Journal of Animal and Feed Sciences, 10, Suppl. 2, 2001, 115 – 121

The effects of different amounts and types of fat on milk fatty acid composition in sheep*

A. Potkański[1], M. Szumacher-Strabel[1], J. Kowalczyk[2], A. Cieślak[1] and M. Czauderna[2]

[1]*Department of Animal Nutrition and Feed Management, August Cieszkowski Agricultural University Wołyńska 33, 60-637 Poznań, Poland*
[2]*The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences 05-11- Jabłonna, Poland*

ABSTRACT

Four milking ewes (50±5 kg) were used in a 4 x 4 Latin square experiments to determine the effects of different sources and amounts of vegetable-origin fat in the diet on the fatty acid composition of milk. Ewes of the control group were fed a diet consisting of meadow hay and concentrate (60:40) that was supplemented for the experimental groups with rape seed oil, hydrogenated rape seed oil, or linseed oil at a level 4, 8 or 10% in dry matter of the diet. Addition of linseed and rape seed oil to the diet decreased ($P<0.05$, $P<0.01$) the level of total saturated fatty acids in milk. Rape seed oil and hydrogenated rape seed oil caused significant ($P<0.05$, $P<0.01$) increases in the level of mono-unsaturated fatty acids, whereas significant differences were not reached ($P>0.05$) when linseed oil was fed to sheep. Also, the total amount of PUFA+MUFA increased in milk ($P<0.05$, $P<0.01$) when diets with linseed and rape seed oil were fed. The level of stearic acid differed depending on the added fat. A lower ($P<0.01$) level of stearic acid was observed when 8% of linseed oil was added, whereas it was higher ($P<0.05$) when 10% of linseed oil and 8% and 10% of rape seed oil were added to the ration. Feeding ruminants rations supplemented with fat of vegetable origin increased the energy content of the diet and also improved the level of desirable fatty acids in milk, e.g., MUFA and PUFA, which may be recommended in the treatment of some diseases.

KEY WORDS: sheep, fat, fatty acids, MUFA, PUFA, milk

---

* Supported by the State Committee for Scientific Research, Grant No. 5 PO6E 011 19

INTRODUCTION

The purpose of modifying animal origin fats is to produce high quality products meeting dietary recommendations for a reduced intake of saturated fatty acids (SFA) and an increased intake of mono- (MUFA) and polyunsaturated (PUFA) fatty acids in the human diet (Jakobsen, 1999). Consuming such enriched products lowers the risk of obesity, cancer, diabetes, and cardiovascular diseases (Grundy, 1999; Voigt and Hagemeister, 2001). Breeding for milk quality is a long-term process and there is always the risk that market demand will have changed by the time the target milk quality has been met. Manipulating milk quality through nutritional changes is the best option. During lactation, the ability to produce large quantities of milk exceeds the capacity of cows to consume enough feed to meet their needs for energy, causing a negative energy balance (Bremmer et al., 1998). Supplementing diets for high producing ruminants with fat helps to overcome limitations in energy supplies and to increase the marketable attributes of their products. Literature data indicates that acceptable fatty acid profiles do not require extreme changes in the fatty acid composition of milk. The aim of the conducted experiments was to determine the effects of different fat sources and amounts in the diet on the fatty acid composition of ewe milk.

MATERIAL AND METHODS

Animals and diets

Four lactating ewes (50±5kg) were used in 4 x 4 Latin square experiments. Three experiments examined how milk fatty acid composition was altered by dietary fats differing in fatty acid concentration: rape seed oil, hydrogenated rape seed oil and linseed oil. In all experiments fat was added to rations that consisted of meadow hay and concentrate (60:40%) at 0, 4, 8 and 10% in dry matter of the diet. The energy value of the rations was 1.21 JPM, whereas the crude protein content was BTJN 120 g and BTJE 129 g/kg. The ewes were milked twice daily at 0800 and 1700, and yields were recorded. Sheep had free access to water and were fed twice daily following each milking. All diets were formulated with wheat meal, soyabean meal, wheat bran and minerals (Table 1).

