Influence of forage type on quality of goat milk and *Caciotta* cheese

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Summary

The aim of this research was to evaluate the effect on chemical, nutritional, aromatic and sensory characteristics of milk and *caciotta* cheese made with milk from animals fed with two single silage (*Triticale* and *Corn silage*) and two single hay (*Oat* and *Alfalfa*). The forage type affected the chemical and organoleptic properties of milk and cheese. Some fatty acids of milk and cheese seem to discriminate origin of products too.

Keywords: forage type, goat, milk quality, cheese quality

Introduction

Over the last few years, several studies have been realized in order to detect the factors that influence quality of dairy products. Recently, the effect of forages ingested by ruminants was underlined for the protected denomination of origin (PDO) products; from this point of view animal feeding is one of the elements that link the product to the *terroir*. In the Mediterranean region, dairy goat diets are usually composed of fresh forages or preserved forages and a small amount of concentrate. Animal diets can modify milk features; also the fatty acid (FA) profile is influenced by feed composition (Chilliard et al, 2001), plant species, plant growth stage and feeding strategy (Di Trana et al, 2004). The relationship among diet of animals and some secondary metabolites in the milk and cheese was observed by Buchin et al, (1999) and Claps et al, (2006). The objective of this study was to determine influences of two types of hay (*Oat* and *Alfalfa*) and two types of silage (*Corn* and *Triticale*) on chemical composition, fatty acid profile, aromatic properties of milk and cheese, and sensory properties of *caciotta* cheese.

Material and methods

The experiment was carried out at CRA of Bella 360m asl. Thirty lactating *Ionica* goats were divided into two homogenous groups. One group was fed with *Triticale silage* (TS) and the other group with *Corn silage* (CS) for 7 days. Then, the same groups were fed with *Oat hay* (OH) and *Alfalfa* hay (AH) for 7 days. Each experimental period was preceded and followed by 10 days of adaptation. Milk cumulative samples, for each group, were collected at the beginning and at the end of each experimental period, and simultaneously, cheese-making was carried out for two consecutive days. The raw whole milk (about same quantity for each group) was filtered and heated in a stainless vat to 36°C. Liquid calf rennet was added in the amount of 35 ml/100 l of milk. After 20-25 min, at the end of coagulation, the curd was cut with a knife in block 10 cm distant, and then perpendicularly at the same distance; after 5 min of rest, the curd was broken into walnut sized pieces. The curd was placed into plastic cylindrical mould and after salting was ripened for 30 days (85% R.H. and temperature 12 °C). For each dietary treatment eight samples of bulk milk and *caciotta* cheese were analysed. Dry matter, total nitrogen, Not Caseinic Nitrogen (NCN) for milk and Nitrogen Soluble (NS) for cheese, Non-Proteic Nitrogen (NPN), fat and ash were measured according to standard methods for milk and cheese. Fatty acid (FA) profile of milk and cheese was measured by gas chromatography according to the method reported in a previous paper (Di Trana et al. 2004). Volatile Organic Compounds (VOC) content in milk and cheese was analysed in duplicate for each dietary treatment by a multiple dynamic headspace extraction and GC-MS (Ciccioli et al. 2004). Samples of milk and *caciotta* cheese were analysed in duplicate. The sensory profile of cheese was detected by ten trained panellists. The differences in milk and cheese quality were determined using analysis of variance with type of forage and period as factors. The period factor was not considered in the statistical model ($P>0.06$). Sensory data were normalise before statistical analysis and submitted to ANOVA repeated measures procedure.

Results and discussion

The dietary treatment significantly affected milk chemical composition (Table 1). The fat content of OH group was significantly lower than in TS, CS and AH groups. Nevertheless, in OH dietary treatment the highest content of protein than other groups was detected. Milk produced by groups fed with hay (OH and AH) showed a higher value of NCN compared to groups that received silage (TS and CS). The highest content of NPN was found in AH group.

Table 1. Mean of pH and chemical composition of milk and caciotta cheese

Parameters	Milk				SEM	*Caciotta* cheese				SEM
	TS	CS	OH	AH		TS	CS	OH	AH	
pH	6.59	6.53	6.55	6.61	0.035	5.29^{a}	4.93^{b}	4.86^{b}	4.93^{b}	0.095
Fat %DM	38.50^{a}	36.42^{a}	31.66^{b}	35.18^{a}	1.143	50.24^{a}	46.42^{b}	43.41^{b}	43.84^{b}	1.511
Protein %DM	28.17^{b}	25.85^{c}	31.19^{a}	29.88^{b}	0.677	44.41^{a}	32.34^{c}	41.11^{ba}	34.67^{bc}	2.347
Ash %DM	5.79^{a}	5.62^{b}	6.17^{b}	7.37^{a}	0.259	7.79^{b}	7.72^{b}	10.21^{a}	10.78^{a}	0.625
NCNmilk- NScheese %DM	0.93^{b}	0.96^{b}	1.47^{a}	1.14^{a}	0.040	1.55^{a}	1.42^{a}	0.99^{b}	1.02^{a}	0.106
NPN %DM	0.27^{cb}	0.25^{c}	0.29^{b}	0.40^{a}	0.009	1.14^{a}	1.11^{a}	0.80^{b}	0.81^{b}	0.088

TS= Triticale Silage; CS = Corn Silage; OH= Oat Hay; AH= Alfalfa Hay. Means within row with different superscripts differ at $P<0.05$

Concerning chemical composition of *caciotta* (Table 1), the highest fat content was found in both groups that received silage (TS and CS) compared to group fed with hay (AH and OH). The same trend was observed for NS and NPN. In *caciotta* cheese produced by TS group the highest content of protein was detected, whereas the lowest protein content was found in CS group. Ash content was highest in the groups that received hay (AH and OH).

The forage type affected FA profile of milk and cheese and both showed a similar trend (Table 2). The milk and cheese of *Alfalfa* hay (AH) group showed the highest SFA content and the lowest MUFA content. The PUFA content in milk significantly increases in AH group whereas in cheese of the same group a slight increase of PUFA was observed.

