Feeding management and production factors affecting goat milk composition and quality. II. Physical and chemical properties and mineral content

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Feeding management and production factors affecting goat milk composition and quality. II. Physical and chemical properties and mineral content

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SUMMARY – Individual milk samples representing the overall morning milking were collected monthly (from April to September) from 24 Saanen goats, uniformly distributed into two herds in Northern Italy with the aim to evaluate the factors affecting physico-chemical properties and mineral content. Herds differed in feeding management system: "Traditional" and "Total mixed ration" ("TMR"). Herd type was related to milk chemical composition; compared to "TMR", "Traditional" herd type improved dry matter content and lowered ash. Milk dry matter was related to fat, protein and lactose; ash was related to milk yield, fat and protein; freezing point was related to lactose, urea and fat. Ca, P and Mg contents were influenced by the herd type, with lower values in "Traditional" than in "TMR". A positive relationship was found between: milk yield and P and K; protein and Ca, P, Mg and Na; lactose and Ca and P; somatic cells and Mg; pH and Na; urea and Na. A negative relationship was found between: protein and K; lactose and Na and K; pH and P. Potassium content was higher for primiparous goats and for single delivery goats.

Keywords: Feeding management, production factors, physico-chemical properties, mineral content, goat milk.

RESUME – *"Gestion alimentaire et facteurs de production influençant la composition et la qualité du lait de chèvre. II. Propriétés physico-chimiques et teneur en minéraux". Des échantillons individuels de lait représentant la traite entière du matin ont été prélevés (à partir d'avril jusqu'en septembre) sur 24 chèvres Saanen, uniformément distribuées en deux troupeaux situés dans le nord de l'Italie, dans le but d'évaluer les facteurs affectant les propriétés physico-chimiques et la teneur en minéraux. Les troupeaux étaient différents quant au régime d'alimentation : "Traditionnel" et "Ration complète" ("TMR"). Le type de troupeau a été lié à la composition chimique du lait ; comparé à "TMR", le groupe "Traditionnel" a amélioré la teneur en matière sèche et fait baisser la teneur en cendres. La matière sèche du lait a été liée au gras, à la protéine et au lactose ; les cendres se sont avérées liées au rendement laitier, au gras et à la protéine ; le point de congélation a été lié au gras, au lactose et à l'urée. La teneur en Ca, P et Mg a été influencée par le type de troupeau, avec des valeurs plus basses dans le "Traditionnel" que dans "TMR". Des relations positives ont été trouvées entre : rendement laitier et P et K ; protéine et Ca, P, Mg et Na ; lactose et Ca et P ; cellules somatiques et Mg ; pH et Na ; urée et Na. Des relations négatives ont été trouvées entre : protéine et K ; lactose et Na et K ; pH et P. La teneur en potassium était plus élevée pour les chèvres primipares et pour les mises bas simples.*

Mots-clés : *Régime d'alimentation, facteurs de production, propriétés physico-chimiques, minéraux, lait de chèvre.*

Introduction

In goat milk dry matter is rather variable (Sawaya *et al.*, 1984; Espie and Mullan, 1990), depending mainly from the breed, while ash content is rather constant. Also freezing point is variable (Parkash and Jenness, 1968; Piergiovanni and Casassa, 1982; Szijarto and van de Voort, 1983; Espie and Mullan, 1990). Minerals, despite their small proportion in milk, are very important because they affect the cheesemaking properties of the milk (Jenness, 1980). Alais (2000) highlights that feeding and environmental factors have a small influence on mineral content. There is a relationship between milk mineral contents and the mineral requirements of the goat (Haenlein, 1980). Other authors study Ca, P and Mg salt equilibrium to delineate their relationships with rennet-coagulation properties (Pierre *et al.*, 1998). The introduction of "TMR" ("Total mixed ration") diet in goat herds could lead to a improving in milk quality. In this research feeding management and production factors affecting physico-chemical properties and mineral content of Saanen goat milk were studied.

