Variability of depot fat composition in fattened cattle as influenced by dietary fats

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Background and objective: In the nutrition of ruminants, the use of fat is quite restricted mainly due to its adverse effects on fibre digestion. Nevertheless, rumen inert fat and partially protected fats from whole crushed oil seeds can be included into ruminant diets in considerable amounts, to make use of its high energy density. Another beneficial effect of most fats is the reduction in methane emission, as recently reported by Ossowski et al. (1996). Beside these desirable effects and despite the intensive microbial modification of the dietary fat in the rumen, it may alter fat composition in animal tissues according to its composition and, therefore, change the characteristics of animal products (Kreuzer et al. 1995). The objective of this investigation was to evaluate the effect of various dietary fat sources on body fat composition of fattening bulls. Special regard was paid to saturated C14 and C16 fatty acids and to *trans* unsatured fatty acids, which are currently of concern as potential risk factors for coronary heart diseases.

Material and Methods: 30 Brown Swiss bull calves were assigned to six dietary groups and fattened to an average live-weight of 500 kg. Diets were based on maize silage and hay supplemented with potato protein, minerals, and concentrates. Concentrates either contained no additional fat (control) or coconut oil, rumen-protected fat (partially hydrogenated), crushed rapeseed, sunflower seed and linseed. Diets were calculated to contain 3 % and 6 % total dietary fat in control and experimental groups, respectively. The individual daily feed allowance was adapted to provide similar net energy and protein supply to all treatment groups according to requirements for growth.
Kidney fat was taken imediatly after evisceration from the left side of the carcasses. The fat was cleaned, vacuum-packed and subsequently frozen at -70 °C until further preparation. Prior to extraction of lipids from kidney fat and feed with hexan/isopropanol (3:2 v/v), triundecanoin was added as an internal standard. Fatty acids were saponified with methanolic NaOH and methylated using boron trifluorid. Analysis of fatty acid methyl esters was performed using a Supelco™ SP-2560 capillary column. Chromatographic conditions involved a constant carrier flow of 1.2 mL/min (helium) and 60:1 split injection at 250 °C. The temperature program was adjusted to achieve a sufficient separation between C18:3 and C20:1 acids. Peaks were identified using standards. As not for all stereo and positional isomers of unsaturated fatty acids standards were available, isomers not specifically identified were summarized to respective fractions.
Table 1 shows the wide variety of the fatty acid composition of the dietary fats in the concentrates of control and the various experimental groups. As expected, the oil seed supplemented concentrates were rich in C18:1, C18:2, and C18:3 for rapeseed, sunflower seed, and linseed, respectively. The coconut oil supplemented concentrate was rich in saturated C8 - C14, particulary in lauric acid. The rumen protected fat contained hydrogenated fats including fish oil, pork fat, and beef tallow. Due to the hydrogenation, considerable amounts of *trans* fatty acids were found in this fat. Additionally, elevated amounts of saturated C20 and C22 derived from the hydrogenated fish oil, and odd-chained fatty acids (C15/17, data not shown), probably deriving from the beef tallow, were detected. Branched-chain fatty acids occurring in the kidney fat due to microbial fatty acid synthesis utilising branched-chain precursors deriving from amino acids were only considered to calculate total fatty acids.

Results and discussion: The high amounts of saturated fatty acids in the kidney fat as compared with dietary fat indicate the large extent to which dietary fatty acids were biohydrogenated by rumen microbes (table 2). Taking into account the less efficient absorption of 18:0 relative to the other fatty acids (Ekeren et al. 1992) and the hepatic desaturation of C18:0 to C18:1, the level of biohydrogenation might have been even higher than could be expected from depot fat composition. Nevertheless, the composition of the kidney fat was significantly affected by the individual dietary fat sources. On a low level, the elevated amounts of C12 and C14 of the coconut oil supplemented group as well as C18 polyenoic acids of the respective experimental oil seed groups and C20/22 of the protected fat group still reflected the composition of the dietary fat source. This indicates that dietary fatty acids escaped microbial modification to a certain extent and were transferred to the body fat.
Kidney fat of all oil seed fed animals was low in C16:0 compared to controls and other groups. This is a desirable effect as C16:0 is known as a potential risk factor of coronary heart diseases. The high amount of C16:0 in kidney fat of the coconut oil fed animals can not be explained by the supply of dietary C16:0 which was on an intermediate level, but might be a result of chain elongation using shorter fatty acids. C16 monoenic acids were also highest in the coconut oil group, whereas only traces were found in dietary fat of this group. This result gives evidence to a certain microbial *de novo* synthesis of these isomers (Gurr, 1974). As a result of microbial fatty acid synthesis, C15 and C17 odd-chained acids were also found in all samples of kidney fat to an amount of about 5 and 10 mg/g total fatty acids, respectively (data not shown).