Table 2. Mean of fatty acid content (% FAME) in milk and caciotta cheese

Parameters	Milk				SEM	*Caciotta* cheese				SEM
	TS	CS	OH	AH		TS	CS	OH	AH	
SFA	61.99 c	66.32 b	66.80 ab	70.46 a	1.25	60.33 c	65.25 a	66.94 a	70.43 b	0.68
MUFA	33.87 b	29.72 a	28.78 a	24.48 b	1.19	35.55 d	30.78 c	28.67 a	24.98 b	0.63
PUFA	4.14 ac	3.96 c	4.42 a	5.07 b	0.10	4.07 ab	3.93 b	4.32 ab	4.53 a	0.18
C18:3n – 3	0.576 cd	0.527 c	0.932 a	1.567 b	0.065	0.602 cd	0.530 c	0.989 a	1.584 b	0.072
CLA	0.440 c	0.429 ac	0.401 a	0.348 b	0.013	0.456 c	0.423 bc	0.395 ab	0.352 a	0.015

TS= Triticale Silage; CS = Corn Silage; OH= Oat Hay; AH= Alfalfa Hay. SFA = Saturated Fatty Acid; MUFA= Monounsaturated Fatty Acid; PUFA = Polyunsaturated Fatty Acid; CLA = Conjugated Linoleic Acid. Means within row with different superscripts differ at P<0.05

The C18:3n-3 content in milk and cheese was higher in hay groups (OH, AH) than in silage groups (TS, CS). Nevertheless, *Alfalfa* hay (AH) group exhibited the highest content of C18:3n-3 in milk and cheese. The effect of conservation (silage vs hay) of the forage seems negligible if it is compared to the genetic differences of plant (Dewhurst, 2005). The *Alfalfa* plant specie is characterized by higher level of C18:3n-3 compared to other plant species (Morand-Fehr and Tran, 2001).The increased level of C18:3n-3 in milk and consequently in cheese of AH group could be linked to higher intake of this fatty acids by the goats. As regard CLA, the lower content was detected in AH group than other groups. The effect of forage type on CLA is more complicated than effect on level of C18:3n-3. CLA content in dairy products depends on the level of the precursors, rumen biohydrogenation and Δ^9desaturase activity in mammary gland (Dewhurst, 2005).

All classes of VOC in milk and *caciotta* cheese were significantly affected by the dietary treatment (Table 3). The highest content of terpenes, compounds of typical vegetable derivation (Mariaca et al, 1997), was detected in milk of animals fed with TS and CS (387.7u.a. and 420.6u.a., respectively) and in the cheeses obtained from the same groups (908.4u.a. in TS and 909.8u.a. in CS). The same relationship between forages ingested by the animals and content of VOCs in milk and cheese was found in *Ragusano* cheese (Carpino et al. 2004) and in goat milk (Fedele et al. 2005).

Table 3. Means of Volatile Organic Compounds (u.a.) in milk and cheese

Parameters	Milk				SEM	*Caciotta* cheese				SEM
	TS	CS	OH	AH		TS	CS	OH	AH	
Alcohols	191.9a	180.3a	205.5a	25.1b	16.4	445.7a	429.9a	566.2b	106.6c	11.1
Aldeydes	205.5a	140.6b	239.7a	235.1a	19.3	132.1b	182.2a	131.1b	90.1c	5.3
Ketones	50.2b	28.6cb	98.1a	24.1c	6.9	29.7b	44.3a	24.9c	15.1d	1.9
Terpenes	387.7a	420.6a	125.7b	67.6b	28.6	908.4a	909.8a	151.9c	316.7b	19.8
Acids	9.5	11.3	13.7	11.9	1.7	170.4c	489.7a	242.8b	26.5d	4.8
A. hydrocarbures	227.2a	127.7b	131.6b	99.7b	17.4	260.3a	297.0b	280.2b	157.6c	3.6

TS= Triticale Silage; CS = Corn Silage; OH= Oat Hay; AH= Alfalfa Hay. Means within row with different superscripts differ at P<0.05

The sensory profile of *caciotta* is shown in Figure 1. Dietary treatment affected some parameters (P<0.001) of sensory profile. In particular, cheese obtained from TS group showed a higher herbaceous odour and lower value of sweet and acid taste and hardness.

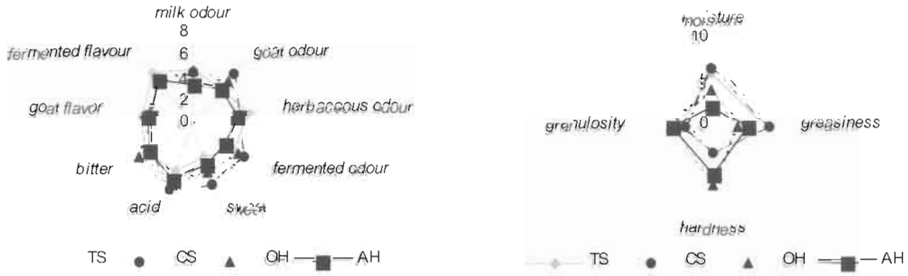

Figure 1. Effect of dietary treatment on sensory profile of caciotta cheese

The sensory differences observed in our cheeses, may be due to milk substances coming directly from animal feeding. Similar relationships were observed by Coulon and Priolo (2002) in dairy and meat products.

Conclusion

The results indicate that chemical composition, fatty acid profile, volatile organic compounds of milk and cheese and sensory properties of *caciotta* cheese vary according to the type of forage. Results are remarkable for the PDO products, in fact animal feeding is one of the elements linking the product to its *terroir*.

