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Composition, yield, texture and aroma compounds of goat cheeses as related to the A and O variants of α_{s1} casein in milk

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Abstract — Sainte-Maure soft cheeses were prepared from two goat milks with extreme composition regarding α_{s1} casein (CN), one having a high α_{s1} CN level (A variant), the other having no α_{s1} CN in its casein (O variant). A and O cheeses from four successive experiments were analyzed after 2 and 13 days of ripening and compared for their characteristics. A milk had a higher total nitrogen matter level, compared to O milk (30.9 versus 23.3 g kg^{-1}), due to the presence of α_{s1} CN (4.7 versus 0.0 g kg^{-1}) and had also a higher fat level (28.5 versus 25.1 g kg^{-1}). The resulting A and O cheeses had the same gross composition at day 2: total solids (TS) = 37.9% (standard deviation 0.1%) and fat/TS = 45.8%. Cheese yields at day 2 were higher by 26% in A cheeses than in O cheeses (15.15 versus 12.00 kg cheese/100 kg milk). The fatty acid distribution in the total fatty acids of A and O cheeses reflected the specific differences already described between A and O milks. Free fatty acid level at day 13 amounted to 3.5% and 3.9% respectively for A and O cheeses. In the free fatty acid fraction at day 13, the distribution of fatty acids was the same as in the TFA of the respective A and O cheeses, meaning that no specificity occurred in the hydrolytic activity of the main working lipase, the *Penicillium candidum* lipase of the surface flora. The texture of the A and O cheeses was different, A cheeses being firmer as determined by organoleptic tests as well as by two types of rheological measurements (Young modulus determination and characterization by penetrometry). Determinations were made on cheeses at day 2 and day 13 and the results showed that the differences at day 13, while already significant, were lowered by the ripening process. The typical goat aroma was significantly lower in A cheese than in O cheese as shown by the results of the organoleptic tests at day 2 ($P = 0.05$) and at day 13 ($P = 0.01$). This was confirmed by the chemical determination (gas chromatography/mass spectrometry) of the goaty volatile aroma compound levels in the cheeses at day 13: these com-

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pounds, hexanoic, octanoic, nonanoic, decanoic, 4-methyloctanoic and 4-ethyloctanoic, were lower by 50% in A cheese compared to O cheese. © Inra/Elsevier, Paris.

goat milk / cheese / α_{s1} casein variant / aroma / yield / texture

Résumé — Composition, rendement, texture et composés d'arôme du fromage de chèvre en relation avec le variant A ou O de la caséine α_{s1} présent dans le lait. Des laits de chèvre, soit riches en caséine α_{s1} (variant A), soit dépourvus de caséine α_{s1} (variant O) ont été utilisés pour préparer des fromages à pâte molle de type Sainte-Maure. Les propriétés physico-chimiques et organoleptiques des fromages obtenus au cours de 4 fabrications successives ont été déterminées après 2 jours et 13 jours d'affinage. Malgré la différence de composition des laits A et O en matière azotée totale (30,9 et 25,3 g kg^{-1}) et en matière grasse (28,5 et 25,1 g kg^{-1}) les fromages A et O obtenus avaient le même extrait sec (EST) et la même teneur en matière grasse dans l'extrait sec (G/S), aussi bien à 2 jours (EST = 37,9 g p 100 g; G/S = 45,8 %) qu'à 13 jours d'affinage (EST = 46,3 g p 100 g ; G/S = 50,8 %). Les laits A et O présentaient donc la même aptitude à la transformation technologique. Cependant, les pertes en matière grasse au cours de la fabrication étaient plus élevées avec le lait O. En revanche, les rendements fromagers (kg de fromage à 36 % EST pour 100 kg de lait) déterminés après 2 jours d'affinage étaient plus élevés de 26 % pour le fromage A (15,15 kg) que pour le fromage O (12 kg). Les proportions des acides gras totaux dans la matière grasse des fromages A et O présentaient les mêmes différences spécifiques que celles précédemment mises en évidence sur les laits A et O. Après 13 jours d'affinage, la teneur en acides gras libres des fromages A et O était égale à 3,5–3,9 % des acides gras totaux. La fraction acides gras libres présentait la même composition en acides gras individuels que les acides gras totaux de la matière grasse. La principale lipase active dans les fromages (lipase de la flore de surface *Penicillium candidum*) réalisait donc une hydrolyse non spécifique des triglycérides. La caractérisation des fromages sur le plan rhéologique, résistance à l'écrasement (module de Young) et résistance à la pénétration (contrainte St) a montré que les fromages A présentaient une fermeté plus grande que les fromages O, aussi bien à 2 jours qu'à 13 jours d'affinage, la différence ayant tendance à s'estomper à la durée d'affinage la plus longue. Les examens organoleptiques ont également mis en évidence la fermeté plus grande de A par rapport à O. De plus, les fromages A ont été jugés différents des fromages O car ils avaient un arôme de chèvre moins développé. La différence d'arôme entre fromages A et O était significative, aussi bien après 2 jours d'affinage ($p = 0,05$) qu'après 13 jours ($p = 0,01$). L'analyse des constituants de la phase volatile des fromages par chromatographie en phase gazeuse couplée à la spectrométrie de masse a permis de quantifier ces différences. Les teneurs des constituants obtenues dans les fromages A étaient 50 % plus faibles que celles des fromages O, en ce qui concerne les composés aromatiques spécifiques de l'arôme de chèvre, soit : hexanoïque, octanoïque, nonanoïque, décanoïque, 4-méthyloctanoïque, 4-éthyloctanoïque. © Inra/Elsevier, Paris.

