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Effect of feeding diets on quality characteristics of milk and cheese produced from Sarda dairy ewes

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SUMMARY – The effect of two feeding techniques on the physico-chemical and microbiological characteristics of milk and cheese was studied in Sarda dairy ewes. The feeding diets were: hay, silage and concentrate mixed together (total mixed ration, UF group) and Italian ryegrass pasture (PA group). Milk composition was significantly different in the two groups: the butyric acid bacteria spore content was higher in UF than PA (1140 UF vs. 20 PA MPN/l; P<0.01) whereas the somatic cell count was higher in PA than UF (P<0.01). There were differences regarding the lactodinamographic characteristics of milk between the two groups (R: 21.52 UF vs. 31.91 PA min.; K_{20}: 9.39 UF vs. 12.42 PA; P<0.05). Fat content in the cheese was higher in UF than PA but the texture was lower in UF cheese.

Key words: Sheep milk, pasture, complete diet, milk composition, cheese quality.

RESUME – *"Effet des régimes alimentaires sur les caractéristiques de qualité du lait et du fromage produits par des brebis laitières de race Sarde". Quarante brebis de race Sarde en lactation ont été divisées en 2 groupes homogènes pour étudier l'effet de l'alimentation sur les caractéristiques physico-chimiques et microbiologiques du lait et du fromage. Les deux groupes de brebis étaient alimentés avec foin, ensilage et concentré mélangé (groupe UF) et avec du pâturage de ray-grass d'Italie (groupe PA). Le lait était significativement différent pour les deux groupes: le taux de spores butyriques était plus élevé dans le lait UF (1140 UF vs. 20 PA MPN/l ; P<0,01), le comptage de cellules somatiques était plus élevé dans le lait PA (P<0,01). Concernant l'aptitude à la coagulation, des différences significatives ont été observées dans les deux groupes (R : 21.52 UF vs. 31.91 PA min. ; K_{20} : 9.39 UF vs. 12.42 PA ; P<0,05). Des différences significatives ont été mises en évidence également sur les fromages au niveau du taux de matière grasse, qui est plus élevé dans le fromage UF. Celui-ci présentait en outre une mauvaise structure.*

Mots-clés : *Lait de brebis, alimentation, composition du lait, qualité du fromage.*

Introduction

In the Mediterranean basin one of the main systems is represented by grazing dairy ewes and in Sardinia, in particular, about 11% of the EU total for sheep milk is produced. The sheep industry is based on a local breed of dairy ewes, managed for late autumn lambing and milked, on average, between January and June. Livestock systems are fed on natural pastures (38% of the total land area) mainly composed of grasses and winter forage crops like oats, barley and Italian ryegrass, are grazed in winter and rested for hay making in spring (Molina *et al.*, 1991). The last two decades have seen the spread of irrigation over the Sardinian lowlands which has resulted in the development of highly-intensified farms. Irrigated forage crops like maize (for silage), lucerne and hybrid forage sorghum represent excellent tools for increasing stocking rate per hectare. Furthermore in these lowlands it is possible to plan lambings for late-winter early-spring in order for milk production to be delayed until the summertime (Fois *et al*., 1997, 1999) thus maximizing the operation of the cheese factories. However milk composition and cheese characteristics are strictly influenced by feeding technique. Over recent years the effect of feeding regimes, in particular the use of maize silage, on milk properties has been studied (Bergere *et al*., 1985; Manfredini *et al*., 1987; Scintu *et al*., 1990), yet there is a lack of information on cheese characteristics (Bergere *et al*., 1985; Manfredini *et al*., 1987).

The aim of the work is to assess the effect of feeding techniques on physico-chemical and microbiological characteristics of milk and cheese.

Materials and methods

The trial was carried out between 23/02/95 and 5/05/95 at Bonassai NW Sardinia (33 m a.s.l., 40°N). Forty Sarda ewes in lactation, all belonging to the forage systems trial, were divided into two groups: the UF group fed indoors on a total mixed ration (maize silage 57% of the dry matter, lucerne hay 22%, sugar beet pulp 5%, maize grain 10%, soya bean meal 6%) and the PA group fed on an open pasture of Italian ryegrass. The chemical composition of the complete diet and pasture offered to the ewes is given in Table 1.

Table 1. Chemical composition of the feedstuffs on offer (means ± standard deviation; s.d.)