Table 1: Fatty Acid Composition of the Concentrates [mg/g Total Fatty Acids]

Treatment	Control	Rape-seed	Sun-flower seed	Lin-seed	Coconut oil	Protected Fat
Saturated FA						
C8:0	2.0	0.9	0.6	0.7	44.0	0.5
C10:0	2.3	0.6	0.3	0.2	47.4	1.0
C12:0	13.3	2.7	0.7	0.2	410.7	2.6
C14:0	6.9	1.7	1.5	0.7	163.8	30.3
C16:0	175.5	58.0	80.5	67.9	105.5	253.7
C18:0	25.3	19.7	42.1	46.7	32.5	259.0
C20/22:0	6.4	9.7	11.0	2.5	2.9	47.8
C24:0	3.6	1.8	3.7	1.9	1.0	2.2
Monoenoic FA						
C16:1 *cis*	1.5	2.3	1.1	0.7	- [1]	4.5
C16:1 x-*trans*	-	-	-	-	-	15.4
C18:1 *cis* (total)	173.5	579.8	230.8	189.8	90.3	117.2
C 18:1 *trans* (total)	-	-	-	-	2.9	141.5
C18:1 Δ9-*trans*	-	-	-	-	-	59.2
C18:1 Δ11-*trans*	-	-	-	-	-	28.5
C20/22:1 *cis*	22.4	12.2	1.8	-	1.2	5.1
C20/22:1 x-*trans*	-	-	-	-	-	14.7
C24:1 *cis*	1.4	1.6	-	-	-	-
Polyenoic FA						
C18:2 Δ12-*cis*	493.0	225.4	613.5	196.6	81.2	61.2
C18:2 x-*trans/cis*	-	-	-	-	-	11.0
C18:3 Δ15-*cis*	57.2	83.8	6.0	482.4	13.4	9.6
C18:3 x-*trans/cis*	1.2	-	1.2	5.1	0.7	12.1
C20/22 x-*cis*	14.4	-	5.4	2.8	-	-

x-trans, x-cis = Sum of not specified isomeres; [1] traces or not detected

Table 2: Fatty Acid Composition of Kidney Fat from Bulls Fed Rations Differing in Dietary Fat Source [mg/g Total Fatty Acids] (n = 5, Mean ± Standard Deviation)

Treatment	Control	Rapeseed	Sunflower seed	Linseed	Coconut oil	Protected Fat
Saturated FA						
C12:0	1.0 ± 0.4 b	0.8 ± 0.1 b	1.3 ± 0.1 b	0.8 ± 0.1 b	7.4 ± 1.7 a	0.9 ± 0.1 b
C14:0	31.7 ± 6.8 b	23.9 ± 2.8 b	29.0 ± 3.5 b	23.8 ± 4.3 b	76.6 ± 9.3 a	29.5 ± 3.2 b
C16:0	263.3 ± 19.4 a	199.5 ± 13.0 b	212.6 ± 15.1 b	203.4 ± 14.8 b	277.0 ± 2.9 a	261.3 ± 7.4 a
C18:0	296.6 ± 24.2 c	385.7 ± 28.9 a	369.6 ± 15.6 ab	394.6 ± 27.7 a	280.0 ± 12.6 c	329.8 ± 23.3 bc
C20:0	2.7 ± 0.6 c	4.6 ± 0.4 b	2.8 ± 0.1 c	2.7 ± 0.3 c	2.7 ± 0.2 c	7.8 ± 1.1 a
C22:0	0.6 ± 0.1 b	0.8 ± 0.1 b	0.9 ± 0.1 b	0.6 ± 0.1 b	0.6 ± 0.1 b	1.9 ± 0.3 a
Monoenoic FA						
C14:1 *cis*	2.7 ± 0.9 b	1.5 ± 0.6 b	1.9 ± 0.4 b	1.4 ± 0.4 b	5.6 ± 1.1 a	2.1 ± 0.5 b
C16:1 *cis*	21.5 ± 1.3 ab	14.5 ± 1.4 cd	15.3 ± 1.5 cd	14.1 ± 1.3 d	22.1 ± 1.8 a	18.2 ± 2.6 bc
C18:1 *cis* (total)	276.9 ± 15.5 a	280.6 ± 21.1 a	258.3 ± 8.5 ab	251.0 ± 17.5 ab	236.7 ± 15.1 b	247.6 ± 11.8 ab
C18:1 Δ9-*cis*	264.6 ± 15.2 a	269.7 ± 21.6 a	244.9 ± 10.5 ab	237.9 ± 19.6 ab	222.2 ± 15.4 b	235.9 ± 11.0 ab
C18:1 Δ11-*cis*	7.6 ± 0.9 ab	7.8 ± 0.6 ab	7.2 ± 0.5 b	6.9 ± 0.4 b	8.8 ± 0.9 a	6.5 ± 0.4 b
C18:1 *trans* (total)	29.6 ± 3.6 b	28.8 ± 5.4 b	44.0 ± 7.5 a	36.2 ± 6.8 ab	29.0 ± 3.0 b	36.4 ± 3.7 ab
C18:1 Δ9-*trans*	3.5 ± 0.6 bc	4.6 ± 0.8 b	4.7 ± 0.7 b	3.7 ± 0.5 bc	3.1 ± 0.3 c	8.4 ± 0.8 a
C18:1 Δ11-*trans*	20.4 ± 3.1 b	18.2 ± 4.2 b	32.2 ± 6.2 a	23.7 ± 5.3 ab	14.9 ± 7.4 b	19.3 ± 2.9 b
C20:1 *cis*	0.9 ± 0.2 bc	1.3 ± 0.1 a	0.8 ± 0.1 bc	0.6 ± 0.1 c	0.8 ± 0.2 bc	1.0 ± 0.1 ab
Polyenoic FA						
C18:2 *cis*	15.4 ± 1.2 a	10.7 ± 0.8 b	15.3 ± 1.2 a	11.5 ± 1.9 b	7.6 ± 1.1 c	9.3 ± 0.8 bc
C18:2 x-*trans*/*cis*	9.2 ± 0.6 bc	7.4 ± 0.6 c	7.6 ± 0.4 c	12.1 ± 1.5 a	10.1 ± 1.0 b	7.8 ± 0.4 c
C18:3 *cis*	3.6 ± 0.4 bc	3.5 ± 0.3 bc	2.4 ± 0.3 bc	7.8 ± 1.3 a	2.2 ± 0.4 c	3.8 ± 0.4 b
C18:3 x-*trans*	0.0 ± 0.1 b	0.1 ± 0.1 b	- [1]	-	-	1.0 ± 0.2 a