lait de chèvre / fromage / variant de la caséine α_{s1} / arôme / rendement / texture

1. INTRODUCTION

In most countries, goat milk is mainly used for cheesemaking, so the selection of animals has been for a long time managed to obtain higher total protein and fat levels in order to increase cheese yields [16, 18]. It is now demonstrated that the main factor driving the milk protein level in goats is related to the α_{s1} casein (CN) alleles: a different secretion level, high, medium, low or null being associated respectively with the A-B-C, D-E, F and O alleles [8]. The early selection, founded on high total protein levels was thereby a selection of the α_{s1}CN variant with a high

secretion level. Now, the selection is carried on directly with animals genetically typed for their alleles at the α_{s1}CN locus [19].

Thus, the selection of goat milk will result in a change in casein composition with an increase in the α_{s1}CN proportion up to a ~ 27% level, compared to the ~ 12% level normally found in traditional goat milks. Such a difference in the composition of casein may have consequences on milk properties which have to be studied.

It seems quite certain from available data that in milks corresponding to a high secretion variant, the high level of α_{s1}CN in the milk goes with some other specific properties of the milks. In particular was reported in A milk, compared to F milk or to O milk, a much lower specific goat flavor, associated with a lower lipase content and lipolysis level, as well as a lower level in free aroma compounds [7, 11, 15]. The other differences observed between milks differing by their α_{s1}CN variant concerned the fat level, fatty acid proportions, pH, casein micelle size and rennet coagulation properties [14, 17].

When cheeses were prepared from the milks either high (A) or low (F) in α_{s1}CN, differences were observed, not only on cheese yields, as expected from the composition of the milks, but also on the texture and the flavor of the cheeses [7, 20].

In the work presented here we aimed to corroborate and complete the observations already made concerning the properties of cheeses differing by their α_{s1}CN level. Soft cheeses were prepared from milks as different as possible concerning the α_{s1}CN level, meaning, A milk with the highest level, and O milk with no α_{s1}CN at all, to enhance the differences to be obtained between cheeses. Analyses of cheeses and calculations concerned yields, rheological properties and chemical composition. The specific goat flavor was also characterized in the cheeses by chemical analysis as well as by organoleptic evaluations.

2. MATERIALS AND METHODS

2.1. Milk and cheeses

A and O milks were collected from three goats each, from the 'Station d'Amélioration Génétique des Animaux' (Inra, Toulouse, France). Goats were homozygous at the α_{s1}CN locus, respectively for the A and O variants. Their casein genotype was determined at the 'Laboratoire de Génétique Biochimique' (Inra, Jouy-en-Josas, France).

A and O milks were collected for one part during the evening milking; these milks were stored overnight in an ice bath and then added to the morning milks of the next day to obtain a ~15 kg batch of milk from each variant.

