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Fatty acid composition of subcutaneous and kidney fat depots of Boer goats and the response to varying levels of maize meal

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The proportion of eight fatty acids (14:0, 16:0, 16:1, 17:0, 17:1, 18:0, 18:1 and 18:2) was measured in the subcutaneous and kidney fat depots of five groups of Boer goat castrates which had been kept for 90 days on one of five different diets. The diets were compiled on an iso- N, -Ca and -P basis and varied in their maize and *Cenchris ciliaris* contents. In general, subcutaneous fat (iodine no 31,3) was less saturated than the kidney depot (iodine no 28,2). This was also reflected in the fatty acid profiles. Increasing levels of maize in the diet were associated with an increase in n-*cis*-9-octadecenoic acid (C 18:1) ($P > 0,01$) in both depot fats and with a decrease in stearic acid (18:0) concentration ($P > 0,05$) in the subcutaneous fat.

Die persentuele verhouding van agt vlugtige vetsure (14:0, 16:0, 16:1, 17:0, 17:1, 18:0, 18:1 en 18:2) in die onderhuidse vet en niervetreserwes is by vyf groepe Boerbokkapaters bepaal. Hierdie kapaters is vir 90 dae respektiewelik vyf verskillende diëte gevoer wat op 'n iso- N, -Ca en -P-basis saamgestel is, maar wat wisselende vlakke van mielies en *Cenchris ciliaris* bevat het. Die onderhuidse vet was oor die algemeen minder versadig as die niervet. (OHV I Nr = 31,3, NV I•Nr = 28,2) soos weerspieël in die jodiumgetal asook vetsuurontledings. Toenemende vlakke van mielies in die dieet is hoogs betekenisvol gekorreleer ($P > 0,01$) met 'n toename in n-*cis*-9-octadecenoësuur (18:1) maar óók betekenisvol gekorreleer ($P > 0,05$) met 'n afname in steariensuur (18:0) soos in die onderhuidse vet waargeneem.

Keywords: Fat depots, fatty acids, nutrition, goats.

Fat remains an important quality determinant of meat. Although the chemical and physical properties of fat usually have little influence on the commercial value of carcasses, these properties do influence the eating and keeping quality of meat (Kempster, Cuthbertson & Harrington, 1982). The degree of saturation of fat as determined by the fatty acid composition, is one of the most important characteristics affecting these quality parameters. Saturated fats solidify easily upon cooling thus affecting the palatability of the meat, and the less saturated fats are easily oxidized leading to rancidity.

Flavour is also influenced by the fatty acids, particularly the C18:1 ($r = -0,33$) and C18:3 ($r = 0,33$) fatty acids in lamb (Crouse, Ferrell, Field, Busboom & Miller, 1982). Nutritional influences on the fatty acid composition and the associated effect on flavour have been found in beef (Westerling & Hedrick, 1979; Brown, Melton, Riemann & Backus, 1979; Melton, Amiri, Davis & Backus, 1982), in lamb (Kemp, Mahyuddin, Ely, Fox & Moody, 1981; Crouse, *et al.*, 1982), and in kid (Bas, Hervieu, Morand-Fehr & Sauvant, 1982). Crouse, *et al.* (1982) reported that greater quantities of C17:0,

C18:1 and C18:2 were associated with increased fatness of lamb carcasses and both Melton, *et al.* (1982) and Ozutsumi, Ito & Kawanishi (1982) reported greater proportions of 18:1 in beef fat as fattening proceeded.

The Boer goat possesses good carcass and meat characteristics which should not be compared directly with those of lamb and mutton (Naudé & Hofmeyr, 1981; Casey, 1982) owing to species differences particularly regarding tissue distribution. The Boer goat also grazes and browses a different spectrum of plants than cattle and sheep, a characteristic which favours combined species grazing practice (Aucamp & du Toit, 1980). The potential of the Boer goat as a meat animal has been recognized throughout Southern Africa (Owen & Norman, 1977; Casey, 1983) and this paper is part of the ongoing evaluation of the Boer goat dealing with the fatty acid composition of the subcutaneous and kidney fat depots and the response in fatty acid composition to increased levels of maize in the diet.