Materials and methods

The study was carried out into 2 dairy goat herds, differing for feeding management system: "Traditional" and "Total mixed ration" (Superchi *et al.*, 2005). From 12 Saanen goats per each herd, individual milk samples representing the overall morning milking were monthly collected (from April to September). Delivery date, parity number and delivery type were considered. In correspondence of test days, lactation stage and milk yield data were recorded. On each milk sample the following analyses were carried out: fat, protein, lactose, urea, somatic cells, pH as described in Superchi *et al.* (2005); freezing point by a thermistor cryoscope; dry matter on 20 g of milk at 100°C; ash (Savini, 1946); Ca, Mg, K, Na, by Atomic Absorption Spectrophotometer (Anonymous, 1982); Pby colorimetry (Allen, 1940). Data were submitted to analysis of covariance (fixed effects: herd type; parity number; month of lactation; month of sampling; type of delivery; month of delivery. Covariates: milk yield, kg; fat, %; protein, %; lactose, %; somatic cells, 10^3/ml; pH; urea, mg/100 ml) by means of SAS statistical software (SAS, ver. 9.1, 2002-2003).

Results and discussion

Mean values and standard deviations

Mean values and standard deviations for milk yield, fat, protein, lactose, somatic cells, pH, urea are reported in Superchi *et al*. (2005). Mean values and standard deviations for dry matter, ash, freezing point and mineral content for the 2 diets are reported in Table 1. There are several researches dealing with goat milk dry matter and ash content. Values for dry matter show a great variability, due also to the different breeds and to their productive characteristics. Our data (11.62%) are similar to results registered by Castagnetti *et al*. (1984) and by Mariani *et al*. (1987). Other studies report much higher values (Piergiovanni and Casassa, 1982). Ash values show a lower variability. The value of this research is similar to that reported by Espie and Mullan (1990). Our freezing point values are similar to some authors (Szijarto and van de Voort, 1983; Espie and Mullan, 1990), but not to Parkash and Jenness (1968) and Piergiovanni and Casassa (1982). This fact can be due to the mineral content that is lower for these latter authors. Calcium values were lower than data of Jenness (1980) but similar to values from Casoli *et al*. (1986). Also P values were lower than data observed in other studies (Jenness, 1980). Values of Mg are in agreement with Casoli *et al*. (1986) and Mariani *et al*. (1987), while Jenness (1980) reports higher values. Sodium results a little lower with respect to Jenness (1980) and Casoli *et al*. (1986). Values for K are lower than data observed by Mariani *et al*. (1987) and Jenness (1980), while higher than those registered by Casoli *et al*. (1986).

Table 1. Dry matter, ash, freezing point and mineral content for the 2 diets. Mean and SD

	Traditional		TMR		Total	
	Mean	SD	Mean	SD	Mean	SD
Dry matter (%)	11.17	1.30	11.99	1.44	11.62	1.43
Ash (%)	0.74	0.03	0.78	0.04	0.76	0.04
Freezing point (°C)	-0.547	0.007	-0.550	0.008	-0.549	0.007
Calcium (mg/100g)	97.29	13.02	113.81	18.23	106.44	18.05
Phosphorus (mg/100g)	73.33	6.02	85.72	9.78	80.19	10.34
Ca/P	1.33	0.17	1.34	0.23	1.33	0.20
Magnesium (mg/100g)	11.66	1.54	13.60	2.50	12.73	2.33
Sodium (mg/100g)	28.72	4.23	33.33	11.82	31.28	9.49
Potassium (mg/100g)	190.95	16.06	180.63	15.87	185.23	16.71
Na/K	0.15	0.03	0.19	0.08	0.17	0.07

Effects of feeding management and production factors on physico-chemical properties

Herd type was related to milk chemical composition (Table 2); compared to "TMR", "Traditional" herd type improved dry matter content and lowered ash ($P<0.05$). The influence of delivery date, parity number and delivery type on dry matter, ash and freezing point was not significant. Goat milk dry matter showed significant ($P<0.0001$) and positive relationships with fat ($b = 0.95$), protein ($b = 1.12$) and lactose ($b = 0.99$), while relationships with milk yield, somatic cells, pH and urea content were not significant (Table 2). Ash was negatively related with fat ($b = -0.01$; $P<0.01$) and positively related with protein ($b = 0.05$; $P<0.0001$) and milk yield ($b = 0.01$; $P<0.05$), but relationships with lactose, somatic cells, pH and urea content were not significant. Freezing point showed relationships only with lactose ($b = -0.012$; $P<0.0001$), urea content ($b = -0.0003$; $P<0.0001$) and fat ($b = -0.002$; $P<0.05$).