Cheese making took place in the laboratory pilot plant. Milks were used raw to prepare traditional Sainte-Maure soft cheeses, according to the protocol previously described [12], but the cheeses, after demoulding and salting were sprayed with a suspension of *Penicillium candidum* spores, as surface flora. The total weight of the cheeses corresponding to one batch was determined on the 2nd day after renneting. Ripening was at constant temperature (13 °C) and hygrometry (90%) during 13 days.

2.2. Analyses

The milk composition, total nitrogen matter (TNM), fat, lactose, total solids (TS), were determined by an infra-red analysis (Dairy Lab, Multispec, York, UK). The total casein level in the milks was estimated from the TNM using the coefficient 0.70 for A milks and 0.66 for O milks [14]. Cheeses were analyzed at the 2nd and 13th day of ripening. The chemical determination consisted of: total solids (TS), fat, total nitrogen matter (TNM), pH 4.2 soluble nitrogen matter (NS) and 12% trichloroacetic soluble nitrogen matter (NPN), fatty acids, lipolysis level, volatile aroma compounds, according to the methods previously described [12].

2.3. Texture measurements

The rheological characteristics of cheeses were determined using two different tests. The preparation of samples involved an overnight equilibration of the cheese temperature at 16 °C, and then the cutting of the cheeses (roughly cylindrical shaped) into slices of round section approximately 1.5 ± 0.1 cm in width. The slices were maintained at 20 °C for 1 h before analysis. Cheese firmness was tested using a constant speed cone penetrometer (Stevens LFRA, Adamel Lhomargy, Ivry-sur-Seine, France) equipped with a 60° cone, for 2-day cheeses, or a 30° cone, for 13-day cheeses. Measurements were at 20 °C. The maximum strength after moving 5 mm inside the cheese at 2 mm s^{-1} was determined and calculations were made according to Korolczuk and Mahaut [9] which allowed to obtain a stress value (St) correlated with the tangential stress. Twelve repetitions were done on three cheese slices for each sample of cheese.

On the other hand, the Young modulus was determined during a compression test using an Instron apparatus (Instron SA, Guyancourt, France) equipped with a 16.88 mm diameter disc which was moved at 2 cm min^{-1} over a total 8 mm depth. Young modulus was calculated on the linear response (1 mm displacement), using Cauchy strain. Four repetitions were done for one cheese.

2.4. Organoleptic tests

After 2 and 13 days of ripening, A and O cheeses were compared by a trained panel (15 subjects) through triangular tests according to French Standard AFNOR NF V09-013 [1]. The rind of cheeses was removed and each cheese was cut into 25 g pieces (one piece per subject). For each experiment, one triangular test was performed (four in total). The results were treated using a one-tailed binomial statistic with a probability of 1/3.

2.5. Confidence limit

Results were compared at the level $P = 0.05$ unless otherwise mentioned.

3. RESULTS AND DISCUSSION

Little variation was observed in the composition of each of the A and O milk batches used in the four successive cheesemaking experiments, as shown by the low standard deviation of their component levels (*table I*). However, the mean composition of A milk and O milk was significantly different, mainly concerning TNM and fat. The difference in TNM can be related to the higher total casein level due to the presence of α_{s1}CN within [15] amounting respectively to 4.7 and 0.0 g kg^{-1} in A and O milks. The proportions of the main individual caseins in the total casein ($\kappa/\alpha_{s2}/\alpha_{s1}/\beta$) were respectively 15/11/21/48 in A milk and 20/14/0/60 in O milk.

A higher fat level was obtained in A milk. Such a result has already been obser-

Table I. Gross composition of milks used for cheesemaking. $n = 4$ (standard deviation).
Tableau I. Composition des laits utilisés pour les fabrications fromagères. $n = 4$ (écart type).

Milk	pH	TS	Fat	TNM	CN
			g kg^{-1}		
A	6.55 (0.03)	108.8 (1.3)	28.5 (1.1)	30.9 (0.3)	21.6 (0.3)
O	6.59 (0.03)	101.7 (1.0)	25.1 (1.8)	25.3 (0.3)	16.7 (0.3)

ved as related to the α_{s1}CN genetic variant A [3] while no explanation until now is available for this increase.