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Energy intake effects at pasture on milk production and coagulation properties in *Girgentana* goats with different α_{s1}-casein genotypes

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Summary

The aim of this study was to investigate whether properties of milk from *Girgentana* goats of different α_{s1}-CN genotypes were affected by the energy intake at pasture. Thirty six goats were genotyped at α_{s1}-CN locus using several genomic techniques and milk protein analysis. Eight genotypes associated with low (FF, 2 goats), medium (AF, AN, BF, BN, 21 goats) and high (AA, AB, BB, 13 goats) α_{s1}-CN level have been typed. The increase in energy intake (E) of goats from low (<1.8 Mcal/d) to medium (1.8-2.0 Mcal/d) and high level (>2.0 Mcal/d) corresponded to an increasing dry matter intake, diet CP percentage, milk yield and clotting parameters, and a reduction in milk fat. Depending on genotypes linked to increasing α_{s1}-CN, milk was higher in casein, curd firming time and curd firmness. Significant interaction between the effects of energy intake and α_{s1}-CN genotype was found for curd firming time and curd firmness, suggesting that changes in milk properties caused by feeding regimen could be different for goats differing in α_{s1}-CN genotype.

Keywords: Girgentana goats, energy intake, pasture, α_{s1}-CN genotype, milk coagulation

Introduction

Nutrition and genetic factors, both inducing changes in milk composition, influence milk properties for cheese-making ability. Goats' feeding is frequently based on pasture; thus, the variations in availability and quality of grazed forage over the seasons produces modifications in feeding level and diet composition of goats, determinant for milk characteristics. Milk properties also depend on the genetic variants of the milk proteins. The α_{s1}-CN polymorphism affects milk casein, and goats carrying alleles associated with a high content of α_{s1}-CN show the best technologies properties of milk for cheese-ability (Ambrosoli et al., 1988). In fact, goats milk with high amount of α_{s1}-CN has longer coagulation time and formed firmer curds (Clark & Sherbon, 2000). Even though nutritional and genetic effects on goat milk properties are known, few studies (Schmidely et al., 2002) has verified the impact of nutrition on milk properties from goats of different milk protein genotypes. In this regard, diet energy (Mackle et al., 1999; Auldist et al., 2000) was found positively related to an increase of α-CN in milk from cows, even though independently of their β-LG and κ-CN phenotypes. This study represents a first approach to verify if changes in properties of milk from Girgentana goats differing for α_{s1}-CN genotype are affected by energy intake at pasture.

Material and methods

In a hilly area of Sicily during Spring, over a 75-d experimental period, 36 goats of Girgentana breed, initially averaging 136±5 DIM and 37.4±5.3 kg of live weight, were allowed to daily graze Italian ryegrass as a monocolture (15 goats) or a mixture with berseem

clover (21 goats), and supplemented with 500 g/d of barley. Blood and milk samples were collected from the same goats. Genotyping was carried out at protein level and at the DNA level, as reported by Sacchi et al., (2006). Eight different genotypes associated with high (HC: AA, AB, BB, 6 and 7 goats for R and BC), medium (MC: AF, AN, BF, BN, 8 and 13 goats for R and BC) and low content (LC: FF, 1 and 1 goats for R and BC) of α_{s1}-CN were found.

From weekly measurements and sampling, regarding milk yield and forage selected by goats, a total of 270 individual observations were achieved. Milk samples were analysed for lactose, fat, SCC, pH, titratable acidity (°SH/50 ml), TN, NPN, NCN and urea. The milk renneting properties, clotting time (r, min), curd firming time (k_{20}, min) and curd firmness (a_{30}, mm), were measured in 10 ml of fresh milk at 35 °C added of 0.2 ml diluted (1.6:100) rennet solution (1:15,000) using a Formagraph instrument. Herbage dry matter (DM) intake of goats at pasture and diet DM digestibility was assessed by the *n*-alkane technique, according to Dove and Mayes, (1991). Analyses for DM, crude protein (CP), fat, ash and structural carbohydrates were carried out on selected herbage and barley seeds. The estimation of net energy of lactation (NE_L) of diet was based on assessed digestibility and equations of Van Soest and Fox, (1992). The calculated data of diet energy intake (E) of goats, ranging from 1.4 to 2.4 Mcal/d of NE_L, were classified according to a low (LE: <1.8 Mcal/d), medium (ME: 1.8-2.0 Mcal/d) and high level (HE: >2.0 Mcal/d), independently of the type of pasture since its effect on energy intake within α_{s1}-CN genotype of goats was found not significant. Data were statistically analysed by GLM procedure of SAS, using a mixed model with energy intake (E), α_{s1}-CN genotype (C) and their interaction (E*C) as fixed effects, and goats within E*C as a random effect. Means differences were assessed by the Student's *t* test. Tables report only parameters showing significant effects.

Results and conclusions

The increasing energy intake (E) of grazing goats (Table 1) corresponded to an increase in diet DM intake and CP, and a reduction in diet DM, whereas NDF had a constant level. These variations have to be related to changes in herbage availability (from 39 to 151 kg DM/goat) and composition (DM 10-58%; CP 8-19 % DM; NDF 42-69 % DM) at pasture.

The a_{s1}-CN genotype (C) did not affect energy intake, whilst DM intake and diet NDF were lower in HC goats, for which a tendency to select more digestible grass, for supporting energy need for high synthesis rate of casein (Schmidely et al., 2002), could be hypothesized.

Table 1. Effects of goats energy intake (Mcal NE_L/d) and genotype for low (LC), medium (MC) and high (HC) α_{s1}-CN on diet DM intake and composition.

	Energy intake (E)			α_{s1}-CN genotype (C)			[1]Sign.		R^2
	<1.8	1.8-2.0	>2.0	LC	MC	HC	E	C	
Observations n.	69	117	84	15	160	95			
NE_L intake, Mcal/d	1.52^{C}	1.86^{B}	2.31^{A}	1.95	1.89	1.85	***	NS	
DM intake, g/d	969^{C}	1140^{B}	1339^{A}	1184^{a}	1149^{a}	1114^{b}	***	*	0.84
Diet NE_L, Mcal /kg DM	1.58^{C}	1.64^{B}	1.72^{A}	1.64	1.64	1.66	***	NS	0.59
Diet DM, %	35.8^{A}	26.4^{B}	21.4^{C}	28.4	27.9	28.5	***	NS	0.64
Diet CP, %	18.3^{Bc}	19.4^{Bb}	21.8^{Aa}	19.7	19.6	19.9	***	NS	0.69
Diet NDF, %	29.6	29.2	28.3	30.3^{a}	28.8^{ab}	28.2^{b}	NS	*	0.64

*1. *=P≤0.05; ***=P≤0.001; NS=not significant. A, B, C: P≤ 0.01; a, b, c: P≤ 0.05.*

The increase in E was related to an increase in milk yield and, because the dilution effect, a decreasing fat (Table 2). The E did not affect protein and casein content, even though LE increased the ratio casein N/TN and the efficiency of N utilization for casein synthesis, and reduced whey protein. Urea was lower at ME, where presumably nitrogen assumption was better balanced to energy. The E markedly affected clotting parameters, higher at the HE; these results seem to reflect the combined effects of the higher casein, even though non significant, related to higher clotting time and curd firming time (Clark & Sherbon, 2000), and the lower fat, related to higher curd firmness (Bencini, 2002).