Twenty-six, milk tooth, male castrates were obtained from the Roodeplaat Research Station where they had been nursed by their dams and weaned on the veld. The animals were brought to the research farm of the University of Pretoria and given a 14-day adaptation period in metabolic crates during which time they were phased onto the experimental diets. Empty bodymasses (starved overnight without food and water), taken at the end of the adaptation period but before the beginning of the trial, were 30,4 ± 4,9 kg. The animals were divided randomly into five groups; five animals to groups 1, 2, 3, and 5 and six to group 4. The nutritional treatments balanced on an iso-N, -Ca and -P basis, are given in Table 1. The dry matter intake was restricted to 90% of *ad libitum* to equalize intake between the groups.

Table 1 Percentage composition of diets containing different amounts of *Cenchris ciliaris* hay and maize meal

	Diet				
Component	1	2	3	4	5
C. ciliaris hay	85	71	57	43	28
Maize meal	2,7	17,6	32	47	62
Fish meal	10	9	8,2	7	7
Urea	1	1	1	1	1
Dicalcium phosphate	0,01	0,4	0,6	0,6	0,6
Limestone	–	–	0,2	0,4	0,4
Salt	1	1	1	1	1
Monosodium phosphate	0,33	0,05	–	–	–

At the end of a 90-day trial period, the mean final empty bodymass was 39,8 ± 4,3 kg and the mean of each group was 36,7; 38,7; 40,2; 39,9 and 43,7 kg for Diets 1 – 5 respectively. An analysis of the influence of nutrition on growth will be reported by Van Niekerk in due course. The goats were slaughtered conventionally and the carcasses chilled overnight at 10°C. Samples of subcutaneous fat from the loin region and kidney fat were carefully removed, placed in polyethylene bags, sealed, and stored at −10°C. Iodine numbers were determined to assess the saturation levels of the two depots according to the Wijs method described by Pomerantz and Meloan (1971). For the determination of fatty acids, the samples were thawed and soaked in hexane overnight, heated and filtered through Whatman $1\frac{p}{s}$ filter paper, the solvent being removed by vacuum siphon. Approximately 20 mg of fat was used for the esterification step. Methyl esters were prepared according to the BF_3/Methanol method (AOAC, 1975). The instrument used was a Varian 3700 gas chromatograph with flame ionization detector, XE60/SGP440 capillary column (Analabs Inc, USA) length 40 m × 0,3 mm ID, helium carrier gas flow rate 2,7 ml/mm, temperature of the column 220°C (isothermal) and the detector 40°C. Eight fatty acids, namely, myristic acid (14:0), palmitic acid (16:0), palmitoleic acid (16:1), heptadecanoic acid (17:0), heptadecenoic acid (17:1), stearic acid (18:0), n-*cis*-9-octadecenoic acid (18:1) and linoleic acid (18:2), were shown to have concentrations > 0,4%.

The mean iodine number of the subcutaneous fat, measured over all treatments, was 31,3 ± 4,9 which did not differ significantly from the lower 28,2 ± 3,5 of kidney fat ($F = 3,13$ NS). The difference in saturation can be explained by an analysis of the fatty acid composition of the two fat depots (Table 2). The two depots differed highly significantly ($P < 0,01$) in fatty acid content in seven of the eight fatty acids measured, the exception being linoleic acid. The proportions of the fatty acids were not in the same ranking order between the two depots either. In the subcutaneous fat n-*cis*-9-octadecenoic acid had the highest concentration (42,95 ± 4,46%) followed by palmitic acid (23,91 ± 1,55%) and stearic acid (15,26 ± 4,17%). Stearic acid formed the greatest fraction in the kidney fat (32,09 ± 3,10%) followed by palmitic acid (26,97 ± 1,80%) and n-*cis*-9-octadecenoic acid (25,16 ± 4,34%). The unsaturated fats of the subcutaneous depot totalled 48,65 percentage units and the saturated fat 43,89 percentage units. In contrast, the unsaturated fats of the kidney depot totalled 27,85 and the saturated fats 64,51 percentage units. The main difference between the two fat depots was the greater proportion of n-*cis*-9-octadecenoic acid in the subcutaneous fat and the greater proportion of stearic acid in the kidney fat.