The experimental cheese yields obtained at day 2 were higher by 26% for A milk, 15.15 (S.D. = 0.22) kg cheese/100 kg milk) than for O milk, 12.00 (S.D. = 0.81) kg cheese/100 kg milk.

The gross composition of A and O cheeses was not different at day 2 nor at day 13 (*table II*). The same total solid level obtained in cheeses meant the same ability of the two milks for cheese transformation, coagulation, acidification and whey draining during the cheesemaking steps. Identical fat/TS ratios meant that the observed different levels of fat and TNM in milks led to the same final equilibrium between fat and casein level in the cheeses. In fact, the ratio fat/CN in O milk was higher than in A milk (1.50; 1.32). Therefore, higher fat losses might have occurred during O milk transformation. Proteolysis after 13 days of ripening was higher in A cheese. The increase concerned the NPN/TNM ratio as well as the NS/TNM ratio, which allowed to conclude that it resulted from an increased production of low molecular mass peptides. Such a proteolysis of casein here obtained with *Penicillium candidum* as surface flora was typical of mould proteases and was previously demonstrated in an industrial goat cheese inoculated with *Geotrichum* [12].

The composition of the total fatty acids of the A and O cheeses was determined at day 13. The same differences in the individual fatty acid proportions of the cheeses were observed (not shown) as those already reported for the corresponding A and O milks [15]. They concerned meanly the C16, C18 and C18:1 levels. Nevertheless, the overall distribution of fatty acids by structural groups was the same in the two cheeses (*table III*). Concerning the composition of the free fatty acids, their individual distributions were the same as those of the corresponding total fatty acids of the cheeses, showing that the main working lipase had no specificity for any fatty acid nor triglyceride position. It seems likely that it was the surface mould lipase of *Penicillium candidum*. From the obtained results this

Table II. Composition of the cheeses at day 2 and day 13. $n = 4$ (standard deviation).
Tableau II. Composition des fromages à 2 jours et à 13 jours d'affinage. $n = 4$ (écart type).

Cheese	pH	TS g p 100 g cheese	Fat/TS (%)	NS/TNM (%)	NPN/TNM (%)
At day 2					
A	4.30	38.0 (0.7)	45.8 (20)	8.8* (0.7)	4.8* (0.2)
O	4.30	37.8 (0.5)	45.8 (1.0)	9.3* (1.0)	4.8* (0.4)
At day 13					
A	4.43 (0.01)	45.9 (0.9)	50.0 (1.8)	18.0 (1.1)	13.3 (1.4)
O	4.47 (0.03)	46.6 (0.8)	51.7 (1.4)	15.2 (1.2)	10.3 (0.9)

* $n = 2$.

Table III. Relative proportions of the different fatty acid classes in the total fatty acids (TFA) and the free fatty acids (FFA) of A and O cheeses at day 13 (% weight) and the lipolysis level (FFA/TFA%). $n = 4$ (standard deviation).

Tableau III. Proportions relatives des différentes classes d'acides gras dans les acides gras totaux (TFA) et les acides gras libres (FFA) des fromages A et O à 13 jours (% poids) et taux de lipolyse (FFA/TFA%). $n = 4$ (écart type).

	Cheese	
	A	O
TFA% (weight)		
Normal saturated	74.7 (1.0)	75.5 (0.7)
Branched saturated	2.5 (0.1)	2.1 (0.2)
Mono unsaturated	19.4 (0.8)	18.9 (0.6)
Poly unsaturated	3.4 (0.1)	3.5 (0.3)
FFA% (weight)		
Normal saturated	72.0 (2.0)	72.8 (0.7)
Branched saturated	3.0 (0.2)	2.3 (0.2)
Mono unsaturated	20.5 (1.6)	20.3 (0.6)
Poly unsaturated	4.5 (0.5)	4.5 (0.2)
FFA/TFA%	3.5 (1.2)	3.9 (0.6)

lipase showed no specificity, contrarily to the *Geotrichum* lipase which preferentially split the C18:1 [13].

The lipolysis levels determined in the A and O cheeses at day 13 (*table III*) were respectively 3.5 and 3.9%. Delacroix-Buchet et al. [7] already observed a lower lipolysis level in A goat milk compared to F goat milks. One might question if the small difference observed in the levels might originate from the different initial lipolysis level observed in the milks [15].