Items	UF	PA
Dry matter (%)	53.0±0.51	17.6±0.56
Crude protein (% DM)	14.7±0.65	23.7±2.28
Extract ether (% DM)	2.3±0.18	4.6±0.13
NDF (% DM)	47.3±3.95	41.6±0.58
ADF (% DM)	28.6±3.27	18.9±0.40
ADL (% DM)	4.9±0.63	1.7±0.83
Ash (% DM)	7.9±0.37	14.6±2.71
Feed Unit (kg/DM)	0.84	0.97

The ewes were balanced for age, lambing period, $_{s1}$-cn and -lg milk polymorphism. The whole bulk milk was collected for each group weekly for 10 weeks. All the analyses were performed in duplicate on each bulk milk, for pH (potentiometric technique), total solids (FIL-IDF, 1987a), fat (FIL-IDF, 1987b), nitrogen fractions (Rowland, 1938), urea (differential pH-metry), somatic cells (SCC) (Fossomatic, Denmark), standard plate count (SPC) (FIL-IDF, 1991), citrate fermenting LAB (MRS modified Bottazzi *et al.*, 1971), coliforms (FIL-IDF, 1985), coliforms and presuntive *E. coli* (VRBA-MUG) and spores of butyric acid bacteria (sBAB) (Bottazzi *et al.*, 1985). Lactodynamographic parameters were determined by Formagraph under the conditions proposed by Piredda *et al.* (1993) and Pirisi *et al.* (1999). Twenty cheese-making trials (10 for each group) were performed with whole bulk milk from the two groups, using a cheese-making pilot plant (Cardenas *et al.*, 1991) made by INRA. A Pecorino Sardo cheese type was manufactured for analytical purposes, in loaves weighing about 1 kg each. Cheese loaves were sweated at 32°C for 5 hours and then salted in saturated brine for 7 hours. The cheeses were ripened for 2 months at 12°C in 85% relative humidity. The following measurements were carried out on fresh and ripened cheese: pH (potentiometric technique), dry matter (FIL-IDF, 1982), fat (Soxhlet extraction) and nitrogen fractions (Gripon *et al.*, 1975). Analysis of variance was carried out using the General Linear Model procedure of the SAS software package (SAS Institute, USA).

Results and discussion

The ewes fed with Italian ryegrass pasture on average yielded 0.45 kg more milk than those fed indoors on total mixed ration (1.003 vs. 0.553 kg, $P<0.01$) and body weight proved higher in UF than PA (52.1 vs. 44.8 kg, $P<0.01$).

The bulk milk composition for the PA and UF sheep groups is given in Table 2.

The UF milk had a significantly higher content of total solids ($P<0.01$) but as regards nitrogen fractions, PA milk showed a high level ($P<0.01$) of true protein, whey proteins and urea. However the casein/true protein ratio in PA milk was significantly lower than in the UF milk ($P<0.01$). This fact could be due both to the high crude protein content in the PA diet (Cannas *et al.*, 1998) and probably to a high SCC in the PA milk (Table 4) (Pirisi *et al.*, 1996).

The pH value was higher in PA than UF ($P<0.01$) probably because of a high SCC in PA milk (Pirisi *et al.*, 1996). This parameter influenced clotting and curd firming time (Table 3), which were higher in the PA than in the UF milk indicating that the aggregation of renneted micelles proceeded faster for UF milk. All this results in a prolongation of the cheesemaking time. No significant differences were found in curd firmness (Table 3). Many authors have observed a very

high positive correlation between milk's pH and coagulation time (Ramet and Weber, 1980; Remeuf *et al*., 1991) in cow and goat milk. Thus the pH value represents the parameter that most influences the different behaviour in milk coagulation.

Table 2. Composition of bulk milk (means ± s.d.)

	UF	PA
PH	6.60±0.03[b]	6.72±0.03[a]
Total solids (g/100 g)	18.54±0.42[a]	18.09±0.28[b]
Fat (g/100 ml)	7.24±0.37	6.98±0.33
True protein (g/100 g)	5.28±0.12[b]	5.66±0.11[a]
Casein (g/100 g)	4.26±0.16	4.36±0.17
Whey protein (g/100 g)	1.02±0.15[b]	1.30±0.10[a]
NPN (g/100 g)	0.04±0.004	0.05±0.006
Urea (mg/100 ml)	44.8±5.77[b]	61.9±6.47[a]
Casein/true protein (%)	76.7±2.36[a]	73.2±1.72[b]

[a,b]P<0.01

Table 3. Lactodynamographic parameters of bulk milks (means ± s.d.)

