IMPACT OF THE DIET ON NUTRITIONAL COMPOSITION OF CHAROLAIS X NELORE CROSS STEERS OF BRASIL

A. Biolatto[1*], A. Callegaro[2], J. S. Vittone[1], M. Lado[1], I. Brondani[2], D. Borchate[2], J. M. Cocco[2], S. Adams[2], J. Klein[2], A. F. Moura[2]

[1] Estación Experimental Agropecuaria Concepción del Uruguay, Instituto Nacional de Tecnología Agropecuaria (INTA), Ruta 39 km 143.5, 3260 Concepción del Uruguay, Entre Ríos, Argentina

[2] Centro de Ciências Rurais, Universidade Federal de Santa Maria, Ministério da Educação, Avenida Roraima, 1000 - Camobi, Santa Maria - RS, 97105-900, Brasil.

[*]biolatto.andrea@inta.gob.ar

Abstract – Fatty acid composition of the *Longissimus dorsi* muscle of 32 steers of Charolais x Nelore cross 20 months old fed with: (SBH) Soybean hulls plus protein nucleus, (WOG) White Oats grain plus protein nucleus, (SBH+WOG) A mixture with a protein concentrate basis and equal percent of soybean hulls and oat grains, were evaluated. On average, beef from SBH - fed steers presented higher concentration of all saturated fatty acids compared to WOG and SBH+WOG diets. Conversely, beef from SBH - fed steers had higher total MUFA content than beef from WOG and SBH+WOG - fed steers. Beef from soybean hulls – fed steers presented higher concentration of components that are considered beneficial to human health, such as *n*-3 PUFA, and a lower *n*-6/*n*-3 PUFA ratio.

I. INTRODUCTION

In most developed countries, meat is a staple food in human diet and contributes substantially to protein, fat, vitamins and minerals intake. For this reason, meat lipids are an important source of fatty acids in the human diet. The fatty acid composition of dietary fat is of great importance in human nutrition and health (1, 2).

Recommendations to improve beef fatty acid (FA) content and composition are based on scientific evidence indicating the positive and negative effects of fat and fatty acid consumption. The FAs, specifically myristic acid (14:0) and 16:0 are typically among the most concentrated fatty acid in meat and have been associated with cardiovascular disease (CVD), colorectal cancer and type 2 diabetes (3). Polyunsaturated FAs on the other hand, particularly *n*-3 PUFA such as α-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have been reported to have positive effects on human health including the potential to reduce the CVD risk, Alzheimer disease, atherosclerosis, obesity, type II diabetes, osteoporosis, dry eye syndrome (3), and depression in adolescents with eating disorders (Swenne, Rosling, Tengblad, & Vessby, 2011). The c-monounsaturated fatty acids (MUFAs) may also have beneficial health effects including hypocholesterolemic, anti-thrombotic and anti-hypertensive properties (4). There is also evidence that some *trans* fatty acid isomers can have positive health effects, and be enriched in beef. Vaccenic acid (*t*11-18:1; VA) may have positive health effects either independently (Field, Blewett, Proctor, & Vine, 2009) or by Δ-9 desaturation to rumenic acid (*c*9,*t*11-18:2, RA, the main natural isomer of conjugated linoleic acid (CLA)) which has purported anti-carcinogenic, anti-diabetic, cardio-protective, antitherogenic, anti-inflammatory and positive immune modulatory properties (5). Consequently, there has been an effort to produce livestock with enhanced fatty acid profiles that are conducive to human health. The object of this research work was to investigate the effect of feeding on the fatty acid composition of M. *longissimus dorsi* (LD) from beef steers.

II. MATERIALS AND METHODS

II.1 Animals and experimental design

This research work was done between June and November of 2011 in the Beef Lab of the Animal Science Department of the Santa María University located in Santa Maria on Rio Grande do Sul, Brasil. Its geographic location is 29° 43' S, 53° 42' W and 95 m

altitude, in the Depressão Central of Rio Grande do Sul State, Brazil.

The experimental animals were 32 steers of Charolais x Nellore cross 20 months old and 275,09 kg average weight, supplied by the experimental herd of the Beef Cattle Lab.