Table 2. Effects of goats energy intake (Mcal NE_L/d) and genotype for low (LC), medium (MC) and high (HC) α_{s1}-CN on milk composition and renneting properties.

	Energy intake (E)			α_{s1}-CN genotype (C)			[1]Sign.			R^2
	<1.8	1.8-2.0	>2.0	LC	MC	HC	E	C	E*C	
Milk, g/d	903^{C}	1035^{B}	1266^{A}	967^{B}	1131^{A}	1096^{A}	***	**	NS	0.86
Lactose, %	4.58	4.61	4.57	4.62^{a}	4.59^{b}	4.55^{b}	NS	*	*	0.71
Fat, %	4.20^{Aa}	4.02^{Ab}	3.57^{Bc}	4.03^{a}	3.80^{b}	3.95^{a}	***	**	*	0.70
TN*6.38, %	3.70	3.84	3.86	3.70^{b}	3.81^{ab}	3.89^{a}	NS	*	NS	0.70
Casein, %	2.87	2.87	2.94	2.66^{Bc}	2.96^{Ab}	3.06^{Aa}	NS	***	NS	0.71
Casein N/TN, %	77.4^{a}	75.2^{b}	76.0^{ab}	72.4^{B}	77.7^{A}	78.5^{A}	*	***	NS	0.56
Casein N/N intake, g/kg	144^{a}	134^{ab}	128^{b}	110^{B}	149^{A}	147^{A}	*	***	NS	0.64
Whey protein, %	0.55^{B}	0.62^{A}	0.63^{A}	0.68^{A}	0.57^{B}	0.56^{B}	**	**	NS	0.62
Urea, mg/dl	50.3^{a}	46.4^{b}	50.2^{a}	49.7	48.6	48.5	*	NS	*	0.73
r, min	9.6^{Bc}	10.6^{ABb}	11.8^{Aa}	10.0	11.1	10.9	***	NS	NS	0.54
k_{20}, min	1.57^{Bb}	1.64^{ABb}	1.85^{Aa}	1.56^{b}	1.66^{b}	1.84^{a}	***	*	***	0.77
a_{30}, mm	42.1^{B}	49.0^{A}	49.0^{A}	41.5^{B}	49.4^{A}	49.2^{A}	***	***	***	0.75

*1. *=P≤0.05; **=P≤0.01; ***=P≤0.001; NS=not significant. A, B, C: P≤ 0.01; a, b, c: P≤ 0.05.*

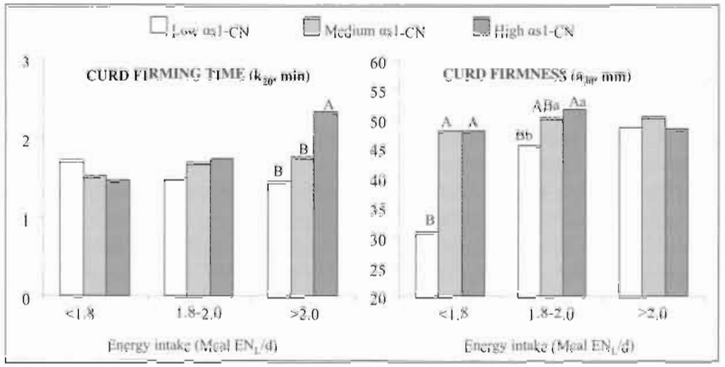

Figure 1. Changes in renneting properties of milk from goats of low, medium and high α_{s1}-CN genotype due to energy intake (A, B: P≤ 0.01; a, b: P≤ 0.05).

The C of goats affected several traits of milk production. In particular, in comparison with other genotypes, LC goats showed lower milk yield, casein content, ratio casein N/NT and efficiency of N utilization for milk casein, in accordance with Schmidely et al., (2002), but, in opposite to these authors, a higher milk fat was found in LC goats, probably because of the effect of both lower milk yield and higher diet NDF, or the low number of cases. Linked

to the lower casein content, curd firming time and curd firmness were lower for LC. These results are supported by Ambrosoli et al., (1988) and Clark and Sherbon, (2000), who found that milk with high level of a_{s1}-CN had higher protein, casein, slower coagulation rate and firmer curds. Significant interactions E*C emerged for lactose, fat and urea. Whereas interactions in lactose and fat are difficult to justify, the interaction for urea, due for the marked increase in LC at HE (48.7, 46.4 *vs.* 55.5 mg/dl in HC, MC and LC; $P \leq 0.05$) can be explained by the excess of diet nitrogen in respect to the lower nitrogen exigency for milk casein formation. However, highly significant interactions were found for curd firming time and curd firmness (figure 1). The first showed an effect of C only at HE, where increased passing from LC to HC. On the contrary, the difference in curd firmness between genotypes disappeared at HE.

In conclusion, this first investigation allowed to evidence as both energy intake and α_{s1}-CN genotype appeared to greatly affect the potential manufacturing properties of goat milk, thus both feeding management and genetic selection have to be optimized in order to improve cheese-making ability of milk produced and maximize cheese yield. The interactions between effects of nutrition and α_{s1}-CN genotype suggest that changes in milk properties caused by feeding regimen could be different for goats differing in α_{s1}-CN genotype. However, especially due to the low number of low α_{s1}-CN observations, further studies are required to confirm and better define these preliminary results, also taking into account genotype combinations of α_{s1}-CN and other milk protein.

