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Effect of diet and breed on milk composition and rennet coagulation properties

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Summary — The effect of diet on the chemical characteristics and rennet coagulation properties of milk from Brown and Friesian cows was examined with three feeding levels (normal, +7 or +14% of INRA requirements) and three forage:concentrate ratios (65:35, 57:43 and 44:56). The experimental period was between the 9th and 20th week of lactation for all the animals. The increase in feeding level led to an increase in milk protein (+0.13 and +0.17%) and casein (+0.09 and +0.15%) and improved the cheesemaking properties of the milk, especially the rate of gel firming. The forage:concentrate ratio did not have any significant effect on milk composition or its cheesemaking properties. An analysis of all the experimental data revealed that the Brown cows produced a milk with a significantly higher content of protein, casein, calcium and phosphorus, with positive effects on the cheesemaking quality and particularly on the gel firmness.

dairy cow / milk composition / cheesemaking qualities / feeding level / forage to concentrate ratio / breed

Résumé — Effet du régime alimentaire et de la race sur la composition du lait et ses propriétés de coagulation. *L'effet de l'alimentation et de la race sur les caractéristiques chimiques et fromagères du lait a été étudié sur trois essais conduits pendant trois années consécutives sur des vaches de race Brune et Frisonne. Pendant 6 semaines après la mise bas, la ration était constituée par 15 kg de foin de prairie permanente et une quantité d'aliments concentrés permettant de couvrir les besoins des animaux selon les recommandations Inra. Dans la phase expérimentale, qui a duré 12 semaines (de la 9e à la 20e après le vêlage), trois niveaux alimentaires (essais 1 et 2) ou trois rapports foin/concentré ont été comparés, selon le schéma suivant : Ier essai, groupe témoin (Ln) rationné selon les mêmes critères que durant la phase préliminaire, groupe expérimental (Lh) avec 7 % d'UFL en plus par rapport aux besoins, obtenu en substituant une partie du foin avec des grains de maïs ; 2e essai, groupe témoin (Ln) obtenu comme ci-dessus, groupe expérimental (Lhh) avec 14 % d'UFL en plus par rapport aux besoins, obtenu également comme spécifié ci-dessus ; 3e essai, groupe témoin (Cl), rationné* *comme les groupes témoins des 1er et 2e essais et avec un rapport foin/concentré égal à 65/35 et deux groupes expérimentaux respectivement avec un rapport foin/concentré égal à 57/43 (Cm) ou 44/56 (Ch). Les groupes étaient constitués de dix sujets dans le Ier essai (quatre Frisonnes + six Brunes) et de huit sujets (quatre Frisonnes + quatre Brunes) dans les 2e et 3e essais. L'augmentation du niveau alimentaire a déterminé une augmentation de la teneur protéique (Ier essai +0,13 % ; 2e essai + 0,17 %) et caséinique (Ier essai +0,09 % ; 2e essai + 0,15 %) du lait ainsi qu'un effet positif sur les paramètres technologiques, en particulier sur la consistance de la coagulation, exprimée soit par la fréquence des échantillons avec la variante k_{20} mesurable dans les 30 min prévues par l'analyse (Ier essai + 11,7 % ; 2e essai +29,6 %), soit sur la valeur du paramètre a_{30} (Ier essai + 3,7 mm ; 2e essai + 9,3 mm). Le rapport foin/concentré n'a pas produit des modifications significatives ni sur la production de lait et sa composition ni sur les paramètres lactodynamographiques. Par rapport à la race, en élaborant les données de toutes les épreuves, la Brune a démontré qu'elle produisait un type de lait plus riche en matière azoté, calcium et phosphore, avec des répercussions positives sur les paramètres technologiques et, en particulier, sur la consistance de la coagulation.*

vache laitière / composition du lait / propriété de coagulation / niveau alimentaire / rapport fourrage–concentré / race

INTRODUCTION

The high levels of productivity attainable from specialised breeds of dairy cows, made possible by the genetic improvement and the adoption of modern husbandry techniques, are often accompanied by a lowering of the milk's nutritional and cheesemaking qualities, the former linked primarily to the fat and protein levels and the latter also defined by a series of rheological parameters.

The problem is most important in those districts where the milk is almost entirely destined for the production of mature cheese; in particular, the cheese factories complain about yield problems related to low acidity, slow and difficult coagulation properties and maturing problems.

