Effect of different forage species supplemented with two carbohydrate sources on short and medium chain fatty acids in sheep milk

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ABSTRACT: Sixty four Sarda dairy sheep fed with diets based on fresh forage were allocated to eight groups to evaluate the effect of corn or beet pulp based supplementation on milk fatty acid composition. Four forage species were compared: annual ryegrass (RY, *Lolium rigidum* Gaudin), sulla (SU, *Hedysarum coronarium* L.), burr medic (BM, *Medicago polymorpha* L.), and garland, a daisy forb, (CH, *Chrysanthemum coronarium* L.). The supplements were iso-nitrogenous but differed in carbohydrate composition consisting either of 60% (DM) of corn (concentrate C) or 40% sugar beet pulp (concentrate BP). The supplementation was iso-energetic (500 and 530 g/d, respectively). Overall during winter period (growing stage of the forages) SU and RY groups showed higher levels of atherogenicity index and C16:0. In winter period BP outperformed C for palmitic acid. In spring AI showed a trend similar to that of winter. Moreover C concentrate gave a better level of AI and myristic acid than BP. This study confirms that forage species and, to a lesser extent, carbohydrate source in the supplement markedly affect medium-chain FA profile and hence atherogenicity index in sheep milk.

Key words: Dairy products, Sheep, Fatty acid, Concentrate.

INTRODUCTION – Dairy sheep feeding is mainly based on fresh forages where represented the more FA is a-linolenic acid (Addis *et al*., 2005) which increase n-3/n-6 ratio of PUFA in milk dairy products; furthermore ruminant products represent a major source of dietary saturated fatty acids often claimed to have detrimental effect human health. Butyric acid, although saturated, is regarded as a beneficial milk component since it is thought to play a role in cancer prevention. Specific saturated fatty acids with 12–16 carbon atoms in human tend to increase the risk on coronary hearth disease (CHD). Among the cholesterol-raising saturated fatty acids, C14:0 appears to be more potent than C12:0 or C16:0. The atherogenicity index (AI=(C12:0+4xC14:0+C16:0)/ (MUFA+PUFA)) calculated by Ulbright and Southgate (1991) is an important indicator of dietary fat healthfulness. The risk of CHD could be reduced by increasing the level of polyunsaturated fatty acid and/or decreasing that of medium chain saturated fatty acid (SFA) in dairy products. The concentration of PUFA in milk can be raised by feeding fresh forages rich in α-linolenic acid even if part of them are hydrogenated in the rumen (Addis *et al*., 2005). The aim of this study was to evaluate the effect of different forage species supplemented with different concentrate source on milk FA composition with particular references to short and medium chain FA.

MATERIAL AND METHODS – Sixty four Sarda dairy sheep fed with diets based on fresh forage were allocated to eight groups at early lactation (44 DIM, winter period, growing stage of the forages) and at mid lactation (98 DIM, spring period, reproductive stage of the forages) to evaluate the effect of corn or beet pulp based supplementation on milk fatty acid composition. Four forage species were compared: annual ryegrass (RY, *Lolium rigidum* Gaudin), sulla (SU, *Hedysarum coronarium* L.), burr medic (BM, *Medicago polymorpha* L.), and garland, a daisy forb, (CH, *Chrysanthemum coronarium* L.). The forages were cut twice daily and offered in four meals daily (for furthern details see Cabiddu *et al*., 2006). The supplements were iso-nitrogenous but differed in carbohydrate composition consisting either of 60% (dry matter basis) of corn (concentrate C) or 40% sugar beet pulp (concentrate BP). The supplementation was iso-energetic (500 and 530 g/d, respectively). The supplements were offered at milking in two daily meals. Dietary intake (measured as difference between offered forages and concentrates and that of corresponding orts) and their chemical composition was detected, Table 1. Milk yield from each experimental group was measured during the last 3 d of each experimental period, and samples of milk were collected to determine fat, protein, lactose, and FA composition (Cabiddu *et al.*, 2006). Milk fatty acid profile was determined by gas chromatographic method (Chin *et al.*, 1992 cited by Addis *et al.*, 2005; Murphy *et al.*, 1990).