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Grazed or preserved forage: a global evaluation of goat milk and cheese quality

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Summary

The present study was undertaken to explore the effect of grazed and preserved forage on the aromatic and nutritional quality of goat milk and cheese. Thirty Maltese goats were randomly divided into two homogeneous groups: group G grazed for 8 hours/day a native herbaceous pasture and supplemented with concentrate; group T was fed native pasture hay and the same concentrate. During three seasons, cumulative milk samples were collected from each group and analysed for volatile organic compounds (VOC), vitamins and fatty acids. The remained milk was processed to produce Caciotta cheese. Group G milk was significantly higher for sesquiterpenes and ketones, tocopherol, retinol, degree of antioxidant protection (DAP), CLA and omega3 than milk from T group. Monoterpenes and alcohols were not affected by type of forage. Similar differences were observed in cheese qualitative profile. Larger differences on sesquiterpenes were observed. These results showed that forage preservation depreciated the global qualitative profile of milk and cheese.

Keywords: forage preservation, grazing, goat, milk quality, cheese quality

Introduction

In the Mediterranean area, the native pasture is the main resource for goat feeding. It is used for grazing during the favourable season. During winter animals are fed indoor with preserved forage (hay from native pasture or seeded grassland) and supplemented with mixed grain (broad bean, maize, barley) or commercial concentrates. Recently, forage role on milk and cheese quality has been evaluated (Coulon et al., 2000) and the effect of grass preservation technique (hay or silage) on sensory characteristics has been shown (Verdier-Metz et al., 2000), but few data are available on goat milk and cheese. VOC's concentration decreases because of the direct exposure of the cut herbage to sun rays. This was verified for terpenes content and profile in goat milk (Fedele et al., 2005) and in cheese (Viallon et al, 1999). Vitamins, thermolabile and light-sensitive, can be modified and forage (pasture vs. conserved forage) is also reported to affect CLA group amount and composition (White et al., 2001).
The aim of this study was to investigate goat milk and cheese quality variations induced by preserved forage (hay) in comparison with grazing.

Material and methods

This experiment was carried out at the experimental farm of CRA-Istituto Sperimentale per la Zootecnia in Bella, Southern Italy. Thirty Maltese goats were randomly divided into two groups, homogeneous for milk yield. Group G grazed for 8 hours/day a native herbaceous

pasture and was supplemented with 600g/day concentrate (14% CP); group T was fed hay harvested from native pasture and 600g/day of the same concentrate. The native pasture botanical composition consisted of grasses (37% of the herbage availability), legumes (28%) and forbs (35%). During winter, spring and summer, cumulative milk samples were collected from each group and immediately analysed for volatile organic compounds (VOC). A duplicate set was stored at -20° C until vitamin and fatty acid analysis. The remaining milk was processed to produce Caciotta cheese.

VOC in milk and cheese were determined by HRGC-MS after thermal desorption of traps performed at 250°C and identified on the basis of their mass spectra (Ciccioli et al., 2004).

Milk and cheese samples for alpha-tocopherol, retinol and cholesterol analyses were hydrolysed in alkaline solution and the extracted residue was analysed by a normal phase HPLC method (Panfili et al., 1994).

Fatty acid profile was determined only in milk sampled in spring. Milk lipids were extracted with chloroform and methanol and subsequently methylated. Fatty acids methyl esters were quantified by gas chromatography (Varian 3800). Separation was made with DB 23, J&W capillary column (60m x 0.25 mm i.d.). The Degree of Antioxidant Protection (DAP) was calculated as the molar ratio between an antioxidant compound (alpha tocopherol) and an oxidation target (cholesterol). Apart from fatty acids, all parameters were considered as average of the three seasons, and the statistical analysis was performed by ANOVA with a model including the kind of forage ($P<0.05$) (SAS, 1987).

Results

In general, milk and cheese from grazed forage showed a very different qualitative profile in respect to preserved forage. Fig.1, showing milk qualitative parameters, demonstrates that milk from grazed herbage was significantly richer in sesquiterpenes and ketones, 4.7 and 2.9 times respectively, than milk from preserved one.

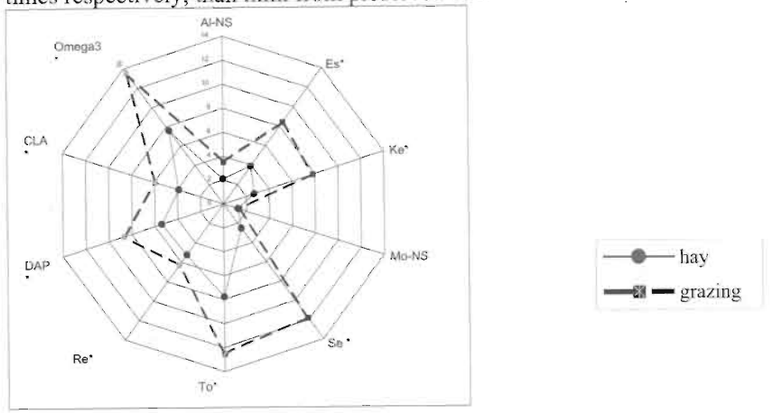

Fig. 1. Qualitative profile of milk from grazing and fed preserved forage goats. Al=Alcohols; Es=Esters; Ke=Ketones; Mo=Monoterpenes; Se=Sesquiterpenes; To=Tocopherol; Re=Retinol; Om3=Omega3. Significant differences with P< 0.05*

On the other side, monoterpenes and alcohols were not affected by the forage type. Also vitamin content showed significant differences. Tocopherol and retinol were 61.3% and 20.0% higher respectively in group G than in group T. Similarly, the degree of antioxidant protection (DAP) was higher in milk from grazing goats (61.1 %) than in milk from goats fed hay. High significant differences were observed also in CLA and omega3 content: the first one was 52.6 % higher in milk from G group than in milk from T group, while omega3 was 79.1% higher.

Similar differences were observed in the cheese's qualitative profile (Fig. 2).

