Lait 80 (2000) 361–370

Original article

Effect of the botanical composition of hay and casein genetic variants on the chemical and sensory characteristics of ripened Saint-Nectaire type cheeses

Isabelle VERDIER-METZ[a]*, Jean-Baptiste COULON[b], Philippe PRADEL[c], Christine VIALLON[d], Hélène ALBOUY[e], Jean-Louis BERDAGUÉ[d]

[a] Laboratoire de Recherches Fromagères, INRA, 36 rue de Salers, 15000 Aurillac, France
[b] Unité de Recherche sur les Herbivores, INRA, Theix, 63122 Saint-Genès-Champanelle, France
[c] Domaine de la Borie, INRA, 15330 Marcenat, France
[d] Station de Recherche sur la Viande, INRA, Theix, 63122 Saint-Genès-Champanelle, France
[e] École Nationale de l'Industrie Laitière et de la Viande, 15000 Aurillac, France

(Received 14 October 1998; accepted 14 January 2000)

Abstract — Forty-two multiparous dairy cows of 3 different breeds (Holstein, Montbéliarde and Tarentaise) were divided into 2 groups (A and B) according to β- and κ-casein genetic variants, and were fed 3 floristically different types of hay (cocksfoot, rye-grass-rich and native mountain grassland hay) according to a 3×3 Latin-square design. The milk produced by these cows was used to make Saint-Nectaire-type cheese, using identical and controlled cheesemaking techniques. The cheeses made from cocksfoot diet milk had higher pH ($P < 0.01$), lower fat in dry matter ($P < 0.05$), more elastic texture and a strong cellar odour ($P < 0.1$). The cheeses produced from the milk of cows fed native mountain grassland hay exhibited a slightly gritty and yellower body, and had a pronounced vinegar and cabbage odour. Rheological analysis confirmed the beneficial effect of the B variant of β- and κ-caseins on milk rennet clotting ability. This effect did not seem to affect the cheeses because they could not be distinguished by any of their sensory characteristics.

milk / cheese / genetic variant / diet

Résumé — **Effet de la composition floristique du foin et des variants génétiques des caséines sur les caractéristiques chimiques et sensorielles des fromages affinés.** Quarante-deux vaches laitières de race Holstein, Montbéliarde et Tarentaise répartis en 2 groupes (A et B) sur la base des variants génétiques des caséines β et κ ont reçu, dans un dispositif expérimental en carré latin 3×3,

* Correspondence and reprints
Tel.: (33) 4 71 45 64 14; fax: (33) 4 71 45 64 13; e-mail: iverdier@clermont.inra.f

3 foins différant par leur composition floristique (foin de dactyle, foin de prairie naturelle, foin de prairie naturelle riche en ray-grass). Le lait de ces animaux a été transformé en fromage de type Saint-Nectaire dans des conditions technologiques contrôlées identiques d'une fabrication à l'autre. Les fromages réalisés avec du lait de foin de dactyle se distinguent des autres par un pH plus élevé ($P < 0,01$), un gras/sec plus faible ($P < 0,05$), mais également par une texture plus élastique ($P < 0,1$) et une forte odeur de cave ($P < 0,1$). Les fromages de prairie naturelle ont présenté une pâte plus jaune ($P < 0,05$) de texture légèrement granuleuse, mais surtout une odeur de vinaigre et de chou prononcée. L'analyse des propriétés rhéologiques des laits confirme l'effet bénéfique du variant B des caséines κ et β sur l'aptitude à coaguler du lait. Cet effet ne semble pas se répercuter sur les fromages puisqu'ils ne se distinguent, selon le variant, sur aucun critère sensoriel.

