EFFECT OF THE INCLUSION OF DIFFERENT SOURCES OF FATS, AS ENERGETIC COMPONENT, IN THE CONCENTRATE ON BEEF QUALITY

A. Guerrero[1], I.N. Prado[1, 2], M.M. Campo[1], E. Muela[1], J.L. Olleta[1], M.V. Valero[1, 2], O. Catalán[3], J. Heras[4] and C. Sañudo[1]

[1]Department of Animal Production and Food Science, University of Zaragoza, C/Miguel Servet, 177, 50013, Zaragoza, Spain.

[2]Department of Animal Science, State University of Maringá, Av. Colombo, 5790, 87020–900, Maringá, Paraná, Brazil.

[3]INZAR, C/ Poeta Luis Cernuda s/n, 50018, Zaragoza, Spain.

[4]Agrícola Mas Jonquer, Sat Sant Mer, Gr. San Mer 61, 17468. Sant Esteve de Guialbes, Girona, Spain.

Abstract – The effect on carcass and meat quality of different fats added at 4% as energetic source was evaluated. Four groups of 8 steers of Friesian breed per treatment were finished in feedlot with palm oil (PAL), tallow (TAL), hydrogenated fat (HYD) or sunflower oil (SUN) for 5 months. All diets were isoenergetic and isoproteic. The 6th rib was used to assess tissue composition. The fatty acid composition was evaluated in *Longissimus thoracis* muscle. Also, a consumer test (120 people) was performed to evaluate tenderness, flavour and overall acceptabilities. HYD group showed the highest percentage of muscle and PAL the lowest ($p \leq 0.001$), because of its highest total fat percentage ($p \leq 0.01$). For fatty acid composition no differences were found among fat groups (SFA, MUFA, PUFA, *n-3, n-6* or their respective ratios). Consumer showed differences in tenderness acceptability ($p \leq 0.001$) among fats, having TAL the lowest acceptability. Consumers preferred ($p \leq 0.001$) meat aged for 7 instead of 21 days. In conclusion, adding fat as energy sources in steers diets did not largely affect meat fatty acid composition, although some modifications in tissue composition and acceptability could be detected.

Key Words – Carcass quality, Fatty acid composition, Meat acceptability

I. INTRODUCTION

Traditionally, the more common source of fat used in cattle feed has been from animal origin such as tallow, lard or mixtures. But alimentary crises BSE, dioxins, etc., have made questionable the use of certain raw materials in animal nutrition. Also, the constant increase of cereal prize in the market has favoured the increase of fat percentage on some diets until 6-7% of total ration [1], versus the common 4% recommended and traditionally used [2]. The function of fat in ruminant feed is varied. It has some technology utilities, because it bind together the different ingredients in the diet, gluing particles of different grain side, which reduces dust formation, and improving concentrate ingestion. The other function of fats in concentrate function is related to its contribution as source of energy (which could be double of starch contribution) [3].

Some authors have been focused on exploring ways to enhance fatty acids composition of beef by supplementing plants oils, oilseeds, rumen protected fats and fish oils [4]. Also, dietary fat has been studied in dairy cattle, focusing in the consequences that those variations produce in milk yield and milk fatty acids composition [5].

The aim of this work was to study whether carcass and meat quality is affected when different fat sources (vegetal, animal, synthetics) are added at 4% of total ration ingredients, as source of energy, to reduce feeding costs in the future, especially if quality was unaffected.

II. MATERIALS AND METHODS

Thirty two steers from Friesian breed of 320 ± 10 days age and 283.2 ± 9.2 kg live weight were randomly assigned to one of four finishing diets (n = 8 per treatment). All used diets were isoenergetic and isoproteic, and they were formulated according to NRC recommendations for Friesian steers from 300 to 400 kg live weight and daily gain of 1.0 kg [6].

The only difference between dietary treatments was the source of fat added in the concentrate, because all fats were included in the same percentage representing the 4% of ingredients. Fat used as energetic source were: palm oil (PAL), tallow (TAL), hydrogenated fat "soap stock palm fatty acids calcium salt" (HYD) or sunflower oil (SUN). Percentage of total fat in ration was around 7.5%, value which included fat specifically added and fat from other diet´s components.