Of the factors which influence the production of milk and its characteristics, two of the most important are the genetic makeup, at an individual and breed level, and feeding. For this latter aspect, an increase in the energy level of the ration normally leads to a rise in the production of milk, although on a limited return basis (Wiktorsson, 1979; Gordon, 1980; Broster and Thomas, 1981; Remond, 1985; Leaver, 1988), accompanied by a positive effect on protein content and a negative effect on the fat content (Emery, 1978; Rook, 1979; Thomas and Chamberlain, 1984; Hoden et al, 1985; Sutton, 1989; Sutton and Morant, 1989; Coulon and Remond, 1991). As a high plane of nutrition is normally obtained from a high proportion of concentrates at the expense of the forage components, its effect is often confused with the change in forage:concentrate ratio. Information about the possible relationships between feeding aspects and the technological characteristics of milk destined for cheesemaking is fairly scarce (Vertes and Hoden, 1989; Vertes et al, 1989; Garel and Coulon, 1990; Laurent et al, 1992; Colin et al, 1993). However, in general, it is difficult to compare the data from the different experiments due to the considerable variability of the experimental conditions.

Following two previous investigations of the effect of feeding level on various aspects of the production and composition of milk from Brown and Friesian cows (Malossini et al, 1990, 1992), the current research examined the effects of the forage:concentrate ratio. The effects of all the diets used in the entire series of trials on the casein and mineral content and the milk's cheesemaking qualities were also considered. For completeness, and to allow more valid comparisons, the milk production and composition data taken from the previous experiments were selected and reanalysed on the basis of identical stages of lactation to the current trial.

MATERIALS AND METHODS

Animals and diets

A total of three trials in the winter–spring period of three consecutive years were conducted with Brown cows (European strain, crossed for one or two generations with American Brown Swiss) and Friesian cows at the S Michele all'Adige Agricultural Institute's farm (Province of Trento). The first two trials investigated the effect of energy level and the third trial, the effect of the forage:concentrate ratio (F:C).

During the first six weeks after calving, all the cows received a ration composed of 15 kg of permanent meadow hay with concentrates offered on the basis of INRA allowances (Hoden et al, 1988); in the first two years, all groups received 0.85 kg/day of protein supplement in addition to the compound feed. On the basis of recordings performed during the preliminary 6-week period and eliminating two Friesian and three Brown cows with a somatic cell count exceeding 500 000/ml (Politis and Ng-Kwai-Hang, 1988), the cows were allotted to experimental groups: ten animals in the first trial (four Friesian + six Brown) and eight animals (four Friesian + four Brown) in the second and third trials.

In each trial, one group continued to receive the same ration as during the preliminary phase and formed the control, while the other groups passed to the experimental diets. The diets used in the three trials were as follows:

Trial 1:

– Control, normal feeding level (Ln).

– High feeding level (Lh), 7% of feed units for milk (UFL) above the allowances, obtained by substituting part of the hay with crushed maize grain.

Trial 2:

– Control, normal feeding level (Ln).

– Very high feeding level (Lhh), 14% of UFL above the allowances, obtained as in trial 1.

Trial 3:

– Control, low proportion of concentrates (Cl), 15 kg of hay and concentrates to cover allowances (as for the control groups in trials 1 and 2).

– Medium proportion of concentrates (Cm), 12.5 kg of hay and concentrates to cover requirements.

– High proportion of concentrates (Ch), 10.0 kg of hay and concentrates to cover requirements.

The high feeding levels (groups Lh and Lhh) will also be referred to by the term *overfeeding*.

In all cases, the hay, the crushed maize and the protein supplement were offered twice a day while the concentrate mix was fed in four fractions through an automatic out-of-parlour feeder.

In order to render the three trials completely comparable, the data from exactly the same stage of lactation were considered (from the 9th to the 20th week after calving).

Experimental records

At 2 week intervals the production of milk and its concentrations of fat, protein and lactose were recorded by an infrared Milk-o-scan mod 203 apparatus. On the morning milk samples, the following were determined:

– Rheological parameters – rennet clotting time (r), time for aggregation (k_{20}), that is, the time from the start of gelation until a firmness of 20 mm was attained, and gel firmness (a_{30}) 30 minutes after adding rennet – by a Foss Electric Formagraph according to the method reported by McMahon and Brown (1982) and using a rennet-type Clerici AB liquid at a concentration of 1 ml/100 ml buffer (coagulation temperature: 36 °C);

– Titratable acidity, expressed as °SH/50 ml;

– Somatic cell count (SSC), using a Foss Electric Foss-o-matic apparatus.