lait / fromage / variant génétique / alimentation

1. INTRODUCTION

The *Appellation d'Origine Contrôlée* (AOC) label precisely defines the conditions under which the milk is produced and processed (cow breed, type of feed, etc.), thus justifying the land-produce relationship. While the effects of production factors on the chemical composition and coagulation of milk have been studied extensively [17, 26, 34], there have been much fewer studies on finished products [16, 28, 29]. Recent studies have revealed the noticeable influence of the type of diet and breed of cow on the organoleptic characteristics of cheese [9, 10, 36, 37]. Yet, few studies have considered the intrinsic effect of the floristic composition of forage, an issue often raised by cheesemakers and the relevance of which to cheese quality has been suggested by some authors [14, 25]. It is also a recognized fact that certain genetic variants of milk caseins have an influence on its clotting capacities [12, 30, 39]: this is true for variant B of β- and, especially, of κ-caseins, resulting in shorter clotting time and firmer curd. To our knowledge, no studies have been conducted on the effect of these variants on the sensory characteristics of cheese, whereas it is known that other genetic variants can perceptibly alter the physico-chemical and sensory characteristics of cheese [13, 28]. The aim of this study was to describe and analyze the chemical composition and clotting properties of milk and the organoleptic characteristics of ripened cheese (Saint-Nectaire type) made from milk produced by cows fed identical nutritional levels of a diet based on 3 different types of hay and belonging to 2 different groups of genetic casein variants.

2. MATERIALS AND METHODS

2.1. Experimental design

Forty-two Holstein, Montbéliarde and Tarentaise multiparous cows calving between November 9 and December 31 were included in the study. To limit the proportion of concentrate in the diet, the animals were selected for their moderate production level. They were divided into 2 equal groups (with balanced milk production and composition) according to the genetic variants of β- and κ-caseins: all group A animals had AA-β- and κ-caseins, whereas in group B the allelic frequency of β- and κ-casein variants was 24 and 74%, respectively. In early lactation, all cows were fed a diet of grass silage (ad libitum) and hay (4 $kg \cdot d^{-1}$), supplemented according to INRA recommendations [24]. Three weeks before the beginning of the experiment, all animals were fed a diet of hay from native mountain grassland (13 kg dry matter per

day [DM/d]) supplemented with a production concentrate according to INRA recommendations [24]. The trial began on March 11. Six 7-head batches (3 batches per group [A or B]) were formed on the basis of their production performance during the 3 pre-experimental weeks. Three experimental periods of 3 weeks then followed, during which every batch was successively fed 3 types of hay: one was cocksfoot monospecific hay (CO), another was a ryegrass-rich hay (RG) and the third came from native mountain grassland (MG). Sixteen plant species were identified in the RG hay, including predominant *Lolium perenne* (38%), *Holcus lanatus* (19%), *Stellaria media* (13%), *Agropyrum repens* (6%) and *Avena pratensis* (5%). In the MG hay, 27 plant species were identified, the predominant ones being *Agropyrum repens* (18%), *Dactylis glomerata* (14%), *Holcus lanatus* (13%), *Trifolium repens* (15%), *Taraxacum* sp. (17%), *Festuca rubra* (8%), *Agrostis tenuis* (6%), *Poa pratensis* (5%), *Poa trivialis* (6%) and *Carum carvi* (< 5%). To equally cover energy and nitrogen requirements in all the cows, the animals were given a cereal and soybean meal-based concentrate in addition to the hay. Hay represented 83% of the total DM of the diet, on average, in each batch. The amounts of concentrate given were determined for the whole experiment, so as to cover the maintenance and milk production requirements, as monitored over the pre-experimental period. These quantities remained unchanged for any given animal throughout the experimental period; only the respective proportions of production concentrate and soybean meal differed according to the diet. Changes in the different diets were carried out over 3 d. Throughout the entire experimental period, the cows were given a mineral additive (6P-22Ca) at a rate of 200 $g \cdot d^{-1}$.

2.2. Cheesemaking

The milk produced by each of the 6 batches was processed into cheese during the last 2 weeks of each period: at each period, 2 of the 6 batches were twice transformed. Forty-eight cheeses (2 cheeses/vat × (6 + 2) batches/period × 3 periods) were made according to the method described by Verdier-Metz et al. [37], modified as follows: the milks were inoculated with 0.9% of a lyophilized mesophilic starter culture (Flora Danica Direct, Sochal, Saint-Etienne-de-Chomeil, France) reconstituted in sterile skimmed milk (100 $g \cdot L^{-1}$) and with a ripening starter (*Cylindrocarpon*; Groupement d'Intérêt Économique, Laboratoire Interprofessionnel de Production, Aurillac, France). Cheeses were placed in a ripening cellar at 15 °C for 1 week, and at 10–12 °C and 97–98% relative humidity for 7 weeks.