Sampling and analysis

Feeds were sampled weekly throughout the experiment. The experiment consisted of four 16-day trials (12 days of adaptation to the diet, the last four for sample collection). During the four-day sample collection time, milk samples were

TABLE 1

Composition of the diet, %

Components	Level of added fat			
	0%	4%	8%	10%
Meadow hay	59.0	57.0	55.0	54.0
Wheat meal	21.0	20.0	19.0	19.0
Rapeseed meal	3.0	3.0	3.0	3.0
Wheat bran	15.0	14.0	13.0	12.0
Minerals	2.0	2.0	2.0	2.0
Fat	-	4.0	8.0	10.0

collected twice daily. Total fatty acid content and composition of milk fat were determined according to the procedures of Heinig et al. (1998), modified by Czauderna et al. (2001).

Statistical analysis

All of the data were analyzed using SAS procedures (User's Guide, 1990).

RESULTS

The results of the experiments confirm the possibility that the fatty acid content of sheep milk can be manipulated by the diet. The addition of linseed (Table 2) and

TABLE 2

Fatty acid composition of milk fat from ewes fed diets supplemented with linseed oil, %

Linseed oil	0%		4%		8%		10%	
	mean	CV	mean	CV	mean	CV	mean	CV
Miristic acid	9.3^{A}	15.7	6.3	17.00	3.5^{A}	76.2	6.2	31.8
Palmitic acid	32.9^{BCa}	19.0	18.5^{Bb}	5.09	8.9^{ACb}	136.2	22.7^{Aa}	17.3
Caprylic acid	2.4	8.4	2.0	3.58	0.9	40.3	1.2	9.5
Lauric acid	2.7	15.5	3.2	28.89	0.8	128.6	1.7	33.8
Stearic acid	9.0^{B}	12.6	10.3	17.11	8.1^{A}	64.1	16.3^{AB}	20.6
Total SFA	56.3^{Ab}	12.8	40.3^{ab}	2.63	22.1^{Aa}	96.2	48.0	9.9
Total MUFA	39.8	12.0	56.9	3.29	48.7	25.8	21.5	25.8
Total PUFA n-3	0.7	31.3	0.8	2.70	1.3	40.6	1.2	25.7
Total PUFA n-6	3.2	70.0	2.9	26.72	4.7	57.4	1.8	50.8
Total PUFA + MUFA	43.7^{Bb}	13.3	60.6^{ab}	2.82	54.7^{ABa}	26.3	51.1^{A}	24.4

means in rows with the same letter differ statistically significant ^{A,B,C} – P<0.01; ^{a,b,c} – P<0.05

rape seed oil (Table 3) to the sheep diet resulted in a decrease in total SFA ($P<0.05$, $P<0.01$) in all experimental groups receiving added fat. Hydrogenated rape seed oil (Table 4) had no influence on total SFA content, although a decreasing tendency was also observed. Rape seed oil and hydrogenated rape seed oil caused a significant ($P<0.05$, $P<0.01$) increase in the MUFA level, whereas it was unchanged when linseed oil was fed to sheep. Also total PUFA and MUFA were increased ($P<0.05$, $P<0.01$) when linseed and rape seed oil were added to sheep

TABLE 3

Fatty acid composition of milk fat from ewes fed diets supplemented with rape seed oil, %

Rape seed oil	0%		4%		8%		10%	
	mean	CV	mean	CV	mean	CV	mean	CV
Miristic	10.5^{Aab}	28.1	7.7^{b}	19.1	6.7^{A}	6.5	7.0^{a}	8.9
Palmitic	32.6^{ABC}	9.9	23.5^{B}	10.4	19.0^{C}	12.8	20.9^{A}	30.7
Caprylic	2.1	35.6	1.5	43.7	1.2	11.2	1.2	21.7
Lauric	3.2	44.2	2.1	32.2	1.8	9.7	1.9	10.6
Stearic	8.7^{ab}	17.6	11.2	15.6	12.9^{a}	12.8	12.8^{b}	8.6
Total SFA	57.1^{AB}	11.2	46.0	6.9	41.5^{B}	4.1	43.8^{A}	15.1
Total MUFA	39.5^{ABC}	17.6	51.3^{B}	8.6	55.4^{C}	3.9	53.5^{A}	12.9
Total PUFA n-3	0.5	8.9	0.5	35.1	1.1	120.9	0.5	19.4
Total PUFA n-6	2.9	56.0	2.2	49.0	2.1	45.1	2.3	36.4
Total PUFA + MUFA	42.9^{ABa}	14.9	54.0^{a}	5.9	58.6^{B}	2.9	56.2^{A}	11.7

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P<0.05$

TABLE 4

Fatty acid composition of milk fat from ewes fed diets supplemented with hydrogenated rape seed oil, %