RESULTS AND CONCLUSIONS – Forage species influenced DMI and chemical composition of ingested diets in both periods. Concentrate composition affected only NDF content during winter, NDF and EE during spring. In the latter period, a significant interaction between forage and concentrate supplementation for NDF and EE was detected (Table 1).

Table 1. Dry matter intake and chemical composition of diet in dairy sheep fed fresh forages and supplemented with beet pulp (BP) or corn grain (C) during winter and spring periods.

		Treatments[1]											
		CH		RY		BM		SU		SEM	Effects[2]		
		BP	C	BP	C	BP	C	BP	C		F	C	F x C
Winter period													
TDMI[3]	(g DM)	1388	1574	1489	1485	1829	1832	1768	1755	46.3	**	ns	ns
Chemical composition of diet													
CP	(% DM)	15.9	15.6	15.9	15.8	23.5	23.5	25.2	25.1	1.12	**	ns	ns
EE	"	2.36	2.40	2.37	2.49	2.17	2.33	1.87	1.72	0.07	**	ns	ns
NDF	"	38.6	37.2	43.0	41.1	33.2	32.1	40.7	38.8	0.92	**	**	ns
Spring period													
TDMI	(g DM)	1020	851	1883	1871	2381	2896	2009	1903	168	**	ns	ns
Chemical composition of diet													
CP	(% DM)	12.9	13.6	12.5	12.8	15.7	15.2	22.2	22.2	0.98	**	ns	ns
EE	"	2.90	3.17	2.24	2.37	2.06	2.11	2.22	2.05	0.10	**	**	**
NDF	"	43.0	37.1	48.3	46.9	48.2	47.9	41.2	39.9	1.07	**	*	*

*[1]Treatments: CH, garland; RY, annual ryegrass; BM, burr medic; SU, sulla; BP, beet pulp; C, corn. 2Effects of forage (F) and concentrate sources (C): *, P<0.05; **, P<0.01; ns, not significant. 3 TDMI=total dry matter intake.*

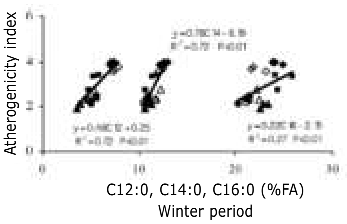
Forage species affected milk FA profile in both periods. CH group had higher butyric acid level during winter whereas in spring was the lowest in the rank (P<0.01). Corn based concentrate increased (P<0.01) butyric acid in both periods. Sulla group was characterized by a trend to higher levels of C12:0 and C14:0 than the others groups, while CH and BM groups showed a low contents of these FA, with an improvement of healthiness of milk fat in both experimental periods. In fact AI was lower in CH group (Table 2) by about 30% as compared with RY and SU groups (P<0.01). Supplementation source and the interaction (FxC) affected some FA in milk (Table 2). BP based concentrate increased C16:0 during winter, and C12:0 with C14:0 in spring with an increase of AI (P<0.01). Myristic acid (Figure 1) and MUFA content in milk are the best predictor for evaluating AI due to the very high negative relationship (R^2=0.85, P<0.01) between C14:0 and MUFA in both experimental periods. In conclusion, the healthiness of milk with reference to butyric acid and AI is strongly affected by the feeding regimen with responses depending upon season and targeted FA. Changes in butyric acid although minor are significant with the best responses in CH fed sheep supplemented with corn in winter and in SU or RY fed sheep in spring. The daisy forage and, to lesser extent, burr medic based diets are beneficial feed with reference to AI in both periods. Corn based supplementation contribute to lowering AI but only in spring.