Finishing was done in feedlot with $12m^2$ paved individual boxes with feeders to supply feed.

Steers were assigned to three different feeding 100% concentrate treatments with a protein nucleus and a calcium supply.

Feeding treatments were designed according to NRC (6) and an estimated intake of 2.54 kg/100kg liveweight with isonitrogen diets, as follow: (SBH) Soybean hulls plus protein nucleus, (WOG) White Oats grain plus protein nucleus, (SBH+WOG) A mixture with a protein concentrate basis and equal percent of soybean hulls and oat grains.

During the experimental period the animals were fed twice a day: 8 a.m. and 2 p.m. Before refeeding, the day before residual feed was collected, weighed and recorded in order to estimate intake.

Voluntary intake was recorded daily weighing the feed supply and the day before remaining. Feed supply was designed to be 50 or 100 g/kg over voluntary intake (7) and was adjusted to the intake of the day before.

When the animals attained the weight to be processed (based on carcass weight) were sent to the packing house after 92 days of the experimental period for the mixture of white oats and 109 days in those fed soybean hulls.

The animals were sent to the commercial packing house and were processed according the RIISPOA (Brazilian rules) and killing out packing house routine. After de killing out process the carcasses were cut by halves (right and left carcasses) and weighed. The cold carcass weight was obtained after of 24 h refrigeration and yield was estimated in relation to the killing weight. In the right half carcass the *Longissimus dorsi* was cut between the 12th and 13th ribs in order to obtain the so called "Section HH" according the methodology suggested by Hankins *et al.* (8) and adapted by Muller *et al.* (9) in order to obtain *de Longissimus dorsi* muscle.

The sample obtained from the *Longissimus dorsi* muscle was identified and frozen for the the fatty acid profile to be analized in the INTA-EEA Concepción del Uruguay Animal Science Lab.

II.2 Analytical procedures

Carcasses were refrigerated in commercial chambers with forced air circulation (0 ± 2 °C) during 24 h. Steaks of *Longissimus dorsi* muscle at 12th rib were taken from each treatment, carefully dissected and used for chemical analysis. All samples were stored at -20°C until analysis were performed.

II.2.1. Fatty acid analysis

Meat samples were cut into 1.5 mm rectangular strips with a razor blade and processed in wet state by the direct FAME synthesis method according to O' Fallon *et al.* (10). The FAME were separated by gas-chromatography using a PerkinElmer Clarus 680 model equipped with a flame ionization detector and an CombiPal automatic injection system using a HP-88 for FAME capillary column (100 m x 0.25 mm i.d., 0.25 m film thickness). The FAME preparation was injected in the split mode with a split ratio of 1:65. Nitrogen was used as the carrier gas with a 1.0 mL/min flow rate. Injector and detector were kept at constant temperatures of 250 °C and 270 °C, respectively. The column oven temperature was increased at 4 °C/min of 80 °C to 220 °C and held for 5 min, increased to 240 °C at 2 °C/min and held for 10 min. Identification was achieved by comparing the retention time of unknown FAME with those of known FAME standard mix (37 FAME, Supelco Inc., Bellefonte, PA, United States). CLA was determined using a standard consisting of a mixture of cis- and trans-9,11- and -10,12-octadecadienoic acid methyl esters (O5632 Sigma). Quantitative analysis of FAME was based on undecanoic acid as internal standard.

III. RESULTS AND DISCUSSION

Beef lipids are not generally regarded as a healthy component of the human diet. There are concerns about its relatively high concentrations of hypercholesterolemic, saturated fatty acids (SFA) and low concentration of hypocholesterolemic polyunsaturated fatty acids (PUFA).

All saturated fatty acids, in general, showed higher values in beef from SBH – feed steers compared to WOG and SBH+WOG (Table 1). Myristic acid (C14:0), a hipercholesterolemic and thrombogenic fatty acid presented a higher value for SBH compared to WOG, but similar when contrasted with WOG+SBH. Palmitic acid

(C16:0), another hipercholesterolemic and thrombogenic fatty acid showed higher amount in beef from SBH – feed steers compared to the other diets.

Table 1. Fatty acid profile of *Longissimus dorsi* muscle of Charolais x Nelore cross steers according to different diets, in mg/100 g of identified FAME (mean ± s.e.).