2.3. Physico-chemical analyses and rheological measurements

2.3.1. Milk

pH (at 20 °C), protein and fat contents (infra-red method, Combifoss 5 400, Foss Electric, Hillerod, Denmark), urea content (dimethylamino-4-benzaldehyde [DMAB] method), total and soluble calcium contents (flame emission method [23]), phosphorus content [21], and casein and soluble protein content [31] were measured in a representative sample taken from each vat. Coagulation properties (rennet clotting time, curd firming time necessary to obtain 20-mm firmness, curd firmness after 30 min) were also measured using a Formagraph apparatus according to the method proposed by McMahon and Brown [27]; 200 µL of a rennet solution (13 mg activated chymosin·L^{-1}) were added to 10 mL milk; measurements were performed at the natural pH of the milk and after standardizing the pH at 6.60 by addition of a few drops of a 10% lactic acid solution; all measurements were duplicated. The genetic variants of lactoproteins were identified by isoelectric focussing of a milk sample [33].

2.3.2. Cheese

The pH was measured at 20 °C by an Ingold electrode (Ingold France, Paris, France) inserted into some ground cheese. DM content was determined by desiccation at 103 °C for 24 h [19]. The fat content of the cheeses was measured by the butyrometric method [22]. A chromameter Minolta CR310 (Minolta France S.A., Carrières-sur-Seine, France) was used for colour measurements. Tests were calibrated by applying the 'Minolta white standard CR-A47', and performed in 3 replicates on a middle slice of cheese. Results were expressed using the L × a × b system according to the Lighting International Commission colour system [8], where L (lightness variable) defines the position of the sample on the light-dark axis, a (red index) on the red-green axis, and b (yellow index) on the blue-yellow axis.

2.4. Microbiological and somatic cell counts

Milk total bacterial count [2], somatic cell count (Somacount, Bentley, Chaska, MN 55318, USA), butyric spore count [7] and coliform count [20] were determined for each vat of cheese milk.

2.5. Cheese sensory characteristics

The sensory characteristics of the cheeses were evaluated according to 3 different procedures, i.e. (i) total appreciation; (ii) detailed analysis of appearance, texture and flavour; and (iii) aroma analysis.

2.5.1. Total appreciation

All of the 48 ripened cheeses were submitted to 8 assessors from the INRA laboratory at Aurillac, who rated each cheese for appearance (score out of 5), body and texture (score out of 5) and taste (score out of 10) according to the criteria described by the Commission de Contrôle du Syndicat du Saint-Nectaire.

2.5.2. Detailed analysis of appearance, texture and flavour

Additionally, the characteristics of 24 cheeses (1 per vat) were assessed by a panel of 10 assessors trained to recognize primary tastes [1] for the assessment of characteristics of various Saint-Nectaire cheeses. Four cheese samples per session were given simultaneously to the panelists, who scored the intensity of 18 attributes (deformation, mould, sticky sight, curd colour intensity, number of openings, regularity of openings, elasticity, odour intensity, pleasantness of smell, stickiness, meltiness, firmness, grittiness, tastiness, taste persistence, saltiness, acidity, bitterness) on a structured scale from 0 to 10.

2.5.3. Aroma analysis

Eleven assessors familiar with the products participated in 2 sessions to evaluate the intensity of 13 odour attributes in 12 cheeses (4 CO, 4 MG and 4 RG) on a continuous scale from 0 to 20. Some sensory attributes were spontaneously generated by assessors (cream-milk, Gruyère-Comté, fruity, hazelnut, musty, cellar, Saint-Nectaire), and some were defined from reference molecules (butter: diacetyl; vinegar: acetic acid; blue: 2-heptanone; feet: isovaleric acid; cheese-vomit: butyric acid; cabbage: dimethyldisulfide). The assessors successively sniffed at random 30 g of each cheese which had been placed in a glass cartridge swept by air at a flow rate of 10 $mL \cdot min^{-1}$.