Determination of diets' chemical composition was performed according to BOE [7]. PALM and HYD diets showed the highest percentage of SAT and SUN the lowest (Table 1). TAL and HYD had the largest percentage of estearic acid (C 18:0), and SUN and TAL the highest levels in C18:1, being HYD the diet with highest C18:3 percentages (data not shown).

Table 1 Chemical and fatty acid composition (%) of the four experimental diets

Chemical composition	PAL	TAL	HYD	SUN
Caloric value (Kcal)	375.7	376.3	377.3	378.7
Moisture	9.82	9.67	9.63	9.56
Protein	13.69	12.35	14.25	14.88
Ash	5.70	5.04	5.87	5.61
Carbohydrates	63.26	65.92	62.41	62.09
Fats	7.54	7.02	7.85	7.86
SFA	2.97	2.01	2.50	1.87
MUFA	2.56	2.95	2.07	3.36
PUFA	1.88	1.90	2.76	2.51

PAL: palm oil; TAL: tallow; HYD: hydrogenated fats; SUN: sunflower oil.

Animals were fed *ad libitum* with their respective concentrate and cereal straw for (5 months). They were slaughtered when reaching commercial characteristics (320 days of age and 424 ± 6.5 kg live weight), in an EU-licensed commercial abattoir. Carcasses were graded visually for conformation and fatness based on the European Grading System Classification SEUROP [ranged from 18 (S+: the best) to 1 (P-: the poorest) and fatness scored based on a 5 point-scale, from 5 (the fattest) to 1 (the leanest)]. Also it was taken morphological measures as internal carcass length in the left carcass side.

At 48 h post-mortem, pH was measured on *Longissimus thoracis* (LT) from left side and it was dissected afterwards. Also, 6th rib was excised, being weighted and kept frozen until its dissection into muscle, fat (subcutaneous and intermuscular), bone, and other tissues (tendons, fascias, blood vessels) according to Robelin *et al*. [8].

For fatty acids analysis, intramuscular fat was extracted from the LT from the 6th rib, following Bligh *et al.* [9]. Methyl esters were formed with KOH in methanol with C 19:0 as an internal standard. To identify the methyl esters of the fatty acids, we used an HP 6890 Gas Chromatograph with a SP 2380 capillary column (100 m x 0.25 mm x 0.20 µm) [10]. Each sample was analyzed in duplicates.

Four 2-cm-thick steaks of each animal from LT were used to study a consumer test under standardized conditions. Samples were vacuum-packed and aged during 7 or 21 days at 2-4ºC, and then frozen until the moment of the analyses. Consumer test was performed in the University of Zaragoza and involved 120 local consumers divided in groups of twenty people. Consumer population was according to Spanish national profile (32.5% between 18-30 years old; 34.2% between 31-50 years old and 33.3% older than 51 years; 48.3% men and 51.7% women). Each sample was cooked covered with aluminum foil in a grill pre-heated at 200 ºC until reaching an internal temperature of 70 ºC, monitored with a penetration thermocouple. Samples were cut in 2x2 cm cubes and kept warm until consumer evaluation (less than 10 minutes from cooking). To avoid order or carry-over effects [11] the samples were served following a randomized design. For each sample, consumers evaluated tenderness, flavor, and overall acceptability in a scale of 9 points.

Carcass and meat attributes were analyzed by analysis of variance, using a General Lineal Model procedure (SPSS 19.0) in which diet was considered as fixed effect. For consumer test, diet, ageing and interactions were evaluated, being consumer considered as random effect. Differences between group means were assessed using Duncan's Multiple Range Test ($p<0.05$).

III. RESULTS AND DISCUSSION

There were not significant differences in carcass quality (cold carcass weight, conformation or fatness scores). Average carcass weight was 222.2 kg, showing a dressing percentage of 52.4 % and a blockiness index of 1.74 (cold carcass weight/internal length), common in dairy breed animals. In all treatments average conformation score was (O) and fatness 3, following SEUROP scale.