	SBH	WOG	SBH+WOG
C14:0	58,9±5,1	52,9±6,6	60,1±8,6
C14:1	11,1±1,1	10,3±1,7	12,4±1,6
C15:0	12,5±2,7	10,3±1,2	6,9±1,7
C16:0	689,4±85,2	591,7±65,9	604,2±71,2
C16:1	77,3±6,6	61,0±10,2	72,7±7,0
C17:0	40,2±8,4	27,8±2,9	19,3±4,3
C18:0	460,0±74,0	465,9±40,1	386,8±81,2
C18:1 *n*-9*c*	1060,5±189,7	959,2±123,8	871,0±94,3
C18:2 *n*-6*c*	132,5±6,7	138,1±6,9	135,3±17,5
C18:3 *n*-6	3,9±0,7	4,1±0,3	4,0±1,1
C20:0	3,1±0,4	2,9±0,2	2,1±0,6
C18:3 *n*-3	19,9±2,3	11,2±1,0	12,3±2,3
C20:1	4,3±1,2	4,3±0,7	3,8±0,6
C18:2 *c*9,*t*11	3,3±0,2	5,0±0,7	5,6±1,1
C20:2	2,1±0,6	1,6±0,5	2,3±0,8
C22:1*n*-9	48,9±1,3	52,3±3,1	42,1±4,4
C22:2	10,7±0,6	9,7±0,8	11,0±2,8
C22:6 *n*-3	5,8±1,3	5,0±0,5	5,9±1,7
SFA[b]	1264,1±173,5	1151,5±109,9	1079,4±163,1
MUFA[c]	1202,1±196,7	1087,1±138,8	1001,9±100,8
PUFA[d]	178,2±9,3	174,7±9,0	176,6±23,8
n-6[e]	136,4±7,1	142,1±7,1	139,3±18,4
n-3[f]	25,7±2,6	16,3±1,2	18,3±3,0
n-6/*n*-3	5,4±0,4	8,8±0,4	7,9±0,7

[a]CLA: conjugated linoleic acid.
[b]SFA = C14:0 + C15:0 + C16:0 + C17:0 + C18:0 + C20:0 + C22:0.
[c]MUFA = C14:1 + C16:1 + C18:1 *n*-9 *cis* + C20:1 + C22:1 *n*-9
[d]PUFA = C18:2 *n*-6 *cis* + C18:3 *n*-6 + C18:3 *n*-3 + *cis*-9, *trans*-11 CLA + C20:2 + C22:2 + C22:6 *n*-3.
[e] *n*-6 = C18:2 *n*-6 *cis* + C18:3 *n*-6.
[f] *n*-3 = C18:3 *n*-3 + C22:6 *n*-3.

The PUFA and MUFA fractions are generally considered beneficial to human health (11). The present study shows that beef from SBH - fed steers had higher MUFA total amounts than beef from WOG and SBH+WOG - fed steers. However, the different diets studied evidenced similar PUFA level.

The last years, have seen a growing interest in *n*-3 PUFA prompted by increasing evidence that these PUFA elicit a wide range of nutritional benefits in the human body. Beef from SBH–fed steers contained higher amount of *n*-3 PUFA than the other diets.

The *n*-6/*n*-3 PUFA ratio is an important index to evaluate the nutritional value of fat. According to the World Health Organization (2) it should be lower than four in human diet.

Even though the *n*-6/*n*-3 PUFA ratio was higher that the recommended value by WHO, steers fed with soyben hulls had a better *n*-6/*n*-3 PUFA ratio compared to the other diets.

IV. CONCLUSION

This study indicates that diet is an important factor that affects the fatty acid profile of beef. From a nutritional point of view, beef from SBH-fed steers seems to be more healthful than beef obtained from the WOG and SBH+WOG diets because of its lower *n*-6/*n*-3 ratio, although this ratio is above the recommended value for human diet. The contribution of beef to dietary intake of SFA, MUFA and PUFA is an important issue to consumers and consequently the meat industry. Further research should be driving at in order to improve beef nutritional quality, very especially the attributes to develop a functional food.

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