2.6. Statistical analysis

The data were processed by analysis of variance [32] by including the diet, the genetic variant, the batch (nested within variant), the assessor (for sensory analysis and olfaction) and the period, as well as the diet-variant interaction, in the model.

3. RESULTS

3.1. Effect of diet

The cheese milks had similar chemical, microbiological and rheological characteristics (Tab. I). The MG and RG milks, however, were richer in solid contents and poorer in urea than the CO milks. The milk pH was similar for the 3 diets. At natural pH, the rennet clotting time of RG milk was shorter than the others ($P < 0.05$). At a standardized pH (6.60), the rheological properties of the milks did not differ significantly (Tab. I).

The cheese yield was similar in the 3 treatments (Tab. II). Concerning the physico-chemical characteristics, the CO cheeses had a higher pH ($P < 0.01$) and a slightly lower fat in DM ($P < 0.05$) than the MG and RG cheeses: their overall scores for appearance, body, texture and taste were slightly but significantly lower than for the other cheeses. The red and yellow indices of MG cheeses were significantly higher ($P < 0.05$) than those of other cheeses: this difference was linked to the higher carotenoid content of MG hay (20.4 against 17.5, and 16.5 $mg \cdot kg^{-1}$ DM for CO and RG hays), which was reflected by a higher carotenoid content in milk (0.11, 0.09 and 0.08 $mg \cdot L^{-1}$ in MG, RG and CO milk, respectively; $P < 0.05$).

Concerning the sensory characteristics, only 4 attributes differed between cheeses. CO cheeses, however, were characterized by more regular openings ($P < 0.01$), a more elastic texture ($P < 0.1$), a bitter taste (non significant), a more pronounced cellar odour ($P < 0.1$) and a milder cream odour (non significant). MG cheeses had a more gritty texture (non significant) and a stronger vinegar and cabbage odour.

3.2. Effect of genetic variants

The physico-chemical and microbiological characteristics of the milks, as well as the somatic cell count, were similar for the 2 genetic variants considered. In contrast, the rheological characteristics of the renneted milk gels were significantly different (Tab. I): at both the natural pH and at the standardized pH, the rennet clotting and curd firming times were shorter for the B variant milks ($P < 0.05$ and $P < 0.01$ respectively), while the gel firmness (measured after firming time equal to the clotting time) was greater ($P < 0.05$). The A and B cheeses had the same physico-chemical characteristics and obtained similar scores for appearance, body, texture and taste during sampling. Any sensory attribute was significantly different between the A and B cheeses.

4. DISCUSSION

4.1. Effect of diet

In this trial, the effects of diet were low and not significant except for the colour of the curd cheese, which was yellower in the MG cheeses than in the others because of the higher carotene content of MG hay. Indeed, the yellow tone in dairy products is due to the presence in the fat phase of certain carotenes, the concentration of which in fat is proportional to the plasma carotene concentration [35], which itself is strongly linked to the feed [16, 35, 36]. Other experiments [10, 37, 38] or observations [4, 29] have, however, displayed significant effects of the diet. Buchin et al. [6] studied the chemical, rheological and sensory characteristics of pressed cooked cheeses made with milk from animals grazing highland pasture, and observed differences in texture (plasmin effect) and flavour (volatile compound composition) according to the botanical composition of the pasture areas. The botanical composition of forages used in our study was not diversified enough to elicit differences like those observed in Abondance cheese. In the same way, Bosset et al. [4] and Dumont et al [15] showed

Table I. Effect of variant and diet on chemical composition and coagulation properties of standardized milk used for cheesemaking.

Tableau I. Effet du variant et du régime alimentaire sur la composition chimique et les propriétés rhéologiques du lait standardisé utilisé pour la transformation fromagère.