The textures of the A and O cheeses were compared using the Young modulus (Ym) quantifying a resistance to compression, and the stress value (St) which measured a resistance to penetration (*table IV*). For cheeses at day 2, A cheeses had higher values for the two tests, showing that A cheeses were obviously firmer than O cheeses. At day 13, only the Young modulus was significantly higher for A cheeses, showing that the difference between cheeses was lessened by the ripening process. It is tempting to cast α_{s1}CN for the observed differences in cheese firmness, as it was the main difference in the composition of the A and O cheeses. They had the same TNM levels at day 2 as well as at day 13, however, the α_{s1}CN proportions in the total casein were respectively 21% and 0%.

Organoleptic tests were performed on the cheeses after 2 and 13 days of ripening (*table V*). A and O cheeses appeared different, although the number of repetitions was low. The difference concerned mainly the flavor between 2-day cheeses ($P = 0.05$) as well between 13-day cheeses ($P = 0.01$), the A cheeses having a lower specific goat flavor. The difference between textures was not so high, nevertheless A cheeses were described in both tests as firmer and less unctuous than O cheeses. A higher firmness of A cheese

Table IV. Rheological characteristics of cheeses at day 2 and day 13. Young modulus (Ym) and stress value (St). $n = 4$ (standard deviation).

Table IV. Caractéristiques rhéologiques des fromages à 2 jours et à 13 jours. Module d'Young (Ym) et contrainte (St). $n = 4$ (écart type).

Cheese	*Day 2*		*Day 13*	
	Ym (kPa)	St (kPa)	Ym (kPa)	St (kPa)
A	116 (4)	10.1 (0.5)	185 (16)	18.7 (1.6)
O	93 (7)	9.0 (0.5)	167 (15)	19.7 (0.8)

Table V. Comparative evaluation of A and O cheeses by organoleptic tests.

Tableau V. Tests organoleptiques comparatifs des fromages A et O.

Discrimination Criteria	Cheese		Comments at day 2
	at day 2	*at day 13*	
Total	A # O (0.05)*	A # O (0.10)	A different from O
Aroma	A # O (0.05)*	A # O (0.01)*	A less aromatic O more goaty
Texture	A # O (0.10)	A # O (0.14)	A firmer O unctuous

* Significant difference (signification level).
* Différence significative (seuil de signification).

compared to F cheeses has already been reported [7].

The volatile neutral and acidic fractions of cheese were extracted. They contained the constituents responsible for the aroma of cheeses. All their chemical constituents were identified. In the volatile neutral fraction of cheeses many components were identified, some of which already being characterized as specific cheese aroma compounds: 2 heptanol/one, 2 nonanol/one, 2 undecanol/one [2]. Nevertheless, their level in the A and O cheeses remained lower than their organoleptic threshold value even after a 13-day ripening period.

In the acidic fraction 16 different compounds were found (*table VI*), mainly normal or branched free fatty acids with chain lengths from C3 to C10. From this, nine compounds having a typical 'cheese' aroma were detected by olfactometry and among these last, six showed a specific 'goat cheese' aroma: hexanoic, octanoic, nonanoic, decanoic, 4-methyloctanoic, 4-ethyloctanoic, as typically found in goat cheese [12]. They were present in all the cheeses at levels higher than their specific threshold value [4]. It is noteworthy that the level of all six were significantly lower in A cheese compared to O cheese, in the ratio of approximately one half (*table VI,*

Table VI. Levels of the compounds characterized in the acidic volatile soluble fraction of the A and O cheeses at day 13; mg kg^{-1} cheese (standard deviation). Compounds having a 'goat cheese' aroma are in italics.

Tableau VI. Teneur des composés caractérisés dans la fraction acide volatile soluble des fromages A et O à 13 jours ; mg kg^{-1} fromage (écart type). Les composés ayant un arôme de « fromage de chèvre » sont en italique.