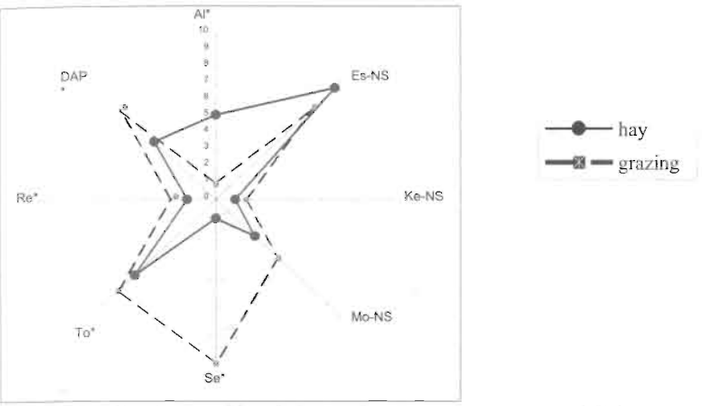

Fig. 2. Qualitative profile of cheese from grazing goats and fed preserved forage.
Al=Alcohols; Es=Esters; Ke=Ketones; Mo=Monoterpenes; Se=Sesquiterpenes; To=Tocopherol; Re=Retinol; Om3=Omega3. Significant differences* with P< 0.05

Despite all qualitative parameters showed higher values in G group, only for the sesquiterpenes and DAP great differences were found. Sesquiterpenes reached values more than eightfold in cheese from fresh herbage (8.66), while the DAP showed in cheese about the same trend of increase (55.1%) found in milk. For the other aromatic parameters, the increasing was moderate and not significant, with exception for alcohols, 81.6% lower in cheeses from G group. Cheese retinol and tocopherol contents were 19.9 and 56.5% higher in G group than in T one.

The VOC variation in milk have been explained with the volatile nature of these molecules, decreasing in forage during harvesting and sun exposure, and can be associated to the goats' selective behaviour during grazing. Actually goat browses apex and flowers of aromatic plants as *Asperula odorosa*, *Geranium molle*, *Cichorium intybus*, etc. on the same pasture (Fedele et al., 2004). Moreover, heat treatments during cheese-making can also causes further volatile molecule losses, as supposed by Coulon et al. (2000). Considering that alpha-tocopherol concentration increases with foliage age, as observed by Tramontano et al. (1993) and Wilmonth et al. (2000) and that the herbage for hay production was cut at flowering stage, higher vitamin content should be present in milk from goats fed hay. The decrease of vitamins in milk from these goats could be explained by the sun effect (high temperature 3-5 days long) (McDonald et al., 1992).

The highest values of CLA and omega3 in milk of grazing group could be related to the grazed herbage, as shown in previous studies on cow milk where the highest content of CLA was observed in milk from year-round grazing cows in comparison with summer grazing and feeding silage-based rations (Jahreis et al, 1997). This difference could be explained by the seasonal evolution of CLA's precursors content in herbage (Di Trana et al., 2004), higher in winter and spring and lower in summer, that corresponds to the usual haymaking period in the Mediterranean regions.

Conclusions

These results showed that forage preservation induced a global change in qualitative profile of goat milk and cheese, by lowering aromatic molecules and micronutrient content in milk. This consideration could have a favourable impact on the valorisation and promotion of milk and cheese from Mediterranean grazing system. Actually the herbage grazed from this native pasture was able to confer to milk and cheese a highest total quality, notwithstanding the concentrate supply, meanly higher through out the whole grazing season.

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Rapid determination of CLA content in milk from grazing Payoya goats using NIR spectroscopy

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Summary

Current position of societal drivers and consumers preferences are favourable to the development of sustainable animal production systems where human desirable foods are obtained. In this context, semi-extensive dairy goat production could play an important role in the occupation, preservation and valorisation of marginal territories. However, specific studies are required to characterize dairy products in an easy, fast and economic way.
The main objective of the present work was to characterize the fatty acid profile (including conjugated linoleic acid, CLA) of milk from semi-extensive and intensive Payoya breed goat production systems, along a 1.5 years period, using NIR spectroscopy.
During the sampling phase, near infrared spectra of liquid fresh milk were acquired using a FOSS-NIRSystem 6500 monocromator in transflectance mode. Calibration equations were obtained for the rapid estimation of total CLA, saturated fatty acids (SFA), monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) contents in liquid fresh milk samples (3 minutes per sample for a complete analysis). Inclusion of these extra information values to dairy products could contribute to the enhancement of the stability of semi-extensive goat production systems in Spain.

Keywords: milk, CLA, NIRS, fatty acids

Introduction

Several evidences can be found in scientific literature (Elgersma et al., 2006) describing a clear pattern of changes in societal drivers (e.g. environment and landscape preservation, animal welfare, etc.) and consumer preferences (e.g. tasty and/or healthy products). The natural consequence of the observed social trends should be the implementation of sustainable systems for the production of the required foods. Achieving this goal can be particularly difficult for dairy goat production systems as, firstly, farmers do not receive an extra payment in addition to the base milk price depending on the rate of grass consumed by goats (as done by some dairy cows cooperatives in The Netherlands) and, secondly, a complete bromatological analysis of milk is not often available (at least at accessible prices). The panorama becomes even more unfavourable due to the lack of analytical tools able to discriminate dairy products coming from different production systems.

One of the most relevant issues concerning to the quality of dairy products is related to the features of their fat. In the USA, dairy products contribute to the human intake of total fat in 15–20%, 25–33% of saturated fat and about 15% of dietary cholesterol (Havel, 1997). Nevertheless, research works confirm that fatty acid profiles can be easily modified with diet (Chilliard et al., 2001, Kennelly, 2001, Tamminga, 2001). In this sense, milk produced by grazing cows proved to have better relations in their fatty acid contents, with higher PUFA

and CLA (particularly C18:2 cis-9, trans-11), than cows with silage based feeding (Elgersma et al., 2006). Gas chromatography is the reference method routinely used for the determination of the fatty acid profile in milk. The precision of the method is adequate and the equipment and reagents involved in the analysis are usual in many laboratories. However, the time required to obtain an analytical result (including sample preparation and chromatographic analysis) can easily exceed 48 hours, a disproportionate elapsed time for a perishable product like milk. In this context, near infrared (NIR) spectroscopy is being considered every day more as a powerful sensor for the analysis of biological fluids (Ciurczak, 2001), owing mainly to that is a very fast, inexpensive, versatile (multi-product and multi-constituent) and no-contaminant technique, moreover its easy management. Acquisition of NIR spectra requires less than 2-3 minutes per sample, showing the suitability of this technique for the analysis of dairy products. In scientific literature, there are several references that support the utility of this technology for quality control and traceability of milk and dairy products (Núñez, 2003), however, references about fat quality are not found.

