GENETIC VARIATION IN THE FATTY ACID COMPOSITION OF CATTLE FAT AND MUSCLE

A.E.O. MALAU-ADULI, B.D. SIEBERT, W.S. PITCHFORD AND C.D.K. BOTTEMA

Department of Animal Science, University of Adelaide,
Waite Campus, Glen Osmond , South Australia 5064.

SUMMARY

Genetic variation in the fatty acid composition of meat and fat biopsy samples collected from 89 Jersey and Limousin cows in a single management group was studied. The animals were part of the J.S. Davies Bovine Gene Mapping Herd.

Results indicated that differences between Jersey and Limousin fats (triglycerides) in the percentages of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were highly significant ($P<0.01$). Limousin cows contained higher percentages of SFA than the Jerseys (46 vs 41% respectively). Jerseys on the other hand exhibited higher levels of MUFA (43 vs 38%) and PUFA (15 vs 9%) than Limousins. There were no breed differences in the fatty acid composition of the meat samples (phospholipids).

INTRODUCTION

Variation between and within breeds of cattle enables geneticists and breeders to select individuals capable of transmitting to their descendants desirable qualities. From the human nutrition perspective, these qualities include leanness and a fatty acid profile with less palmitate and more oleate and stearate, since the latter have been shown to be cholesterol-lowering in humans (Bonanome and Grundy, 1988).

Data from mature (Huerta-Leidenz et al., 1993) and young (Leat, 1977) cattle differed in fatty acid profiles due to age differences. When the dietary regime (Rumsey et al., 1972) or anatomical site (Westerling and Hedrick, 1979) varied, so did the fatty acid composition. This makes it difficult to compare breeds in a fair way because of the confounding of age, fatness, plane of nutrition and other extrinsic factors (Yoshimura and Namikawa, 1983). In this study, biopsy samples of non-lactating cows of the same age, reared in the same herd, under the same management and grazing without any form of concentrate feeding were analysed. The aim was to study breed differences in the fatty acid composition of the fat and meat from Limousin and Jersey cattle.

MATERIALS AND METHODS

Animals and management

The animals used in this study are part of the parental generation of the J.S. Davies Cattle Gene Mapping Resource Herd held at Martindale, a property located about 150 kilometres north of Adelaide, South Australia. They consisted of 89 Jersey and Limousin non-lactating cows aged 20 to 96 months (average of 47 months of both breeds). Their respective average weights were 365 and 547 kg. They were all grass-fed with some supplementary oaten hay and silage constituting a major dietary source during the summer. They were all maintained under the same routine management. Cows were sampled in January, 1994.

Biopsy technique

The animals were restrained in a crush and the hair around the shoulder muscle clipped. The clipped area was disinfected with a betadine scrub solution and a 5ml lignocaine anaesthetic injection was administered subcutaneously at the site of sampling. A 10ml intramuscular terramycin LA antibiotic injection was given to prevent infection. An incision 8-10 cm long was made through the hide . Using a pair of sterile forceps to hold the incised skin, a subcutaneous fat sample of approximately 3g was taken in addition to 3g of meat. The incision site was stitched using metal staples after antiseptic cream and powder were applied as wound dressing to prevent infection. The stitched site was coated with tar to prevent contact with dust and flies. The meat and fat samples were weighed and cut in triplicates of 1g each. Samples were immediately frozen in liquid nitrogen. These were later flushed with N_2 gas and transported to the laboratory and stored at -80°C until analysed for fatty acid composition. After surgery, the animals were checked daily and the wound healed in about one week.