There were not differences in pH (Table 2), having all groups common values for normal beef meat. In relation to tissue composition, statistical differences appeared between diets, related to percentage of muscle ($p \leq 0.001$), intermuscular fat ($p \leq 0.01$), total fat ($p \leq 0.001$) and bone ($p \leq 0.05$).

Table 2 Effect of fat added in the diet on final meat pH and tissue composition (%) of Friesian steers

Items	PAL	TAL	HYD	SUN	s.e.d.	Sig.
pH	5.53	5.57	5.51	5.52	0.01	ns
Tissue composition (6th rib)						
Muscle	54.8a	57.5b	60.7c	57.5b	0.50	***
Subcutaneous fat	6.16	5.95	5.13	5.81	0.60	ns
Intermuscular fat	19.8b	17.1a	14.8a	17.3a	0.35	**
Total fat	26.0c	23.1b	19.9a	23.1b	0.57	***
Bone	14.1a	14.3b	14.2b	14.3b	0.27	*
Other tissues	5.11	5.10	5.11	5.13	0.20	ns

PAL: palm oil; TAL: tallow; HYD: hydrogenated fats; SUN: sunflower oil.
s.e.d.: standard error of the difference.
ns: no significant; *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$

HYD group showed the greatest percentage of muscle, being significant higher from the other groups, and the lowest percentage of total fat, having also the smallest percentage of intermuscular fat. But in this parameter HYD did not have statistical differences with the other diets, except with PAL fat. Also, PAL treatment showed the lowest percentage of muscle and bone. On the other hand, TAL and SUN did not show statistical differences between them.

In general, Friesian young bulls finished under intensive conditions show between 60-65% of muscle and 20-22% of bone [12, 13], thus the values obtained in the study were normal for castrated animals. However, the percentage of fat from the rib dissection could be considered as high, probably due to the castration that increases the deposition of total fat.

Although there were differences in fatty acid composition (SAT) among the different fats added in the diets, those differences were not reflected in the fatty acid profile of the meat (Table 3). Few statistical differences appeared between groups; only in some specific minor fatty acids (results not shown). Thus, a tendency ($p \leq 0.1$) in (C14:0) where PAL diet showed the highest value but only significant different from HYD treatment. Also in (C14:1), being HYD the diet with lowest value and TAL the highest. Or in (C20:1 n-9), where PAL showed the lowest value and SUN the highest.

Table 3 Effect of fat added in the diet on fatty acid composition of the intramuscular fat (%) of Friesian steers

Item	PAL	TAL	HYD	SUN	s.e.d.	Sig.
SFA	49.34	48.89	49.12	47.99	0.55	ns
MUFA	44.58	44.83	43.94	45.73	0.62	ns
PUFA	5.20	5.28	5.92	5.34	0.32	ns
n-6	4.74	4.81	5.39	4.85	0.32	ns
n-3	0.21	0.20	0.23	0.20	0.01	ns
PUFA/SFA	0.10	0.11	0.12	0.11	0.01	ns
n-6/*n*-3	22.36	23.63	23.03	24.04	0.99	ns

PAL: palm oil; TAL: tallow; HYD: hydrogenated fats; SUN: sunflower oil.
s.e.d.: standard error of the difference, ns: no significant

In the consumer test, tenderness acceptability significantly differed among diets ($p \leq 0.001$), showing also a tendency in overall acceptability ($p \leq 0.1$). However, the ageing effect was more significant ($p \leq 0.001$) in all attributes.

Differences in tenderness acceptability were showed at 7 days of ageing, being TAL the treatment with significant lower scores (6.4) *vs.* 6.9-7.0 showed in the rest of groups (Table 4). PAL was the diet with highest values in flavour acceptability and overall acceptability, but without statistical differences with the rest of groups.