x-trans, x-cis = Sum of not specified isomeres; [1] traces or not detected
Means within one row lacking a common letter differ significantly (Scheffé, $P < 0.05$)

C18:1 Δ11-*trans* was detected in the kidney fat of all animals as the predominant C18:1 *trans* acid. According to Harfoot and Hazlewood (1988), this isomer is formed as a penultimate product of biohydrogenation. Therefore, it can be concluded that C18:1 *trans* isomeres originating either from feed in the case of the protected fat (C18:1 Δ9-*trans*) or from ruminal biohydrogenation of C18 di- and trienic acids (sunflower seed, linseed), were transferred to depot fat to a certain extent. Similary to these findings Kennelly (1996) reported increased C18:1 *trans* isomers in milk fat using oil seeds in dairy cow nutrition. Total C18 *trans* was not elevated in the protected fat group, probably because the dietary supply of unsaturated C18 was very low in this group. In the linseed group somewhat elevated amounts of various stereo and positional C18:2 isomers, obviously intermediates of the pathway from linolenic to stearic acid, were found. Nevertheless, the high amount of C18:0 in the kidney fat of this group indicated that most of the linolenic acid was completely hydrogenated to stearic acid. The sunflower seed group showed the highest amount of C18:1 Δ11-*trans* and, therefore, total C18:1 *trans* fatty acids. This cannot be explained only by the high amount of total dietary polyenic C18, since the linseed diet was even richer in these acids. An explanation might be given regarding the specific pathways of microbial biohydrogenation. Harfoot and Hazlewood (1988) pointed out that two distinct groups of bacteria are necessary to completly hydrogenate linoleic and linolenic acid to stearic acid. But only in the case of α-linolenic acid, the same group of bacteria performing the final step from 18:1 Δ11-*trans* to stearic acid is also involved in preceding steps of the biohydrogenation. Therefore, a high supply with dietary α-linolenic acid probably made this group of bacteria more competitive resulting in a larger extent of complete biohydrogenation.

Conclusions: The composition of the dietary lipid sources significantly altered the composition of depot fat. This was concluded to be due to a direct transfer of fatty acids of dietary origin to the depot fat and due to different amounts of dietary C18 mono- and polyenic acids undergoing rumen biohydrogenation. Dietary supplementation with crushed oil seeds resulted in lower amounts of C16:0 but somewhat raised amounts of C18:1 *trans* fatty acids, except for rape seed. In the case of the partially hydrogenated rumen protected fat, dietary *trans* fatty acids were transferred to depot fat to some extent.
Its a matter of conjecture how far differences in major and minor fatty acid fractions will affect other characteristics of the kidney fat and beef products.

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