The main objective of the present work was to characterize the fatty acid profile (including conjugated linoleic acid, CLA) of milk from semi-extensive and intensive Payoya breed goat production systems, along a 1.5 years period, using NIR spectroscopy, in order to perform an analytical procedure for the tipyfication of milk obtained in different production systems. Inclusion of these extra information values to dairy products could contribute to the enhancement of the stability of semi-extensive goat production systems in Spain.

Material and methods

Milk samples

Milk samples were collected periodically (each 1 or 2 months) from bulk tanks in 7 semi-extensive farms (with different grazing degree) and 1 intensive goat farms (zero grazing) during a year and a half. Semi-extensive farms were located in the north mountain range of Cádiz (Southern Spain), while the intensive farm belongs to an experimental unit of the University of Huelva (Southern Spain). The goat breed selected for the study is called Payoya, a Southern Spain autochthonous and endangered breed.

Gas chromatography analysis

Fatty acid profiles were determined with a gas chromatograph Agilent 6890 (N Network A.C. System), provided with a 7683 automatic injector and a HP-88 column (100 m x 0.25 mm di, 0.2 um). Extraction and direct methylation were performed in a single step procedure based on the method published by Sukhija and Palmquist, (1998). Individual fatty acids were identified by comparing their retention times with those of an authenticated standard fatty acid mix Supelco 37 (Sigma Chemical Co. Ltd., Poole, UK). Identification of the CLA isomers 9cis-11trans, 11cis-13trans, 10trans-12cis and 10cis-12cis CLA was achieved by comparing retention times with those of another authenticated standard mix (Sigma Chemical Co. Ltd., Poole, UK). Fatty acids were expressed as a percentage of total fatty acids.

NIR analysis

Reflectance spectra were obtained on a Foss NIRSystems 6500 SY-II monochromator, from 400 to 2498 nm, every 2 nm. Samples were scanned using a transflectance cam-lock ring cell (3.75 cm diameter) with 0.1 mm pathlength and provided with a golden reflectance surface

(FOSS ref. IH-0355-1). The spectrum of each sample was the average of the spectra of 3 fat sub-samples. Modified Partial Least Squared (MPLS) calibrations were obtained using ISI software. The calibrations were developed using a maximum of 2 passes of automatic outliers (T and H) elimination. T outliers are defined as samples with significant differences between their laboratory and predicted values, while H outliers are defined as samples whose spectra show excessive distance (H > 3) to the spectral centre of the calibration set (Shenk & Westerhaus, 1995). Performance of NIRS equations was evaluated by examining the statistical values obtained for calibration: 1-VR (determination coefficient for cross validation) and SECV (standard error of cross validation).

Results

Fatty acid profile of milk samples

Due to the reduced pluviometry registered during the experimental work (from January 2005 to June 2006), feeding systems in the intensive and semi-extensive farms resulted to be similar and, consequently, and that may explain the lack of significant differences in the fatty acid profiles of milk from the studied production systems. Table 1 shows the main fatty acid indexes calculated for the 104 samples analyzed.

Table 1. Fatty acid indexes of milk from Payoya breed goats (% of identified methyl esters)

Index	Mean	Minimum	Maximum	SD
SFA	67.15	54.15	75.37	3.88
MUFA	25.75	18.63	34.76	3.23
PUFA	7.09	3.88	12.86	1.73
Total CLA	1.20	0.19	9.50	1.55
SCFA	20.18	9.79	30.00	3.40
MCFA	34.96	25.66	49.74	4.63
LCFA	44.85	28.78	64.55	6.65
Desirable	46.52	32.94	64.91	6.04

SFA= saturated fatty acids; MUFA= monounsaturated fatty acids; PUFA= polyunsaturated fatty acids; Total CLA: isomers 9cis-11trans, 11cis-13trans, 10trans-12cis and 10cis-12cis CLA; SCFA = short chain fatty acids; MCFA = medium chain fatty acids; LCFA = long chain fatty acids; Desirables = PUFA+MUFA+C18:0 (cis isomers) (according to Huerta-Leindez et al., 1996).

Table 2. Calibration statistics obtained for fatty acid indexes of milk from Payoya breed goats

Index	SECV	1-VR
SFA	2.299	0.640
MUFA	1.953	0.592
PUFA	1.226	0.285
Total CLA	0.446	0.574
SCFA	2.160	0.548
MCFA	2.992	0.548
LCFA	4.443	0.542
Desirable	3.872	0.582

SECV = standard error of cross validation; 1-VR = determination coefficient for cross validation; SFA= saturated fatty acids; MUFA= monounsaturated fatty acids; PUFA= polyunsaturated fatty acids.; Total CLA: isomers 9cis-11trans, 11cis-13trans, 10trans-12cis and 10cis-12cis CLA; SCFA = short chain fatty acids; MCFA

= medium chain fatty acids; LCFA = long chain fatty acids; Desirables = PUFA+MUFA+C18:0 (cis isomers) (according to Huerta-Leindez et al., 1996).

NIR calibrations obtained for the estimation of individual fatty acids showed best results for major constituents, with coefficients of determination between 0.003 and 0.616. Calibrations for fatty acid indexes (Table 2) reported higher coefficients of determination, except for PUFA. Nevertheless, as indicated by Shenk and Westerhaus, (1996), despite coefficients of determination between 0.50 and 0.69 are indicative of a good ability to discriminate samples with low, medium or high values for the tested constituent, these equations must be considered as not adequate for their use in routine analysis.