The determination of the casein content, following the AOAC (1990) method, and the mineral concentrations – Ca and Mg by atomic absorption spectroscopy and P by spectrophotometry – were performed at intervals of 4 weeks.

The estimated nutritive value of the feeds, expressed in UFL, was calculated from an equation based on the chemical composition (Demarquilly et al, 1978) for the concentrates and an equation obtained previously for hays from the same zone (Malossini et al, 1973) for the hay.

The principal data concerning the animals at the beginning of the experiments are reported in table I; table II presents the characteristics of the feeds used.

Statistical analysis

The milk production, also expressed as 4% fat-corrected milk (FCM), and composition data for each of the three trials were analysed with a bifactorial model (Breed and Diet) with interaction. The mean values of the preliminary period were introduced as covariate factors.

Not all the samples analysed yielded formagraphs with a final gel consistency greater than or equal to the 20 mm in the 30 minutes allowed by the test; furthermore, some samples did not form a detectable coagulum within this time, and so no clotting time could be recorded. The percentage distributions of the samples capable of supplying, within the time allowed by the method, the formagraphic trace parameters were tested with χ^2 according to a two-factor model (Breed and Diet) using the CATMOD procedure in the SAS (1991) statistical package.

Table I. Initial traits of the cows (mean and, in parentheses, standard deviation).

	Trial 1, diets		*Trial 2, diets*		*Trial 3, diets*		
	Ln	*Lh*	*Ln*	*Lhh*	*Cl*	*Cm*	*Ch*
Animals *(n)*	10	10	8	8	8	8	8
Lactation number	2.7	2.4	2.5	2.7	2.9	2.3	2.4
Liveweight (kg)	594	611	618	604	606	590	629
	(56)	(65)	(66)	(52)	(50)	(50)	(57)
Milk yield (kg/day)	26.4	25.7	28.8	29.2	27.5	25.7	26.7
	(3.9)	(5.8)	(5.0)	(5.4)	(4.3)	(5.1)	(6.1)
FCM yield (kg/day)	24.5	24.3	26.0	26.0	25.8	24.3	25.5
	(3.5)	(4.7)	(4.4)	(5.3)	(4.1)	(4.2)	(5.2)
Milk composition							
Fat (%)	3.54	3.68	3.39	3.25	3.58	3.69	3.75
	(0.24)	(0.46)	(0.50)	(0.21)	(0.29)	(0.36)	(0.39)
Protein (%)	2.90	2.88	2.83	2.78	2.90	2.95	3.04
	(0.17)	(0.20)	(0.19)	(0.22)	(0.21)	(0.33)	(0.19)
Casein (%)	2.18	2.14	2.23	2.19	2.21	2.28	2.32
	(0.22)	(0.22)	(0.19)	(0.23)	(0.15)	(0.26)	(0.21)
Casein/protein (%)	76.8	76.5	76.7	76.4	76.5	76.7	76.6
	(3.8)	(4.6)	(3.6)	(3.9)	(4.9)	(3.5)	(3.5)
Lactose (%)	5.02	5.02	5.02	4.99	5.02	5.02	5.04
	(0.19)	(0.16)	(0.18)	(0.18)	(0.19)	(0.15)	(0.19)
Ca (g/L)	1.10	1.11	1.12	1.12	1.14	1.11	1.15
	(0.05)	(0.07)	(0.06)	(0.08)	(0.08)	(0.10)	(0.11)
Mg (g/L)	0.097	0.096	0.098	0.096	0.095	0.101	0.099
	(0.008)	(0.009)	(0.008)	(0.008)	(0.006)	(0.011)	(0.008)
P (g/L)	0.88	0.90	0.89	0.91	0.88	0.90	0.98
	(0.08)	(0.08)	(0.08)	(0.09)	(0.09)	(0.11)	(0.10)

FCM: 4% fat-corrected milk.

Table II. Chemical composition and nutritive value of feedstuffs (dry matter basis).