Fatty acid analysis

Subcutaneous fat and muscle samples were analysed for their fatty acid composition by methods similar to that described by Christie (1976) and Sinclair and O'Dea (1987). Approximately 100 mg of tissue was frozen in liquid nitrogen and ground to a fine powder in a stainless steel pestel and mortar. Lipids were extracted using a chloroform:methanol (2:1) solvent mixture containing BHT as an anti-oxidant. Phospholipid and triglycerides were separated by thin layer chromatography using a petroleum ether:acetone (3:1) solvent system. Extracts of fat samples or scrapings of the thin layer plates were dissolved in hexane and methylated by the use of 0.5 M sodium methoxide in methanol. High resolution fatty acid analysis was carried out with a Hewlett Packard (model 5890) gas liquid chromatograph fitted with a capillary column (50 m x 0.32 mm (BP 20) SGE, Melbourne) using a split system. This allowed the separation and identification of the C14 to C24 saturated and unsaturated fatty acids by comparison with authentic standards. Individual fatty acid concentrations were expressed g/100g total fatty acid.

Statistical Analyses

Least squares analysis of variance was carried out using the general linear models of SAS (1989) that included the fixed effect of breed while age and interactions between breed and age were fitted as covariates. Least squares means and differences between means were computed.

RESULTS AND DISCUSSION

Fatty acids in fat

The proportions of fatty acids in subcutaneous fat tissue grouped into saturated and unsaturated fat classes for Jersey and Limousin cattle are shown in Figure 1.

The differences in the fatty acid classes were due to significant differences in some of the individual fatty acids that comprise the triglycerides of these classes. This is illustrated in Table 1 which shows the concentration of the saturated fatty acids, palmitic (C16:0) and stearic (C18:0), of the mono-unsaturated fatty acid, oleic (C18:1), and of the poly-unsaturated fatty acids, linoleic (C18:2) and linolenic (C18:3).

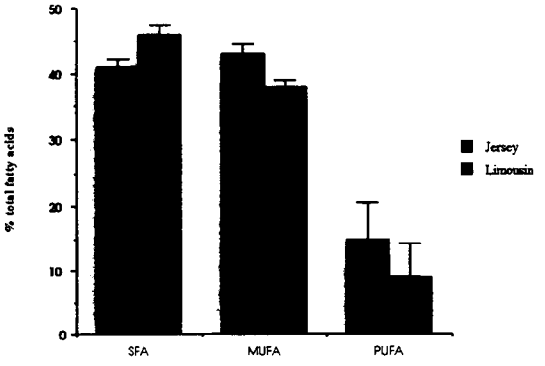

Figure 1. The saturated (SFA), mono-unsaturated (MUFA) and poly-unsaturated (PUFA) fatty acids of fat of Jersey and Limousin cattle.

Table 1. Least square means (±SEM) of the concentration of individual fatty acids of the triglycerides of fat from Jersey and Limousin cows (w/w %total fatty acid).

Fatty acid	Jersey (n=30)	Limousin (n=24)	Significance
C16:0	25.0 ± 0.6	26.4 ± 0.7	P<0.05
C18:0	12.0 ±0.6	15.3 ± 0.6	P<0.01
C18:1	34.8 ± 1.9	31.3 ± 1.4	P<0.05
C18:2	3.2 ± 0.6	2.8 ± 0.7	P<0.01
C18:3	1.0 ± 0.1	1.4 ± 0.2	P<0.05

The storage fats of ruminants contain a high proportion of saturated fat and a similar proportion of mono-unsaturated fat. There are however, differences between breeds. This is illustrated in Figure 1 and Table 1. The fat depots of animals of an early maturing breed such as the Jersey have a higher proportion of a mono-unsaturated fatty acid such as oleic acid in comparison to late maturing animals such as the Limousin. A similar situation was apparent in the work of Sinclair and O'Dea (1987) who examined the meat fats of pure Hereford and Simmental x Hereford grazing at two stocking rates where the concentrations of oleic acid were 32-36% and 39-42% respectively. It was not obvious in the work of Huerta-Leidenz et al (1993) however where the fat of fully mature Brahman and Hereford cows had concentrations of oleic acid of 48 and 49% respectively. Leat (1977) concluded that from lifetime studies of Angus and Friesian cattle that the fatter an animal of a given breed, the more mono-unsaturated the fat.