	UF	PA
R (min)	21.52±1.62[b]	31.91±1.97[a]
K_{20} (min)	9.39±1.15[b]	12.42±0.93[a]
A_{2R} (mm)	27.03±0.85	26.59±1.77

[a,b]P<0.01

The microbiological characteristics of the bulk milks (Table 4) were quite good but the number of sBAB were higher in the UF (P<0.01) than in the PA milk, according to Bergere *et al*. (1985) and Scintu *et al*. (1990), and the SCC was significantly different (P<0.01).

Table 4. Somatic cell count and microbiological characteristics of bulk milk (means ± s.d.)

	UF	PA
SCC (lg/ml)	5.91±0.06[b]	6.25±0.06[a]
SPC (lg CFU/ml)	5.35±0.63	4.86±0.54
Citrate fermenting (lg CFU/ml)	1.42±1.34	1.70±1.31
Coliforms (lg CFU/ml)	3.60±1.16	3.01±0.93
E. coli (lg CFU/ml)	1.31±0.72	0.79±0.73
sBAB (MPN/l)	1140±700[a]	20±60[b]

[a,b]P<0.01.

Table 5 shows that the whey of the PA milk was significantly higher in total nitrogen content than the UF milk and this was due to the higher soluble protein content of the PA milk for which a minus TN recovery in cheese (P<0.01) and in adjusted cheese yield was evidenced (P<0.01) demonstrating that UF milk had the highest cheesemaking efficiency.

Table 5. Whey composition and cheese yield (means ± s.d.)

	UF	PA
Dry matter (g/100 g)	9.28±0.17	9.20±0.32
Fat (g/100 g)	1.74±0.22	1.90±0.28
Total nitrogen (gN/100 g)	0.27±0.02[b]	0.29±0.01[a]
Adjusted cheese yield (%)	19.1±0.72[a]	18.3±0.56[b]
TNRR† (%)	77.2±2.87[a]	71.8±2.96[b]
FRR†† (%)	83.2±3.15	80.4±3.60

†TNRR: Total Nitrogen Recovery Rate.
†† FRR: Fat Recovery Rate.
[a,b]P<0.01.

Chemical composition of both 1-day-old and 2-month-old cheeses did not show much difference (Table 6), although full ripened cheeses made from PA milk were significantly lower in fat than those from UF milk (P<0.01) (+3.5% in UF vs. PA ripened cheese). In particular this could be due to the high fat content and to a better fat recovery rate in the UF milk which significantly influenced cheese composition, although not in a significantly different way to the PA milk.

Table 6. Composition of 1 day and 2 month old cheese made from bulk milks (means ± s.d.)

	UF	PA
1 day old cheese		
pH	5.30±0.07	5.38±0.08
Dry matter (g/100 g)	59.72±0.78[a]	58.59±0.77[b]
Fat (g/100 g)	31.90±1.01[a]	30.28±0.98[b]
Total nitrogen (gN/100 g)	3.57±0.12	3.62±0.17
SN/TN† (%)	6.53±0.59	6.96±0.82
2 month old cheese		
pH	5.47±0.09	5.43±0.08
Dry matter (g/100 g)	70.57±1.08	70.04±1.09
Fat (g/100 g)	37.07±1.09[a]	35.76±1.09[b]
Total nitrogen (gN/100 g)	4.14±0.06	4.24±0.09
SN/TN† (%)	16.8±1.07	15.9±1.99

†SN/TN: Soluble Nitrogen/Total Nitrogen.
[a,b]P<0.01.

The spores of BAB in fresh and ripened cheese were not significantly different in the two groups. Nevertheless, visual texture analysis of the cheeses revealed that in the UF cheeses eyes of average and large size, spread over all the samples, were always present. On the contrary, the PA cheeses showed very small eyes in only a few samples.

Conclusions

The results of the trial show that milk produced by ewes fed on pasture has better microbiological characteristics, higher true and soluble protein than milk produced by ewes fed on a total mixed ration. Lactodynamographic properties and cheese yield parameters were better in UF milk, for sheep milk, and this is very important, its destination being cheesemaking. However the cheeses produced with UF milk sometimes showed bad structure because of the presence of butyric acid bacteria spores. Further studies on this subject will have to be carried out on other

types of cheese, in particular on hard cheese with long ripening time to verify the influence of feeding diets on qualitative characteristics with particular reference to the cheese body and the lipolysis.

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