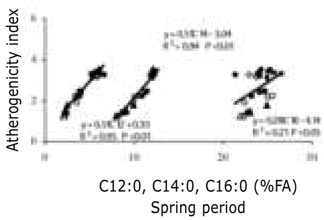
Table 2. Milk fatty acid profile in dairy sheep fed fresh forages at stall supplemented with beet pulp (BP) or corn grain (C) during winter and spring periods.

		CH		RY		BM		SU		SEM	F1	C1	F x C
		BP	C	BP	C	BP	C	BP	C				
Winter period													
C4:0	(%FA)	4.87^{B}	5.30^{C}	4.75^{B}	4.83^{B}	4.06^{A}	4.51^{B}	4.91^{BC}	4.73^{B}	0.07	**	**	**
C12:	(%FA)	3.75^{A}	4.77^{AB}	5.35^{B}	5.02^{B}	5.45^{B}	5.17^{B}	7.15^{C}	7.58^{C}	0.25	**	ns	*
C14:0	(%FA)	11.06^{AB}	11.96^{B}D	11.42^{AC}	11.89^{A}D	11.00^{AB}	10.72^{A}	12.64D	12.34^{C}D	0.15	**	ns	ns
C16:0	(%FA)	22.95^{BC}	21.94^{AB}	24.87^{C}D	25.21D	21.00^{A}	21.39^{AB}	24.27^{C}D	22.20^{AB}	0.33	**	*	**
SCFA	(%FA)	16.61^{A}	20.81^{B}	22.02^{B}	21.41^{B}	21.19^{B}	21.28^{B}	25.84^{C}	26.87^{C}	0.64	**	*	**
MCFA	(%FA)	40.02^{A}	40.82^{A}	43.73^{B}	44.06^{B}	39.59^{A}	39.47^{A}	46.29^{B}	44.07^{B}	0.54	**	ns	ns
AI[2]		2.07^{A}	2.48^{A}	3.14^{B}	3.16^{B}	2.32^{A}	2.27^{A}	3.93^{C}	3.69^{BC}	0.14	**	ns	ns
Spring period													
C4:0	(%FA)	4.03^{A}	4.27^{AB}	4.50^{AC}	4.63^{BC}	4.17^{AB}	4.48^{AC}	4.63^{C}	4.87^{C}	0.06	**	**	ns
C12:0	(%FA)	2.37^{A}	2.11^{A}	5.45^{C}	5.60^{C}	4.01^{B}	3.51^{B}	6.28D	5.92^{C}D	0.32	**	**	ns
C14:0	(%FA)	9.27^{B}	8.20^{A}	12.16E	12.68E	11.24D	10.16^{C}	12.20E	11.94DE	0.32	**	**	**
C16:0	(%FA)	23.56^{AB}	22.41^{A}	25.62^{B}	25.15^{AB}	24.06^{AB}	24.34^{AB}	23.18^{AB}	23.57^{AB}	0.28	**	ns	ns
SCFA	(%FA)	10.64^{A}	9.75^{A}	21.57^{C}	22.12^{C}	16.67^{B}	16.19^{B}	23.98D	23.83D	1.11	**	ns	ns
MCFA	(%FA)	37.59^{AB}	34.87^{A}	45.74D	45.84D	41.83^{C}	40.55^{BC}	43.64^{C}D	43.47^{C}D	0.79	**	ns	ns
A[I]		1.58 ^{A}	1.32^{A}	3.26^{C}	3.35^{C}	2.37^{B}	2.09^{B}	3.40^{C}	3.24^{C}	0.17	**	*	ns

*[1]Effects of forage (F) and concentrate sources (C): *, P<0.05; **, P<0.01; ns, not significant.;*
[2]AI=(C12:0+4xC14:0+C16:0)/(MUFA+PUFA).

Figure 1. Relationship between lauric myristic and palmitic acid with AI level in milk from sheep fed with CH (BP▲, C Δ) RY (BP ■, C □) BM (BP●; C ○) or SU (BP ◆, C ◇).





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