Effects of feeding management and production factors on mineral content

Minerals showed significant relationships with some of the most important constituents of goat milk (Tables 2 and 3). In particular there was a positive relationship between protein and calcium ($b = 13.54$; $P<0.001$), phosphorus ($b = 7.43$; $P<0.001$), magnesium ($b = 1.39$; $P<0.01$) and sodium ($b = 10.37$; $P<0.0001$), while a negative one was found between protein and potassium ($b = -15.65$; $P<0.0001$). Fat was not significantly related with any of the considered minerals, while lactose showed positive relationships ($P<0.0001$) with calcium ($b = 30.41$) and phosphorus ($b = 11.38$), and negative relationships ($P<0.0001$) with sodium ($b = -15.40$) and potassium ($b = -26.37$). A negative relationship was registered between pH and phosphorus ($b = -25.04$; $P<0.01$) while a positive one between pH and sodium ($b = 26.05$; $P<0.0001$). Milk yield was significantly and positively related with phosphorus ($b = 2.27$; $P<0.05$) and potassium ($b = 5.55$; $P<0.001$). Somatic cells were related with magnesium ($b = 0.0002$; $P<0.01$) and potassium ($b = -0.003$; $P<0.0001$), while urea content was related only with sodium ($b = 0.15$; $P<0.01$). Na/K ratio was positively related with protein ($b = 0.08$), somatic cells ($b < 0.0001$), pH ($b = 0.18$) and urea content ($b = 0.001$) and negatively with lactose (-0.08); calcium to phosphorus ratio was positively related only with pH ($b = 0.71$) and lactose ($b =1.20$). Ca, P and Mg contents were influenced ($P<0.05$) by the herd type, with lower values in "Traditional" than in "TMR"; probably this fact is related to the different milk yield. Potassium content was higher for primiparous goats ($P<0.01$) and for single delivery goats ($P<0.05$). Delivery date affected particularly Mg ($P<0.05$) and K ($P<0.05$) contents. The month of lactation affected, particularly, Na and K contents ($P<0.05$), and, consequently, Na to K ratio ($P<0.05$). Ca was lower for milk sampled in June ($b = -19.02$; $P<0.05$), P for milks sampled in July ($b = -7.71$; $P<0.05$), Mg for milks sampled in July ($b = -2.15$; $P<0.05$) and August ($b = -1.42$; $P<0.05$); K resulted lower for milks sampled in April ($b = -26.76$; $P<0.05$) and May ($b = -27.33$; $P<0.01$). Na, on the contrary, was significantly higher in milks sampled in April ($b = 12.04$; $P<0.05$). Consequently, Na to K ratio resulted higher for milks sampled in April and May ($P<0.05$).

Conclusions

The physico-chemical characteristics of Saanen goat milk are not affected by the considered production factors, while the same characteristics are influenced by feeding management system. Macro-mineral element content is mainly affected by the sampling month and the delivery month. The feeding management system influences Ca, P and Mg contents, that are lower in the "Traditional" type. This survey highlights that besides to production factors, a fundamental role to determine the quality of goat milk is played by the feeding management system, that must be considered for the valorisation of goat milk.

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Table 2. Relationships of feeding management and production factors with dry matter, ash, freezing point and magnesium