	Hay			*Concentrate mix* [1]	*Supplement* [2]
	Trial 1	*Trial 2*	*Trial 3*		
Crude protein (%)	10.1	9.9	9.9	18.3	43.1
Crude fibre (%)	33.5	32.8	33.1	7.1	11.4
Ether extract (%)	2.4	2.2	1.9	4.8	1.6
Ash (%)	8.0	8.3	6.7	9.7	16.6
NDF (%)	62.3	64.2	60.4	23.6	10.2
ADF (%)	41.4	40.6	42.2	8.4	5.9
ADL (%)	5.7	5.9	5.6	1.8	0.6
Net energy (UFL/kg)	0.65	0.63	0.61	1.06	1.09

[1] Composition: grains (maize, barley) 44%, maize gluten feed 11%, whole soybean 11%, wheat middlings 11%, maize germ meal 10%, molasses 4%, oil meals (soybean, linseed) 5%, vitamins and minerals 4%. [2] Composition: soybean oil meal (50% crude protein) 80%, lucerne meal 20%. NDF: neutral detergent fibre; ADF: acid detergent fibre; ADL: acid detergent lignin; UFL: feed unit for milk.

The values of the r and a_{30}, relating to the samples which did coagulate within 30 minutes, were analysed with the complete bi-factorial model.

The differences between the breeds, distributed in equal numbers between the treatments, were tested with a monofactorial model using the data obtained in the three trials.

RESULTS AND DISCUSSION

Effect of the diet

Feeding level (trials 1 and 2)

Intakes, milk production and composition

Notwithstanding the different levels of overfeeding planned in the two trials, the increased intake of energy by the experimental groups in comparison with their respective controls (table III) was similar in both trials (+2.7 UFL in trial 1 and +2.9 UFL in trial 2). This was because the rations were calculated for each individual milk yield (including the planned increase in dietary allowance for each cow) and because the productive response was higher with the lower degree of overfeeding (trial 1).

In effect, the overfeeding determined an increase of production (table IV), compared to the control, slightly higher in trial 1 than in trial 2 (+13.2% vs +10.4%, respectively) in terms of milk, but markedly higher in terms of FCM (+15.3% vs +7.2%, respectively).

In trial 2 there was a significant interaction between breed and diet for milk production, with a much more marked response to the overfeeding by the Brown cows (+19.3%) than the Friesians (+1.9%); the difference was even more accentuated for the FCM (Brown = 17.6%, Friesian = –2.0%). However, given that this interaction was observed in only one of the trials, in the absence of further evidence it does not appear to be advisable to draw any general conclusions in terms of the behaviour of these two breeds.

The fat content, in contrast with reports of other research (Huber and Boman, 1966; Krohn and Andersen, 1980; MacLeod et al, 1983; Briceno et al, 1987), diminished only

Table III. Feed intake.

	Trial 1, diets		Trial 2, diets		Trial 3, diets			Breed	
	Ln	*Lh*	*Ln*	*Lhh*	*Cl*	*Cm*	*Ch*	*Brown*	*Friesian*
Hay (kg DM/day)	12.0	10.1	12.3	8.6	12.3	10.2	8.1	10.6	10.5
Concentrate [1] (kg DM/day)	6.9	10.3	7.5	11.6	6.9	8.0	10.3	8.6	9.1
Concentrate (%DM)	36	50	37	56	36	44	56	44	46
DM (kg/day)	18.9	20.4	19.7	20.2	18.4	18.2	19.2	19.2	19.6
Crude protein (%)	13.9	14.0	14.3	14.5	12.8	13.4	14.4	13.9	13.9
NDF (%)	48.9	42.0	47.4	37.3	47.0	44.3	39.8	44.1	43.5
Net energy [2] (UFL/day)	14.9	17.6	15.7	18.6	15.0	15.0	16.2	16.0	16.5

[1] Concentrate mix, maize grain and protein supplement. [2] Values obtained without considering associative effects computed into the rationing. DM: dry matter; NDF: neutral detergent fibre; UFL: feed unit for milk.

Table IV. Milk yield and composition: effect of the diet.