Table 2 Fatty acid composition of subcutaneous and kidney fat depots pooled for all diets and tested for differences using the *t* test

	Fat depot		Statistical analysis[a]	
Fatty acid	Subcutaneous Mean ± SD	Kidney Mean ± SD	*t* value	Significance
14:0	2,99 ± 0,57	3,39 ± 0,35	2,98	a
16:0	23,91 ± 1,55	26,97 ± 1,80	6,43	a
16:1	3,21 ± 0,78	1,17 ± 0,18	12,75	a
17:0	1,72 ± 0,31	2,06 ± 0,38	3,42	a
17:1	1,54 ± 0,44	0,54 ± 0,09	10,99	a
18:0	15,26 ± 4,17	32,09 ± 3,10	16,52	a
18:1	42,95 ± 4,46	25,16 ± 4,34	14,86	a
18:2	0,95 ± 0,12	0,99 ± 0,15	0,97	NS

[a] $P < 0,01$, NS = not significant

The effect of the varying levels of maize meal on the fatty acid composition of the two fat depots are shown in Table 3. The effects were highly significant for n-*cis*-9-octadecenoic acid with the concentration increasing correspondingly with the greater level of maize in the diet. Stearic acid showed a significant drop in the subcutaneous fat, while in the kidney fat a marked drop in concentration was observed between the 17,6% level of maize and the 62,0% level, although this was not statistically significant at the 5% level. In both depots the level of palmitic acid showed a non-significant decrease.

Table 3 Effect of maize meal in diet on fatty acid composition of subcutaneous fat (SCF) and kidney fat (KF)

Maize meal in diet (%)	Fatty acid composition (mean ± SD)															
	14:0		16:0		16:1		17:0		17:1		18:0		18:1		18:2	
	SCF	KF	SCF	KF	SCF	KF	SCF	KF	SCF	KF	SCF	KF	SCF	KF	SCF	KF
2,7	3,18	3,24	25,06	27,54	2,76	1,12	1,96	2,38	1,32	0,54	19,48	32,98	6,98	21,22	0,94	0,88
	±0,56	±0,35	±1,59	±1,93	±0,61	±0,13	±0,30	±0,68	±0,19	±0,11	±3,52	±3,14	±3,08	±2,43	±0,21	±0,19
17,6	3,08	3,36	24,32	26,90	3,00	1,04	1,70	2,26	1,42	0,52	16,38	34,50	41,48	22,14	0,94	0,90
	±0,74	±0,33	±1,04	±0,39	±0,56	±0,05	±0,27	±0,25	±0,28	±0,08	±4,85	±1,27	±4,76	±1,04	±0,11	±0,10
32,0	3,18	3,66	23,82	26,84	3,52	1,30	1,50	1,84	1,62	0,56	14,10	30,80	45,10	26,98	0,96	1,04
	±0,75	±0,42	±2,23	±2,40	±0,88	±0,27	±0,16	±0,17	±0,13	±0,11	±2,55	±4,13	±2,28	±4,76	±0,13	±0,11
47,0	2,87	3,43	23,27	26,72	3,20	1,12	1,65	1,95	1,70	0,48	14,90	32,68	43,98	25,63	0,98	1,03
	±0,46	±0,29	±1,53	±2,42	±0,98	±0,13	±0,23	±0,22	±0,36	±0,10	±3,66	±2,59	±2,82	±4,02	±0,10	±0,14
62,0	2,68	3,26	23,24	26,88	3,58	1,30	1,82	1,90	1,62	0,60	11,52	29,38	46,78	29,70	0,90	1,06
	±0,29	±0,34	±0,58	±1,64	±0,72	±0,12	±0,44	±0,14	±0,90	±0,07	±2,48	±1,78	±2,18	±2,61	±0,07	±0,17
F											3,47 [a]		7,30 [b]	5,65 [b]		
df 4,21																

[a]$P > 0,05$; [b]$P > 0,01$ (One way ANOVA for each fatty acid).

A comparison of the fatty acid content of fat depots in the Boer goat as reported here and the fatty acid contents of other species (Ozutsumi, *et al.*, 1982; and Crouse, *et al.*, 1982), and in the goat (Bas, *et al.*, 1982), would be incorrect owing to the influence that nutrition, notably the carbohydrate source, has on the fatty acid profile. This has also been reported by the above-mentioned authors as well as Westerling, *et al.* (1979) and Brown, *et al.* (1979). Despite this, similarities exist between the results reported here and those of Bas, *et al.* (1982), both in respect of nutritional effects and the high levels of n-*cis*-9-octadecenoic and palmitic acid in the subcutaneous fat, and the high levels of stearic, octadecenoic, and palmitic acids in the kidney fat.

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