Table 4 Consumer approaches for acceptabilities of Friesian meat with different fats added in the diet. (n = 120) §

Attribute	Ageing	PAL	TAL	HYD	SUN	sed
Overall	7 days	7.08 z	6.73 z	6.93 z	6.93 z	0.30
acceptability	21 days	5.91 y	5.68 y	5.62 y	5.93 y	0.39
Tenderness	7 days	6.98 bz	6.49 az	7.03 bz	6.99 bz	0.33
acceptability	21 days	6.85 y	6.09 y	6.40 y	6.38 y	0.38
Flavour	7 days	7.17 z	6.95 z	6.93 z	7.00 z	0.28
acceptability	21 days	5.62 y	5.71 y	5.48 y	5.69 y	0.40

PAL: palm oil; TAL: tallow; HYD: hydrogenated fats; SUN: sunflower oil.
§Using a 9 point scale (1: dislike extremely; 9: like extremely).
y, z: different letters in same column indicate significant differences ($p<0.05$). Ageing effect.
a, b: different letters in same row indicate significant differences ($p<0.05$). Diet effect.

In all attributes, the scores given at 21 days of ageing were lower than those at 7 days, and especially in flavour acceptability, which could be related to an excessive increase of lipid oxidation (from 1.35 to 4.3 mg malonaldehide/kg meat; results not shown). In any case, meat was scored over 5.4 points in a 9 point scale, which could be considered as a positive evaluation.

IV. CONCLUSION

The inclusion of a 4% of total ingredients with different sources of fat: animal (tallow), hydrogenated and vegetal (palm and sunflower), do not have any effect on some carcass characteristics, but can slightly influence its tissue composition, although values obtained are inside the common range in dairy breeds. When fat is added as a source of energy and it is supplied without protection, fatty acid profile of meat is unaffected by the type of fat used, presenting a typical composition of intensively reared animals. Consumers' acceptability is more affected by ageing than by the different sources of fat used in the diet of the animals.

ACKNOWLEDGEMENTS

This research was financed by CDTI and Agricola Sat Sant Mer. The authors thank the technical assistance of Animal Production Department and personnel implicated in some parts of the process.

REFERENCES

1. Castro, T., Jimeno, V. & Cabezas, A. (2011). Modificación del perfil lipídico de la carne de vacuno hacia una grasa más saludable desde el punto de vista de la salud humana. Anembe 94: 20-27.
2. Vasconcelos, J. T. & Galyean, M. L. (2007). Nutritional recommendation of feedlot consulting nutritionist: The 2007 Texas Tech University survey. Journal Animal Science 85: 2772-2781.
3. Angulo, E. & Puchal, F. (1995). Tecnología de fabricación de piensos. Ed. Universidad de Lleida.
4. Duckett, S. K. & Gillis, M. H. (2010). Effect of oil source and fish oil addition on ruminal biohydrogenation of fatty acids and conjugated linoleic acid formation in beef steers fed finishing diets. Journal of Animal Science 88: 2684-2691.
5. Chilliard, Y. & Ferlay, A. (2004). Dietary lipids and forage interactions on cow and goat milk fatty acid composition and sensory properties. Reproduction Nutritional Development 44: 467–492.
6. NRC. (1996). Nutrient Requirements of Beef Cattle. 7th edition. National Academic Press, Washington, DC.
7. BOE. (1979). Métodos oficiales de análisis de productos cárnicos. 29 Agosto 1979, BOE nº: 207: 20221-20300.
8. Robelin, J. & Geay, Y. (1975). Estimation de la composition de la carcasse des taurillons á partir de la composition de la 6ª côte. Bulletin Technique CRZV INRA Theix 22: 41-43.
9. Bligh, E. G. & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. Canadian Journal Biochemistry and Physiology 37: 911-917
10. Carrillho, M. C., López, M. & Campo, M. M. (2009). Effect of the fattening diet on the development of the fatty acid profile in rabbits from weaning. Meat Science 83: 85-95
11. Macfie, H. J., Bratchell, N., Greenhoff, K. & Vallis, L. V. (1989). Designs to balance the effect of order presentation and first-order and carry over effects in hall test. Journal of Sensory Studies 4: 129-148.
12. Monsón, F., Sañudo, C. & Sierra, I. (2005). Influence of breed and ageing time on the sensory

meat quality and consumer acceptability in intensively reared beef. Meat Science 71: 471-479.

13. Partida, J. A., Olleta, J. L., Campo M. M., Sañudo, C. & María, G. A. (2007). Effect of social dominance on the meat quality of Young Friesian bulls. Meat Science 76: 266-273.