		Dry matter, %			Ash, %			Freezing point, °C			Magnesium, mg/100g		
Parameter		Estimate	SE	P	Estimate	SE	P	Estimate	SE	P	Estimate	SE	P
Intercept		0.1322	1.7208	0.9389	0.9369	0.2517	0.0003	-0.4332	0.0548	0.0000	11.5336	13.1570	0.3827
Milk yield, kg/d per goat		0.0178	0.0354	0.6167	0.0110	0.0052	0.0368	-0.0000	0.0011	0.9693	0.4182	0.2708	0.1255
Fat, %		0.9501	0.0204	0.0000	-0.0100	0.0030	0.0011	-0.0017	0.0006	0.0107	-0.1333	0.1560	0.3949
Protein, %		1.1224	0.0606	0.0000	0.0484	0.0089	0.0000	-0.0019	0.0019	0.3392	1.3913	0.4631	0.0033
Lactose, %		0.9886	0.0781	0.0000	-0.0191	0.0114	0.0982	-0.0117	0.0025	0.0000	-0.6674	0.5971	0.2662
SCC, x1000/ml		0.0000	0.0000	0.5397	0.0000	0.0000	0.3293	-0.0000	0.0000	0.2960	0.0002	0.0001	0.0085
pH		0.1576	0.2476	0.5259	-0.0336	0.0362	0.3563	-0.0054	0.0079	0.4919	1.0625	1.8930	0.5758
Urea, mg/100 ml		0.0012	0.0021	0.5677	0.0003	0.0003	0.3329	-0.0003	0.0001	0.0000	-0.0136	0.0163	0.4066
Parity number	1	-0.0597	0.0433	0.1710	0.0069	0.0063	0.2782	0.0011	0.0014	0.4088	-0.0292	0.3311	0.9300
	2	0			0			0			0		
Lactation months	1	-0.3961	0.2798	0.1598	0.0265	0.0409	0.5192	-0.0034	0.0089	0.7060	-1.3616	2.1390	0.5258
	2	-0.2789	0.2496	0.2664	0.0390	0.0365	0.2878	-0.0014	0.0079	0.8608	-1.8220	1.9083	0.3419
	3	-0.2043	0.2004	0.3105	0.0201	0.0293	0.4937	-0.0023	0.0064	0.7221	-1.6230	1.5326	0.2920
	4	-0.1149	0.1619	0.4794	0.0222	0.0237	0.3511	-0.0014	0.0052	0.7886	-0.4722	1.2379	0.7037
	5	-0.0708	0.1187	0.5524	0.0189	0.0174	0.2792	0.0005	0.0038	0.9007	-0.8332	0.9078	0.3608
	6	-0.0786	0.0840	0.3515	0.0222	0.0123	0.0740	-0.0030	0.0027	0.2582	-0.1774	0.6421	0.7829
	7	0			0			0			0		
Month of sampling	April	0.1466	0.2483	0.5562	-0.0307	0.0363	0.3999	0.0043	0.0079	0.5896	-2.5596	1.8983	0.1804
	May	0.0177	0.2190	0.9356	-0.0538	0.0320	0.0961	0.0037	0.0070	0.5996	-2.8297	1.6744	0.0940
	June	0.0734	0.1513	0.6284	-0.0411	0.0221	0.0659	-0.0001	0.0048	0.9855	-1.7924	1.1568	0.1243
	July	0.0347	0.1190	0.7714	-0.0408	0.0174	0.0210	0.0026	0.0038	0.4969	-2.1524	0.9099	0.0198
	August	0.0064	0.0883	0.9424	-0.0219	0.0129	0.0922	-0.0014	0.0028	0.6229	-1.4247	0.6748	0.0371
	September	0			0			0			0		
Delivery type	Single	-0.0946	0.0533	0.0790	0.0032	0.0078	0.6848	0.0011	0.0017	0.5358	-0.7149	0.4078	0.0825
	Twin	0.0000	.	.	0.0000	.	.	0.0000	.	.	0		
Herd type	"Traditional"	0.1276	0.0589	0.0325	-0.0178	0.0086	0.0409	-0.0036	0.0019	0.0566	-1.2640	0.4504	0.0060
	TMR	0			0			0			0		
Delivery month	February	-0.2603	0.1812	0.1539	0.0266	0.0265	0.3186	-0.0047	0.0058	0.4142	-3.0037	1.3856	0.0324
	March	-0.1410	0.1522	0.3564	0.0233	0.0223	0.2968	-0.0053	0.0048	0.2729	-2.8451	1.1638	0.0162
	April	-0.1368	0.1420	0.3377	0.0044	0.0208	0.8343	0.0014	0.0045	0.7562	-2.6089	1.0857	0.0180
	May	0			0			0			0		

Table 3. Relationships of feeding management and production factors with calcium, phosphorus, sodium and potassium