Fatty acids in muscle

There were no differences between the breeds in the saturated and un-saturated fatty acid classes of the structural fat of muscle. These fatty acids derived from phospholipid have a higher proportion of poly-

unsaturated fat and less saturated or mono-saturated fat than depot fat. The poly-unsaturated fatty acid linoleic (C18:2) found in many cereal concentrates and linolenic (C18:3) that occurs in forage, appear in muscle phospholipid, at times at concentrations as high as 20%of total muscle phospholipid. The metabolite of C18:2, arachodonic acid (C20:4), can also reach levels as high as 10%. Differences are found between breeds. The concentration of these fatty acids in the present study are shown in Table 2.

Table 2. Least square means (± SEM) of the concentration of individual fatty acids found in the muscle phospholipid of Jersey and Limousin cows (w/w%total fatty acids).

Fatty acid	Jersey	Limousin	Significance
C18:2 n-6	6.2 ± 0.4	7.1 ± 0.4	N.S.
C18:3 n-3	1.5 ± 0.2	2.1 ± 0.2	N.S.
C20:4 n-6	4.0 ± 0.3	6.1 ± 0.4	$P < 0.01$

The concentrations of the C18:2 and C18:3 reflect the dietary sources of these fatty acids. Linolenic acid (C18:3) is found in green leaf plants but its content is not high in dry grass. The significant difference between breeds most probably reflects differences in feed consumption, although it could also reflect differences in fatty acid absorption. Sinclair and O'Dea (1987) reported levels for Hereford and SimmentalxHereford of 12%(C18:2) and 4% (C18:3), although diet and individual breed values were not reported. Siebert (unpublished data) found concentrations for C18:2 of 18% for Jersey crossbred steers and 23% for European crossbred steers after fattening in the feedlot. The hydrogenation of un-saturated fatty acids with concentrates in the feedlot is not as high as with forage diets and more unsaturated fats escape hydrogenation (Doreau and Ferlay, 1994). The concentration of C20:4 usually reflect the proportion of C18:2 as it is a metabolic product of that acid, but C18:3 competes for the enzyme enabling the conversion.

The fatty acid profile of storage fat shows breed differences depending on the stage of maturity of animals. Individual fatty acid concentrations in muscle phospholipids show differences which are dependent on dietary fatty acids. The breed differences of both may not be direct metabolic differences but indirect in that they reflect stage of maturity or feed consumption differences.

REFERENCES

BONANOME, A. and GRUNDY, S.M. (1988). *N. Engl. J. Med.* **318**:1244
CHRISTIE, W.W. (1989). "Gas chromatography and lipids". The Oily Press: UK 307 pp
DOREAU, M. and FERLAY, A. (1994). *Animal Feed Sci. & Tech.* **45**:379
HUERTA-LEIDENZ, N.O., CROSS, H.R., SAVELL, J.W., LUNT, D.K., BAKER, J.F. PELTON, L.S. and SMITH, S.B.(1993). *J. Anim. Sci.* **71**:625
LEAT, W.M.F. (1977). *J. Agric. Sci.(Camb.)* **89**:575
RUMSEY, T.S., OLTJEN, R.R., BOVARD, K.P. and PRIODE, B.M. (1972). *J. Anim. Sci.* **35**:1069
SAS Institute, Inc. (1989). "SAS user's guide: Statistics". Version 5.04, SAS Institute, Inc., Cary, NC.
SINCLAIR, A.J. and O'DEA, K. (1987). *Food Tech. Aust.* **39**:228
WESTERLING, D.B. and HEDRICK, H.B. (1979). *J. Anim. Sci.* **48**:1343
YOSHIMURA, T. and NAMIKAWA, K. (1983). *Jap. J. Zootech. Sci.* **54**:97