	Feeding level						Forage:concentrate ratio			
	Trial 1, diets			Trial 2, diets			Trial 3, diets			
	Ln	*Lh*	*RSD*	*Ln*	*Lhh*	*RSD*	*Cl*	*Cm*	*Ch*	*RSD*
Milk yield (kg/day)	22.8^{b}	25.8^{a}	1.64	26.0^{b1}	28.7^{a1}	1.99	23.6	23.7	24.7	1.58
FCM yield (kg/day)	21.6^{b}	24.9^{a}	1.57	23.6^{b2}	25.3^{a2}	1.59	22.3	21.8	22.8	1.74
Milk composition										
Fat (%)	3.67	3.83	0.32	3.44	3.21	0.21	3.69	3.51	3.52	0.09
Protein (%)	2.95^{b}	3.08^{a}	0.08	2.94^{b}	3.11^{a}	0.08	2.95	2.98	2.97	0.10
Casein (%)	2.32	2.41	0.20	2.25^{b}	2.40^{a}	0.18	2.28	2.30	2.31	0.19
Casein/protein (%)	78.6	78.2	3.03	76.5	77.2	2.97	77.3	77.2	77.8	4.41
Lactose (%)	4.94^{b}	5.02^{a}	0.06	4.95^{b}	5.02^{a}	0.05	4.94	4.99	5.01	0.09
Ca (g/L)	1.11	1.16	0.08	1.06	1.16	0.08	1.14	1.14	1.16	0.09
Mg (g/L)	0.100	0.101	0.008	0.103	0.104	0.011	0.94	0.98	0.99	0.009
P (g/L)	0.87	0.94	0.07	0.92	0.95	0.09	0.88	0.89	0.95	0.09
Daily yield:										
Fat (g/day)	834^{b}	974^{a}	80	880^{b}	919^{a}	66	858	819	861	77
Protein (g/day)	670^{b}	785^{a}	47	754^{b}	886^{a}	63	689	698	726	44
Lactose (g/day)	$1\,123^{b}$	$1\,292^{a}$	82	$1\,277^{b}$	$1\,439^{a}$	74	1 166	1 177	1 136	78

[1] Significant interaction Breed x Diet. Ln: Brown 25.4, Friesian 26.6; Lhh: Brown 30.3, Friesian 27.1. [2] Significant interaction Breed x Diet. Ln: Brown 22.7, Friesian 24.4; Lhh: Brown 26.7, Friesian 23.9. On the row, within trial: ^{a,b} $P < 0.05$. RSD: residual standard deviation; FCM: 4% fat-corrected milk.

slightly, and nonsignificantly, in group Lhh. It can thus be assumed that, notwithstanding the high proportion of concentrates, the rumen microbial population did not undergo any significant modifications, probably due to the quantity of hay, which ensured an adequate supply of structural carbohydrates, the division of the concentrates through the day and the use of maize grain, which is known to be relatively slowly degraded.

The milk protein content was rather low in all the experimental groups, and this was probably a direct consequence of the stage of lactation considered (Schmidt and Van Vleck, 1974). However, the overfeeding led to a significant increase in the protein levels, with respect to the controls, of 0.13% with diet Lh and 0.17% with diet Lhh. This positive response is in agreement with similar research which reported increases of between 0.06 and 0.24% (Huber and Boman, 1966; MacLeod et al, 1983; Bertrand et al, 1987; Depeters et al, 1988; Fraser and Leaver, 1988; Spörndly, 1989; Colin et al, 1993; Macheboeuf et al, 1993).

The mean percentage of casein in the protein ranged between 76.5 and 78.6% in the four groups and was not influenced by feeding level, in agreement with reports from other authors (Vertes et al, 1989; Martin and Coulon, 1991; Laurent et al, 1992; Colin et al, 1993). The percentage of casein in the milk, as for the protein, tended to increase with feeding level, with differences of +0.09% with respect to the control in trial 1 and +0.15% in trial 2. The casein content was always rather low if compared with the threshold level of 2.4% considered critical for good cheesemaking (Pecorari and Mariani, 1990).

Lactose, which is one of the milk components least subject to variation, also underwent a small but significant increase (0.08% with diet Lh and 0.07% with diet Lhh) following the increase in feeding level.

The average concentrations of calcium and phosphorus increased with feeding level, although the differences were not significant due to the high variability of the analytical data. The tendency can, however, be justified by the fact that about two-thirds of the calcium and one-half of the phosphorus in milk are linked to the micellar complex (Alais, 1984), so it would be expected that their contents vary in proportion to changes in the protein and casein. The feeding levels had no effect on milk magnesium.