Hydrogenated rape seed oil	0%		4%		8%		10%	
	mean	CV	mean	CV	mean	CV	mean	CV
Miristic	9.9^{ad}	17.1	9.0^{bc}	19.9	6.3^{cd}	19.2	6.0^{ab}	30.1
Palmitic	25.9^{abc}	5.4	23.2	8.9	19.1^{bc}	11.3	18.5^{a}	9.9
Stearic	10.4	23.8	10.2	12.9	11.9	8.4	12.2	29.7
Total SFA	46.1	6.5	42.4	18.8	37.3	10.2	36.6	12.3
Total MUFA	49.5^{ab}	7.3	54.1	6.5	59.4^{b}	6.3	60.1^{a}	8.3
Total PUFA n-3	0.4	102.6	0.3	80.4	0.4	65.0	0.3	72.3
Total PUFA n-6	4.1	16.7	3.3	12.7	2.9	45.5	2.9	50.6
Total PUFA + MUFA	53.9	5.7	57.3	6.6	62.7	6.1	63.4	7.1

means in rows with the same letter differ statistically significant ^{A,B,C} – $P<0.01$; ^{a,b,c} – $P< 0.05$

rations. The concentration of miristic and palmitic acids was lower in the milk of all sheep in the experimental groups ($P<0.05$, $P<0.01$), regardless of the type and amount of supplemented fat. The level of stearic acid differed depending on the added fat. A lower ($P<0.01$) level of stearic acid was observed when 8% of linseed oil was added, whereas higher ($P<0.05$), when 10% of linseed oil and 8 and 10% of rape seed oil were added to the ration.

DISCUSSION

Ruminant fat is an important part of the human diet in many countries, particularly milk fat, which represents up to 75% of the total consumption of fat from ruminants and up to 25-35% of total saturated fat (Chilliard et al., 2000). Milk fatty acids, such as oleic acid and polyunsaturated fatty acids (especially n-3), have a potential antiatherogenic or anticarcinogenic role, but some saturated fats also have a potential negative effect on human health. It is now clear that it is mainly lauric, myrictic and palmitic fatty acids that are responsible for increasing plasma total and LDL cholesterol concentrations, while the other major SFA, stearic acid, has been shown not to increase total cholesterol or LDL-cholesterol (Williams, 2000). Linseed oil, rape seed oil, as well as hydrogenated rape seed oil added to sheep diets decreased the level of undesirable fatty acids.

Also in the experiment carried out by Brzóska et al. (1998) the addition of vegetable-origin fat to diets significantly decreased the concentration of saturated acids in milk. During the last 20 years, intensive research has been conducted to increase the content of unsaturated fatty acids in milk fat (Wagner et al., 1998). According to Coppock and Wilks (1991) supplemental dietary fat changes the fatty acid composition of milk and in some cases it may suppress milk fat yield. In experiments carried out by adding rape seed oil and hydrogenated rape seed oil, MUFA levels increased in milk, as did total PUFA+MUFA when linseed and rape seed oil were added to sheep rations. DePeters et al. (2001) reported that canola oil treatments decreased the palmitic acid content and increased the oleic acid content of milk fat compared with the control.

Recently, there has been increased focus on a nutritional approach to both the prevention and cure of many diseases (Sasaki, 2000). Feeding fat of vegetable origin in ruminant rations increases the energy content of their diet and also improves the level of desirable nutrients, e.g., MUFA and PUFA, which may be beneficial in the treatment of some diseases.

REFERENCES

Bremmer D.R., Ruppert L.D., Clark J.H., Drackley J.K., 1998. Effects of chain length and unsaturation of fatty acid mixtures infused into the abomasums of lactating dairy cows. J. Dairy Sci. 81, 176-188

Brzóska F., Gąsior R., Brzóska B., Zyzak W., 1998. Modification of the fatty acid profile of cows milk for human needs by feeding Ca-fatty acid salt of linseed or fish oil. Book of Abstracts of the 49th Annual Meeting of EAAP, Warsaw (Poland), p. 84 (Abstr. N5.2)

Chilliard Y., Ferlay A., Mansbridge R.M., Doreau M., 2000. Ruminant milk fat plasticity: nutritional control of saturated, polyunsaturated, *trans* and conjugated fatty acids. Ann. Zootech. 49, 181-205