Compound	Cheeses				t
	A		O		
Propanoic	0.076	(0.022)	0.066	(0.008)	NS
2-me propanoic	0.074	(0.009)	0.086	(0.023)	NS
Butanoic	4.93	(0.78)	7.15	(0.69)	NS
3-me butanoic	1.25	(0.20)	1.31	(0.25)	NS
3-3 dime butanoic	1.56	(0.07)	1.54	(0.23)	NS
Pentanoic	0.588	(0.041)	0.965	(0.070)	**
Hexanoic	214	(28)	333	(30)	*
2-me hexanoic	0.134	(0.018)	0.145	(0.021)	NS
4-me hexanoic	0.288	(0.051)	0.434	(0.030)	*
2 Et hexanoic	0.359	(0.173)	0.506	(0.191)	NS
Heptanoic	3.87	(0.97)	7.55	(0.37)	***
Octanoic	113	(20)	209	(16)	**
4-me octanoic	0.718	(0.137)	1.175	(0.056)	*
Nonanoic	1.192	(0.205)	2.89	(0.180)	***
4-et octanoic	0.048	(0.088)	0.109	(0.020)	*
Decanoic	36.9	(6.0)	83.1	(16.1)	*

*, **, ***: significant difference at $P = 0.05, 0.01, 0.001$.
*, **, ***: différence significative à $p = 0{,}05 ; 0{,}01 ; 0{,}001$.

figure 1). This is in agreement with the results of the organoleptic tests.

In *table VII* the amounts of some volatile free fatty acids (C6, C8, C10) extracted from the soluble fraction are compared to their individual total FFA content in the cheese, estimated from the solvent extraction and gas chromatography analysis. The proportion extracted in the volatile fraction, calculated from *table VII*, goes from 100% for C6 or C8, meaning a total extraction of the free volatile acids of the cheese, to 10% for C10. These proportions are very different from those obtained in a preceding work, where they were in the range of 1 to 5% [12]. Such a difference can not be explained at this time.

Comparing now in *table VII*, the A and O cheeses, total contents of C6, C8 and C10 in TFA were found at approximately the same levels. The corresponding FFA values in A cheese were lower by ~ 15% compared to O cheese, which agree well with the whole lipolysis level of cheeses, already discussed. More surprising were the results of the free volatile soluble fraction analysis, the values in A cheeses being lower by 36 to 55% than the values in O cheeses. In fact, the values obtained for C6 and C8 in A cheese were close to those from the fat fraction, while the O cheese values were much higher. The C10 behaved differently because it is not soluble in water due to its higher chain length, thus its level was much lower than in the fat

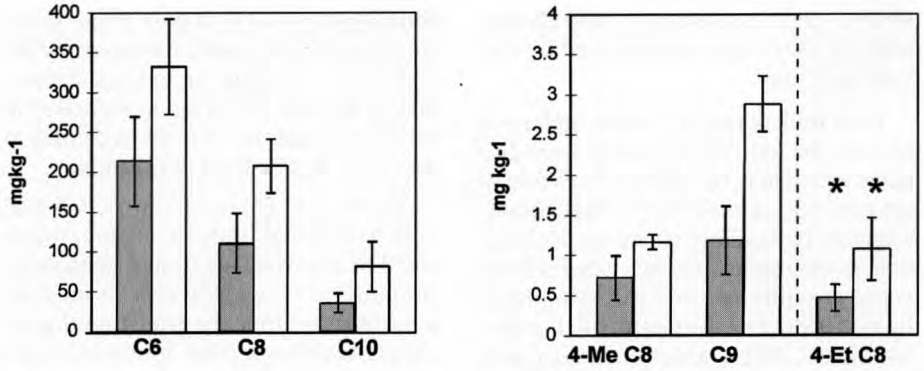

Figure 1. Specific goat aroma compounds in A (■) and O (□) cheeses at day 13 (n = 4). Levels in mg kg^{-1}; (*) Values × 10 on the graph. Bars: standard deviation.

Figure 1. Composés d'arôme spécifiques de la flaveur chèvre dans les fromages A (■) et O (□) à 13 jours (n = 4). Concentrations en mg kg^{-1} ; (*) Valeurs × 10 sur le graphique. Barres : écarts types.

Table VII. Levels in A and O cheeses at day 13 of some free fatty acids participating in the aroma (C6, C8, C10). Comparison of levels in the acidic volatile soluble fraction and in the total free fraction of cheese; g kg^{-1} cheese.