In both trials, the overfeeding affected positively and significantly the daily fat, protein and lactose production, due to the combined effect of the higher individual values of both the milk production and its constituent concentrations.

Rennet coagulation properties, acidity and somatic cells

The clotting time was measured, following normal laboratory practise, within 30 minutes of adding the rennet; therefore, some data is missing for samples with slower or no coagulation times. The frequency of samples capable of coagulating within 30 minutes was always higher than 90% and was never influenced by the feeding level (table V). Similar percentages have been recorded by Mariani et al (1982): 90.2% in samples taken between the 4th and 7th month of lactation, and by Zannoni et al (1981), who reported values of 93%.

The overfeeding led to higher frequencies of samples with k_{20} values measurable within 30 minutes, respectively, 11.7% (ns) and 29.6% ($P < 0.05$) more than the controls for diets Lh and Lhh.

The average coagulation times obtained for the four groups in the two trials were around 17 minutes, only slightly higher than those reported by Mariani et al (1982) for milks with good coagulation times.

The firmness of the gels was always rather weak, but there was a tendency to improve, in both trials, with the high feeding level diets. This effect would have been

Table V. Rennet coagulation properties, acidity and somatic cells: effect of the diet.

	Feeding level						Forage:concentrate ratio			
	Trial 1, diets			Trial 2, diets			Trial 3, diets			
	Ln	*Lh*	*RSD*	*Ln*	*Lhh*	*RSD*	*Cl*	*Cm*	*Ch*	*RSD*
r within 30 minutes [1] (%)	96.6	90.0		90.5	97.7		97.2	93.4	96.3	
k_{20} within 30 minutes [2] (%)	71.6	83.3		56.4^b	86.0^a		69.5	53.2	60.6	
r (min and s)	17'48"	17'12"	3'13"	17'12"	16'06"	3'32"	16'54"	18'30"	17'20"	2'31"
a_{30} (mm)	22	25	6	17^b	27^a	8	19	18	20	8
Titratable acidity (°SH/50 ml)	3.6	3.6	0.14	3.6	3.7	0.14	3.4	3.5	3.5	0.14
SSC (n x 1 000/ml)	112	51	73	101	119	130	168	112	153	131

[1] Samples with r detected within 30 minutes. [2] Samples with k_{20} detected within 30 minutes. On the row, within trial: $^{a, b}$ $P < 0.05$. RSD: residual standard deviation; r: clotting time; k_{20}: time for aggregation; a_{30}: gel firmness; SSC: somatic cell count.

linked to the casein levels, which are closely related to gel firmness (Mariani et al, 1982; Storry and Ford, 1982; Grandison et al, 1985; Politis and Ng-Kwai-Hang, 1988; Garel and Coulon, 1990; Laurent et al, 1992; Macheboeuf et al, 1993).

The feeding level had no effect on titratable acidity, which showed negligible differences between the groups, or the somatic cells, the number of which was extremely variable within groups.

Forage:concentrate ratio (trial 3)

Intakes, milk production and composition

The feeding plan adopted led to F:C ratios of 64:36, 56:44 and 44:56, respectively, for groups Cl, Cm and Ch, with small differences in terms of total UFL consumed (table III).

As can be seen from table IV, the variation in the F:C ratio did not affect the production or the composition of the milk. In fact, in the numerous experiments which demonstrated effects on milk yield and quality, the increase in the quantity of concentrates and the consequent reduction in the F:C ratio were almost always accompanied by an increase in feeding level (Huber and Boman, 1966; Gordon, 1977; MacLeod et al, 1983; Bertrand et al, 1987; Depeters et al, 1988; Fraser and Leaver, 1988; Spörndly, 1989). However, when the F:C ratio varied at the same feeding level, variations in milk yield and quality were only obtained when the F:C ratio was heavily unbalanced towards the concentrates (Broster et al, 1977, 1985; Sutton et al, 1977; Journet and Chilliard, 1985; Thomas and Martin, 1988; Sutton, 1989).

Rennet coagulation properties, acidity and somatic cells

The F:C ratio also had no significant effect on the rheological parameters, the titratable acidity or the somatic cell count (table V). In general, the values of the various parameters were similar to the ones recorded in the control groups in trials 1 and 2.