	Variant[1]		Diet[2]			RSD[3]	Significance		
	A	B	MG	CO	RG		V	D	V × D
N	12	12	8	8	8				
Milk composition									
Fat[4] (g·kg^{-1})	33.7	34.1	34.4	33.3	33.9	0.6	ns	*	ns
Protein[4] (g·kg^{-1})	32.0	32.1	32.6	31.3	32.3	0.5	ns	**	ns
Casein/protein (%)	81.3	81.5	81.2	81.6	81.4	1.0	ns	ns	ns
Calcium (g·kg^{-1})	1.35	1.37	1.39	1.35	1.33	0.06	ns	ns	ns
Phosphorus (g·kg^{-1})	0.93	0.93	0.94	0.91	0.94	0.06	ns	ns	ns
Urea (g·kg^{-1})	0.34	0.36	0.30	0.42	0.32	0.03	ns	**	ns
Somatic cell count (log·mL^{-1})	4.95	5.04	4.89	5.05	5.05	0.44	ns	ns	ns
Clostridium (spores·mL^{-1})	182	208	192	184	208	59	ns	ns	ns
Coliforms (log·mL^{-1})	2.46	1.80	2.60	2.01	1.80	0.66	ns	ns	ns
Processing characteristics									
pH[5]	6.67	6.69	6.68	6.68	6.68	0.02	ns	ns	ns
At milk natural pH									
Rennet clotting time (min)	12.4	9.6	11.2	11.1	10.6	0.4	*	*	*
Curd firming time (min)	6.7	3.8	5.3	5.5	4.9	0.5	**	ns	ns
Curd firmness[6] (mm)	28.7	34.5	31.9	31.0	31.9	3.3	*	ns	ns
At milk pH adjusted to 6.60									
Rennet clotting time (min)	13.8	10.2	12.3	12.0	11.7	0.2	*	ns	ns
Curd firming time (min)	7.7	4.2	5.4	6.6	5.9	1.4	**	ns	ns
Curd firmness[6] (mm)	26.9	34.2	31.0	29.5	31.3	3.0	**	ns	ns

[1] A: variant A of β-casein and κ-casein; B: variant B of β-casein and κ-casein.
[2] MG: native mountain grassland hay; CO: cooksfoot hay; RG: ray-grass-rich hay.
[3] Residual standard deviation.
[4] After partial skimming.
[5] Of the mean sample on which rheological characteristics were measured, after partial skimming.
[6] At (2 × rennet clotting time).
Significance of difference: * $P < 0.05$; ** $P < 0.01$; ns: no significant.

[1] A : variant A des caséines β et κ ; B : variant B des caséines β et κ.
[2] MG : foin de prairie naturelle de moyenne montagne ; CO : foin de dactyle ; RG : foin de prairie naturelle enrichie en ray-grass.
[3] Écart-type résiduel.
[4] Après écrémage partiel.
[5] De l'échantillon moyen sur lequel ont été mesurées les caractéristiques rhéologiques, après écrémage partiel.
[6] À (2 × temps de coagulation).
Niveau de signification : * $P < 0,05$; ** $P < 0,01$; ns : non significatif.

aromatic differences between lowland and mountain cheeses. These different studies and observations [4, 6, 15] were made with pressed cooked cheeses. But a similar study made on Morbier cheese [5] revealed only few differences between lowland and mountain produce. The uncooked pressed cheeses, like the Saint-Nectaire-type cheese used in our study, do not appear to be the best models to enhance the significant effects of diet.

Table II. Effect of variant and diet on cheese characteristics.
Tableau II. Effet du variant et du régime alimentaire sur les caractéristiques du fromage.