Coppock C.E., Wilks D.L., 1991. Supplemental fat in high-energy rations for lactating cows. Effects on intake, digestion, milk yield and composition. J. Anim. Sci. 69, 3826-3837

Czauderna M., Kowalczyk J., Potkański A., Szumacher-Strabel M., Chojecki G., 2001. Quantification of conjugated linoleic acid and other essential fatty acids in ovine meat, milk, fat and intestinal digesta. J. Anim. Feed Sci. 10, Suppl. 2, 385-392

DePeters E.J., German J.B., Taylor S.J., Essex S.T., Perez-Monti H., 2001. Fatty acid and triglyceride composition of milk fat from lactating Holstein cows in response to supplemental canola oil. J. Dairy Sci. 84, 929-936

Grundy S.M., 1999. The optimal ratio of fat to carbohydrate in the diet (Review). Ann. Rev. Nutr. 19, 325-341

Heinig K., Hissner F., Martin S., Vogt C., 1998. Separation of saturated and unsaturated fatty acids by capillary electrophoresis and HPLC. Amer. Lab., May, 24-29

Jakobsen K., 1999. Dietary modifications of animal fats: status and future perspectives. Fett-Lipid 101, 475-483

SAS®, 1990. SAS/STAT Users Guide (Release 6.03). SAS Institute Inc., Cary, NC (USA)

Sasaki T., Kanke Y., Kudoh K., Nagahashi M., Toyokawa M., Matsuda M., Shimizu J., Takita T., 2000. Dietary n-3 polyunsaturated fatty acid and status of immunocompetent cells involved in innate immunity in female rats. Ann. Nutr. Metab. 44, 38-42

Voigt J., Hagemeister H., 2001. Dietary influence on a desirable fatty acid composition in milk from dairy cattle. J. Anim. Feed Sci. 10, Suppl. 1, 87-103

Wagner K., Aulrich K., Leibzien P., Flachowsky G., 1998. Research note: Effect of duodenal infused unsaturated fatty acids on dairy milk composition. Arch. Anim. Nutr. 51, 349-354

Williams C.M., 2000. Dietary fatty acids and human health. Ann. Zootech. 49, 165-180

STRESZCZENIE

Wpływ dodatku tłuszczu na skład kwasów tłuszczowych mleka owiec

Głównym celem modyfikowania składu kwasów tłuszczowych w mleku zwierząt przeżuwających jest obniżenie poziomu nasyconych kwasów tłuszczowych (głównie mirystynowego, laurynowego i palmitynowego) oraz zwiększenie ilości jedno- i wielonienasyconych kwasów tłuszczowych. W przeprowadzonych doświadczeniach materiał doświadczalny stanowiły cztery owce mleczne o średniej masie ciała 50±5 kg, na których badano wpływ dodatku tłuszczu do diety składającej się z siana i mieszanki treściwej (60:40%) na zawartość kwasów tłuszczowych w mleku. Przeprowadzono trzy doświadczenia, w układzie kwadratu łacińskiego 4 x 4. Dodatek tłuszczu stanowił olej rzepakowy, uwodorniony olej rzepakowy oraz olej lniany podawane w ilości 0, 4, 8 i 10% suchej masy dawki. Oznaczono poziom i skład kwasów tłuszczowych w mleku. Dodatek oleju lnianego i rzepakowego obniżył ($P<0,05$; $P<0,01$) poziom nasyconych kwasów tłuszczowych w mleku owiec, natomiast dodatek oleju rzepakowego oraz uwodornionego oleju rzepakowego spowodował wzrost ($P<0,05$; $P<0,01$) poziomu jednonienasyconych kwasów tłuszczowych. Stwierdzono również wzrost ($P<0,05$; $P<0,01$) sumy PUFA i MUFA, przy dodatku oleju lnianego lub oleju rzepakowego do paszy. Poziom kwasu stearynowego w mleku owiec otrzymujących dawkę z dodatkiem 8% oleju lnianego był najniższy ($P<0,01$), natomiast po dodaniu do pasz 10% oleju lnianego lub 8 i 10% oleju rzepakowego poziom tego kwasu był istotne wyższy ($P<0,05$) niż u owiec pozostałych grup. Dodatek tłuszczu pochodzenia roślinnego do dawki dla owiec mlecznych zwiększa nie tylko poziom energii w dawce, ale także modyfikuje korzystnie skład kwasów tłuszczowych w mleku.