Effect of the breed

Intakes, milk production and composition

The intakes observed for the two breeds (table III) essentially reflect their milk production. The productive response and the milk are shown in table VI. Given the small number of animals used in the trials, it is not realistic to comment on the differences in milk yield between the two breeds, so the most interesting aspects relate to the milk quality parameters. In particular, significant differences – always in favour of the Brown cows – were recorded for the levels of protein (0.22%), casein (0.27%), lactose (0.08%), calcium (0.11 g/L) and phosphorus (0.05 g/L). The superiority of the Brown over the Friesian cows in terms of protein and casein content is well recognized, although there are a lack of comparisons under exactly the same husbandry conditions. According to Italian official records (AIA, 1993), the average protein content of the milk was exactly 0.22% higher in the Brown cow in comparison with the Friesian cow.

Rennet coagulation properties, acidity and somatic cells

The milk from the Brown cows differed from the Friesian cows (table VII) for a higher frequency of samples with r and k_{20} values detectable within the standard time of 30 minutes.

The level of titratable acidity in the milk was equal for the two breeds, with a value of 3.6, which is entirely compatible with a good cheesemaking efficiency (Alais, 1984). The number of somatic cells in the milk was significantly lower in the Friesian cows.

CONCLUSION

The investigation, carried out for 3 years in the same environment and considering the

Table VI. Milk yield and composition: effect of the breed.

	Breed		*RSD*
	Brown	*Friesian*	
Milk yield (kg/day)	24.0	25.0	5.27
FCM yield (kg/day)	22.7	23.8	4.30
Milk composition:			
Fat (%)	3.65	3.48	0.40
Protein (%)	3.10[a]	2.88[b]	0.19
Casein (%)	2.45[a]	2.18[b]	0.21
Casein/protein (%)	78.9[a]	75.4[b]	4.69
Lactose (%)	5.02[a]	4.94[b]	0.14
Ca (g/L)	1.16	1.05	0.08
Mg (g/L)	0.100	0.099	0.009
P (g/L)	0.94	0.89	0.16
Daily yield			
Fat (g/day)	876	884	143
Protein (g/day)	741	744	253
Lactose (g/day)	1 203	1 282	205

On the row: [a, b] $P < 0.05$. RSD: residual standard deviation; FCM: 4% fat-corrected milk.

Table VII. Rennet coagulation properties, acidity and somatic cells: effect of the breed.

	Breed		
	Brown	*Friesian*	*RSD*
r within 30 minutes [1] *(%)*	97.7[a]	91.3[b]	
k_{20} within 30 minutes [2] (%)	77.2[a]	58.4[b]	
r (min and s)	16'46"	17'44"	3'22"
a_{30} (mm)	26[a]	17[b]	10
Titratable acidity (°SH/50 ml)	3.6	3.6	0.21
SSC (n x1 000/ml)	163[a]	66[b]	90

[1] Samples with r detected within 30 minutes. [2] Samples with k_{20} detected within 30 minutes. On the row: [a, b] $P < 0.05$. RSD: residual standard deviation; r: clotting time; k_{20}: time for aggregation; a_{30}: gel firmness; SSC: somatic cell count.

same phase of lactation, demonstrated differences in milk production, its composition and its suitability for cheesemaking which were related to dietary and breed factors.

An increase in energy supply above the actual feeding requirements led not only to a higher production of milk but also to higher concentrations of protein, casein, calcium and phosphorus; the frequency of samples having a measurable k_{20} value was also improved.

The absence of negative effects on fat content could be justified considering two particular aspects: the first is the not particularly high level of production – the average for the groups in the preliminary phase ranged from 25.7 to 29.2 kg/day – so that even the overfeeding did not lead to exceptionally high energy levels; the second is the basal ration, composed of hay, which, in all the diets, ensured a sufficient supply of structural carbohydrates.

In contrast, the forage:concentrate ratio at a normal feeding level did not affect milk production, its composition or its cheesemaking characteristics. In this context, it should be considered that the three diets did not have extreme forage:concentrate ratios, which would have been unsuitable under practical farming conditions.

The lack of significant Breed x Diet interactions in terms of milk composition and the rheological parameters, demonstrated that the consequences of dietary modifications were independent of breeds.

The Brown, in comparison with the Friesian cows, produced a milk with a higher content of protein, casein, calcium and phosphorus, having a positive effect on the renneting ability, especially the gel firmness.

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