	Variant[1]		Diet[2]			RSD[3]	Significance		
	A	B	MG	CO	RG		V	D	V × D
Fresh cheese yield[4] (%)	7.7	7.5	7.5	7.6	7.6	0.2	*	ns	ns
Dry matter recovery[5] (%)	51.9	52.1	52.3	51.5	52.1	1.0	ns	ns	ns
Dry matter (%)	53.7	52.6	54.0	53.4	53.5	1.1	ns	ns	ns
Fat in dry matter (%)	51.0	51.4	51.0	50.8	51.7	1.0	ns	*	ns
Solids not fat (%)	36.5	35.9	36.7	36.1	35.8	1.4	ns	ns	ns
pH	5.43	5.39	5.39	5.44	5.39	0.04	ns	**	ns
Colour measurements[6]									
L	85.8	86.3	86.0	85.8	86.4	0.7	ns	ns	ns
Red-green index	–1.6	–1.9	–1.6	–1.8	–1.8	0.1	*	**	ns
Blue-yellow index	24.6	25.7	25.6	24.9	24.9	0.8	ns	*	ns
Appearance (/5)	3.3	2.9	3.3	3.1	3.0	0.5	ns	**	**
Texture (/5)	3.6	3.6	3.6	3.5	3.7	0.4	ns	**	ns
Taste (/10)	7.0	7.1	7.1	6.9	7.1	0.5	ns	*	ns
Sensory profile									
Opening number	4.4	4.4	4.2	4.6	4.5	1.5	ns	ns	ns
Opening regularity	4.4	4.9	3.8	5.2	4.8	1.5	ns	**	ns
Elastic texture	4.3	4.5	4.5	4.6	4.1	1.1	ns	+	ns
Sticky texture	3.1	3.5	3.2	3.3	3.4	1.0	ns	ns	ns
Melting texture	3.7	3.9	3.7	3.9	3.8	1.1	ns	ns	ns
Firm texture	4.9	4.8	4.9	4.7	5.0	1.0	ns	ns	ns
Gritty texture	1.9	1.5	1.9	1.5	1.6	1.2	ns	ns	ns
Odour intensity	4.8	4.9	4.9	4.8	4.9	1.0	ns	ns	ns
Pleasant odour	5.3	5.3	5.3	5.4	5.2	1.0	ns	ns	*
Taste intensity	4.7	4.9	4.6	5.0	4.8	0.7	ns	ns	ns
Taste persistence	4.7	4.8	4.6	4.9	4.8	0.8	ns	ns	ns
Salty taste	4.8	4.6	4.7	4.8	4.6	0.7	ns	ns	ns
Acid taste	2.0	1.9	2.0	1.9	2.0	1.1	ns	ns	ns
Bitter taste	2.6	2.6	2.4	2.8	2.5	1.3	ns	ns	ns
Odour analysis									
Butter	9.5	8.9	9.6	8.7	9.3	4.5	ns	ns	ns
Cream	9.9	9.0	10.9	7.8	9.6	4.4	ns	ns	ns
Vinegar	4.7	4.8	5.8	4.4	4.0	3.2	ns	ns	ns
Gruyère cheese	8.9	8.4	8.7	8.6	8.7	4.0	ns	ns	ns
Saint-Nectaire cheese	8.3	9.0	8.4	8.6	9.0	4.3	ns	ns	*
Blue	4.2	4.8	3.4	4.4	5.6	3.4	ns	ns	ns
Hay	2.9	2.8	2.9	2.2	3.4	2.2	ns	ns	+
Feet	5.2	6.3	6.4	5.8	5.2	3.4	ns	ns	ns
Vomit	6.0	6.0	6.0	6.3	5.7	3.5	ns	ns	ns
Cabbage	3.0	3.8	5.7	2.4	2.1	3.1	ns	*	ns

Table II/Tableau II. (Continued/Suite).

	Variant[1]		Diet[2]			RSD[3]	Significance		
	A	B	MG	CO	RG		V	D	V × D
Fruity	4.9	4.6	3.7	4.7	5.8	2.8	ns	ns	*
Hazelnut	5.3	4.5	4.5	4.6	5.8	2.9	ns	ns	ns
Musty	3.9	4.3	3.8	4.5	4.0	2.8	ns	ns	ns
Cellar	4.5	5.6	4.6	6.2	4.5	3.3	ns	+	ns

[1] A: variant A of β-casein and κ-casein; B: variant B of β-casein and κ-casein.
[2] MG: native mountain grassland hay; CO: cooksfoot hay; RG: ray-grass-rich hay.
[3] Residual standard deviation.
[4] Kg fresh curd/100 kg milk.
[5] 100 × [(curd weight × curd DM)/(milk weight × milk DM)].
[6] Defined in the text.
Significance of difference: +: $P < 0.1$; *: $P < 0.05$; **: $P < 0.01$; ns: no significant.