		Calcium, mg/100g			Phosphorus, mg/100g			Sodium, mg/100g			Potassium, mg/100g		
Parameter		Estimate	SE	P	Estimate	SE	P	Estimate	SE	P	Estimate	SE	P
Intercept		-181.844	106.8711	0.0918	179.1363	55.6193	0.0017	-95.9260	41.3862	0.0224	453.8604	77.6086	0.0000
Milk yield, kg/d per goat		2.0697	2.1996	0.3489	2.2707	1.1447	0.0499	-0.6815	0.8518	0.4255	5.5530	1.5973	0.0007
Fat, %		-1.5211	1.2673	0.2327	0.0704	0.6595	0.9152	-0.1737	0.4908	0.7241	-1.4665	0.9203	0.1141
Protein, %		13.5429	3.7618	0.0005	7.4340	1.9578	0.0002	10.3658	1.4568	0.0000	-15.6541	2.7318	0.0000
Lactose, %		30.4118	4.8500	0.0000	11.3809	2.5241	0.0000	-15.4015	1.8782	0.0000	-26.3718	3.5220	0.0000
SCC, x1000/ml		0.0010	0.0007	0.1552	0.0001	0.0004	0.8864	0.0005	0.0003	0.0718	-0.0030	0.0005	0.0000
pH		20.2473	15.3762	0.1908	-25.0430	8.0023	0.0023	26.0515	5.9545	0.0000	-20.4159	11.1660	0.0703
Urea, mg/100 ml		-0.0089	0.1322	0.9466	0.0143	0.0688	0.8361	0.1543	0.0512	0.0032	-0.0733	0.0960	0.4467
Parity number	1	-1.9730	2.6897	0.4649	1.8748	1.3998	0.1834	-1.5153	1.0416	0.1487	5.1405	1.9533	0.0098
	2	0			0			0			0		
Lactation months	1	4.5670	17.3750	0.7932	-0.5836	9.0425	0.9487	-21.4946	6.7285	0.0018	26.9272	12.6175	0.0352
	2	9.2143	15.5006	0.5535	1.0363	8.0671	0.8980	-18.7084	6.0027	0.0024	25.8920	11.2564	0.0234
	3	7.1832	12.4488	0.5652	0.0026	6.4788	0.9997	-15.4360	4.8208	0.0018	19.3528	9.0402	0.0346
	4	10.3895	10.0553	0.3039	-0.0484	5.2331	0.9926	-9.4349	3.8939	0.0171	11.0768	7.3020	0.1323
	5	6.4611	7.3737	0.3829	-0.4987	3.8375	0.8969	-7.2509	2.8555	0.0126	7.2204	5.3547	0.1804
	6	1.1933	5.2156	0.8195	-0.7270	2.7144	0.7893	-4.9170	2.0197	0.0166	7.5349	3.7875	0.0493
	7	0			0			0			0		
Month of sampling	April	-9.8795	15.4194	0.5231	-4.5917	8.0248	0.5684	12.0436	5.9712	0.0463	-26.7620	11.1974	0.0186
	May	-18.3130	13.6012	0.1811	-7.5850	7.0785	0.2864	9.6800	5.2671	0.0689	-27.3383	9.8770	0.0067
	June	-19.0212	9.3960	0.0455	-8.7263	4.8900	0.0772	6.3646	3.6386	0.0832	-8.7513	6.8233	0.2025
	July	5.2320	7.3911	0.4806	-7.7103	3.8466	0.0476	3.6765	2.8622	0.2018	-9.6442	5.3674	0.0752
	August	1.5225	5.4809	0.7817	-5.2975	2.8525	0.0661	-0.5158	2.1225	0.8085	0.6990	3.9802	0.8609
	September	0			0			0			0		
Delivery type	Single	-6.3604	3.3128	0.0576	2.1780	1.7241	0.2093	-0.4731	1.2829	0.7130	6.1140	2.4057	0.0125
	Twin	0.0000	.	.	0.0000	.	.	0			0		
Herd type	"Traditional"	-7.7117	3.6584	0.0374	-5.4493	1.9040	0.0051	-1.1628	1.4167	0.4136	-4.0456	2.6567	0.1308
	TMR	0			0			0			0		
Delivery month	February	0.4501	11.2552	0.9682	1.6698	5.8576	0.7762	-11.0874	4.3586	0.0124	26.4617	8.1734	0.0016
	March	-6.0474	9.4531	0.5237	1.2761	4.9197	0.7958	-6.6456	3.6608	0.0723	21.8097	6.8648	0.0020
	April	-3.6221	8.8189	0.6821	-4.0012	4.5896	0.3853	-2.2632	3.4151	0.5090	13.1546	6.4042	0.0425
	May	0			0			0			0		

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