Tableau VII. Teneur des fromages A et O à 13 jours en acides gras libres participant à l'arôme (C6, C8, C10). Comparaison des teneurs obtenues dans la fraction acide volatile soluble et dans la fraction FFA du fromage ; g kg^{-1} fromage.

Fraction	Cheese		$\frac{O-A}{O}$ (%)
	A	O	
Total fat	230.0	241.0	–5
C6	6.2	6.5	–5
C8	7.1	7.2	–1
C10	26.2	26.7	0
Free fatty acids	8.0	9.4	–14
C6	0.217	0.254	–14
C8	0.145	0.188	–23
C10	0.660	0.790	–16
Free in volatile soluble fraction			
C6	0.214	0.333	–36
C8	0.113	0.209	–46
C10	0.037	0.083	–55

fraction. Nevertheless, its level in the soluble fraction of A cheese was also lower, by 55%, than in O cheese, as found for C6 and C8.

The higher levels of aroma compounds in the free volatile soluble fraction of O cheese could mean that much aroma compounds were associated with water

soluble specific constituents in O cheeses and that they were not extracted by solvent partition.

Goat milk contains a rather high level of fat in the form of very small sized globules which may be considered as part of the aqueous skimmilk [5]. Milk lipases might be particularly active on this fraction, as they are mainly in a water soluble state, possibly the bile salt stimulated lipase (BSSL) or, certainly, the lipoprotein lipase (LPL), which is in goat milk for one half or more soluble in the milk serum [6]. The products resulting from this type of lipolysis might be retained in the aqueous phase absorbed on some specific constituents. This water soluble fraction of the aroma compounds would be more easily released in a volatile state and more rapidly perceived during the organoleptic tests, explaining the observed differences between the cheeses. The O milk having a higher lipolytic activity [15], more of these aqueous soluble products of the lipolysis would be found in the resulting O cheese. Observations leading to the same conclusions have been made by Lamberet et al. [11], comparing A and F cheeses made after reciprocal protein-fat exchanges: the higher goat flavor was better related to the F skimmilk, meaning to the F aqueous phase, than to the F fat itself.

4. CONCLUSION

When goat milk high in α_{s1}CN (A milk) was used to make cheeses, the obtained yields were higher by 26% than with milks deprived of α_{s1}CN (O milks).

Presently in France, goat bulk milk received in the plants has an α_{s1}CN average level comprised between 4 to 6 g kg^{-1} milk, as determined by some analyses in our laboratory. The higher amount of α_{s1}CN obtainable in milk through a selection of animals is ~ 7.2 g kg^{-1} milk with an homozygous goat [8]. If goat cheese yields are considered as mainly monitored by the α_{s1}CN level of milk, an extended selection of animals might led to increases in the cheese yields by 13 to 5% according to the actual α_{s1}CN level of the milk.

The cheeses obtained from α_{s1}CN rich milk were found firmer in texture, which could be an advantage from a technological point of view. However, it must be kept in mind that the traditional goat cheese is characterized by its unctuous creamy texture.

The main characteristic of the cheeses from high α_{s1}CN milk remains their weak specific goat cheese aroma compared to the traditional goat cheese, or to O milk cheese. The results we have obtained clearly confirm this point. The difference in aroma levels already appears after 2 days of ripening and seemed therefore mainly due to differences in the early milk lipase activity in milk and curd before whey draining. The mould lipase of the surface flora also probably participates in the hydrolysis of the aroma compounds during ripening [10]. However, this mould lipase seems to act in similar ways and levels in the two types of cheeses and so may contribute to a lesser extent in the difference of aroma.

This low ability of high α_{s1}CN milk to produce free aroma compounds during ripening could in the end give rise to quality problems, as the organoleptic specificity of goat cheeses will be lowered. It is already claimed by some French industrial cheesemakers that goat cheeses produced from the present bulk milks have a lower goat aroma and typicality than traditional cheeses produced in the time when goat selection was not so extended.

As the selection of goat milk on the α_{s1}CN level will certainly be continued, due to economical considerations, we have to study how to increase the goat flavor in these milks. We have to answer why a different lipolytic activity occurs in the

milks, and why it is associated during selection with the α_{s1}CN producing gene.

It would be suitable to dissociate the two characters and to lead a separate selection on the specific goat aroma, meaning on the milk lipase pool, and on their activation.

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