[1] A : variant A des caséines β et κ; B : variant B des caséines β et κ.
[2] MG : foin de prairie naturelle de moyenne montagne ; CO : foin de dactyle ; RG : foin de prairie naturelle enrichie en ray-grass.
[3] Écart-type résiduel.
[4] Kg caillé frais/100 kg lait.
[5] 100 × [(poids de caillé × teneur en MS du caillé)/(poids de lait × teneur en MS du lait)].
[6] Défini dans le texte.
Niveau de signification : + : $P < 0,1$; * : $P < 0,05$; ** : $P < 0,01$; ns : non significatif.

However, the observations made by Agabriel et al. [3] showed differences between farmhouse Saint-Nectaire cheeses according to the feeding conditions of the cows: an important variability in cheesemaking conditions, less controlled than in our experiment, could be one of the reasons for the observed differences.

On the other hand, Viallon et al. [38] showed that the terpene content of cheese varied according to the composition of the forage, but any significant effects of terpenes and sesquiterpenes on the sensory characteristics of cheese remain to be proven. Moreover, Coulon et al. [10, 37] showed that when forage was given as hay, the cheeses contained lower levels of certain volatile compounds than those made from a grass silage-based diet: it also seems that forage preservation and storage as dry hay may not be the most appropriate method of enhancing the organoleptic differences in the corresponding cheeses.

4.2. Effect of genetic variants

This study confirmed the very beneficial effect of variant B of κ- and β-caseins on the rheological properties of coagulated milk [12, 30]. However, the results of this trial seem to indicate that this beneficial effect on milk coagulation does not have any repercussions on the physico-chemical and sensory characteristics of the corresponding cheeses. This phenomenon had already been noted by Walsh [39], and conflicts with other observations made on other genetic variants [11] or on other species [13, 18], where the beneficial effect of a particular variant, like variant C of β-casein, on account of its sensitivity to plasmin action [28], or variant AA of caprine α_{s1}-casein (the influence of which is linked to differences in fatty acid composition and lipolytic activity compared to other variants) on the cheesemaking ability of milk has an impact on texture (firmer and less elastic

cheese) and on flavour. In this trial, the greater firmness of curd from variant B milk was not reflected by a difference in cheese texture: apparently, processing had corrected the curd firmness. It should be noted that the whole study was conducted with the same processing technology, and no corrective action was taken. Delacroix-Buchet et al. [13] showed that depending on the cheesemaking technique used (comparing a pressed and a soft cheese), the differences in cheese texture related to the casein-α_{s1} variant were not identical: it is therefore possible that the technology applied in our study was not the most appropriate to elicit the possible effects of the genetic variants.

5. CONCLUSION

In this study, conducted under controlled production and cheesemaking conditions, the differences noted between the characteristics of cheeses derived from floristically different hays were not as noticeable as those observed by other authors [4, 15]. Studies are underway to validate the hypothesized explanations for these differences in results. Also, it appears that differences in coagulation properties as obtained through genetic variants of milk caseins are not systematically reflected by differences in the sensory characteristics of the cheeses, which could be linked to alterations in cheese physico-chemical composition; this was not observed in the present study. Moreover, it is possible that in a product (like Morbier or Saint-Nectaire cheese), the role of ripening flora, which was not studied, may have hidden some differences linked to diet and/or genetic variants.

ACKNOWLEDGEMENTS

We thank E. Albaret, M. Javorek and their staff for the samplings and measurements, R. Lavigne for the cheesemaking, M.F. Mahé who characterized the genetic variants of lactoproteins and the 'Pôle Fromager AOC Massif-Central' for supporting the study. This study was supported by a grant from the Fonds National d'Aménagement et de Développement du Territoire. We are grateful to P. Rousseau-Cunningham for assistance with the English translation and rewriting.

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