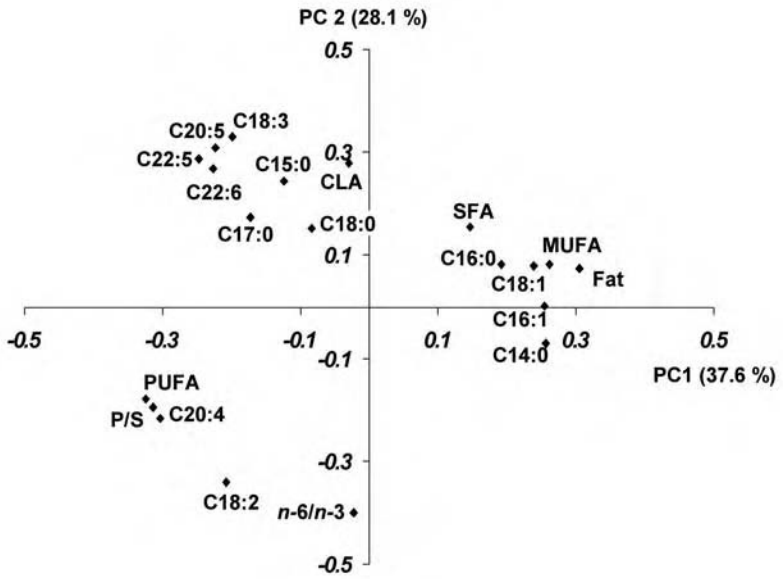

Figure 1. Projection of the fatty acid data in the plane defined by the two first principal components.

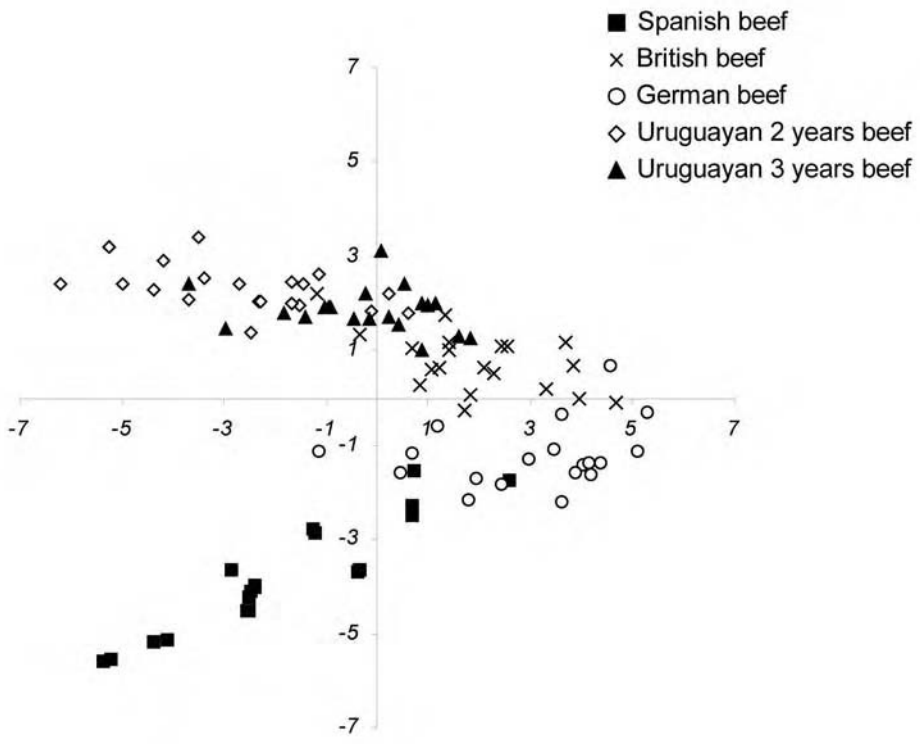

Figure 2. Projection of the fatty acid data of the five groups studied in the plane defined by two principal components.