Conclusions

NIR calibrations could be used for screening purposes, allowing the rapid discrimination of samples on their fatty acid profiles. The qualitative procedure used to express the results (% of total identified methyl esters) is probably responsible of the limited prediction ability of the calculated equations, as NIR absorbance is usually best correlated to parameters expressed as weight percentage of total sample. Thus, further work is in progress in order to transform fatty acid contents in g per 100 g of fresh milk for the achievement of better calibration results. Additionally, new milk samples are being analysed to include the effect of higher pluviometry in the pasture grazed by the animals.

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Some of the factors involved in cheese quality: breed, type of rennet and smoking process

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Summary

The diversity of goat cheeses can be due to many factors. In this paper the effects of breed, type of rennet and smoking process used are described. Many traditional cheeses are linked to a local breed, but can a breed characterize a product? As a particular breed can influence milk composition, it can therefore subsequently induce changes in the physicochemical characteristics of the cheese, in particular protein concentration. Fat and fatty acids are more related to animal feeding regimes. In experimental cheeses, where the breed is the only factor that varies, some differentiation in sensorial profile can be shown. Traditional cheese-makers have used natural rennet pastes as preparation for curdling goat and sheep milk, which it seems to be an essential and distinguishing element for the development of the typical taste and texture of the local cheeses, especially the sharp and "pecorino" or goat taste. In some other cheeses aqueous extracts of dry flowers from the wild thistles, a different species of the *Cynara* genus have been used, mainly for clotting sheep milk; differences in sensorial (bitter taste and creamy textures) and chemical properties have been found in these instances. The use of these traditional coagulants has been gradually replaced by diverse commercial rennets; these practices mean an important loss in the diversity and authenticity of traditional cheeses. Other factors that can be a source of differentiation for cheeses include the smoking process, which is one of the most ancient food preserving techniques, although today this process plays an important role in the colour, texture, aroma and taste of cheeses. Volatile components and sensory properties are affected by the different materials used for smoking. This practice can be a useful tool for the identification of traditional cheeses that used to be smoked or for developing new high quality and attractive cheeses.

Keywords: cheese quality, goats breeds, rennet, smoking process

Introduction

It is well known that goat milk has played an important role in human nutrition for a long time, especially in populations living in arid environments (Morand-Fehr et al., 2000). Goat milk and cheeses can play different role in livestock development; on one hand they have nutritional importance, especially in many countries where the goat is the only farm animal that can be an important source of high quality protein (milk, cheese, and meat). In other countries, goat milk and cheese can be an alternative in case of intolerance to other milks or where there are digestive pathologies. There is a third point of view for the development of goat cheeses and it is linked with its organoleptic properties that can be well appreciated by consumers in the new marked tendencies where there is an important place for very well differentiated products.

The physicochemical composition and sensory properties of goat cheeses depend on many factors such as feeding, which influence the quality of goat cheeses through the composition of the milk. However, technological and genetic aspects can also interact and often mask the effect of diet. Frequently on-site experience has led to the conclusion that many aspects are interacting, although it is only under experimental conditions that it is possible to analyze the effect of any particular feature by itself.

The objective of this paper is to describe the effect of breed, type of rennet and smoking process on goat cheese quality. The first question is what quality is; there is a primary concept that is "sanitary quality" - it is obvious that no cheeses can be a risk for human health. There is another point of view regarding the "nutritional or dietary quality" of goat cheeses; its estimated cheese chemical composition and bioavailability. There is another definition of quality that is "sensory quality" and it is related with organoleptic and gastronomic cheese proprieties. Nonetheless, where consumer's preferences are concerned, the most important factor is usually the price, although the label, packaging and marketing strategies play a more important role than some other considerations. Branded products are dominated by cow milk products, whereas goat cheeses, excepting some countries such as France, are not as well accepted. There are many traditional goat cheese varieties that can have an important niche in this difficult and global market as long as they are well defined and their characteristic attributes shown.

Further to the comment at the end of the paper published by Verdier-Metz et al. (1998), it is very important not to forget that the results obtained for a specific cheese are only directly applicable to this particular cheese and under the experimental conditions employed. Before adopting for other products the findings must be confirmed through strict research.

The final purpose of the present paper is to show how goat breeds and some technological practices (type of rennet and smoking process) can be important tools for the definition and differentiation of traditional cheeses and can even contribute to the production of new types of cheeses.

Breed effect

All factors affecting milk quality should also influence cheese making and the characteristics of the cheese, although the effects of genetic factors in milk are still not fully elucidated (Coulom et al., 2004). There are many studies concerning cows' milk that show genetic factors involved in milk composition, their technological properties and their repercussion in cheese quality and yield (Macheboeuf et al., 1993; Verdier-Metz et al., 1998; White et al., 2001; Auldist et al., 2002, 2004; Coulon et al., 2004; Todaro et al., 2004; Casandro et al., 2005; Malacarne et al., 2006). However, in scientific literature, references regarding influence of goat breeds in cheese quality are limited (Ronningen, 1965; Skjevdahl, 1979; Pizzillo et al.,1992, 1996, 2005; Fresno et al., 2001; Coulom et al., 2004; Kumar & Kansar, 2005) and those on ovine species even more so (Coulom et al., 2004). Furthermore, many of the references that involved different genotypes included more than one aspect, so it is difficult to show the isolated effect of the breed. Many recent researches are focusing on the effect of animal genetics on lactoprotein polymorphisms and their repercussion on milk suitability for cheese-making and cheese quality (chemical and sensorial); an admirable review has been summarized by Coulom et al. (2004). Nevertheless, the conjugated linoleic acid (CLA) content in milk depends on the type of feed provided to the animals, recent studies involved other factors such as breed (Kelsey et al., 2003; Kewalramani et al., 2003; Kumar & Kansar, 2005; Tsiplakon et al., 2006).

In many studies the comparisons are made between a local breed, usually linked to a labelled product, and conventional dairy cattle (Friesian or Holstein), whereas other research evaluates these international breeds compared with dual purpose breeds. Local or dual purpose breeds, normally have a higher concentration of most milk components, especially

protein and casein (Macheboeuf et al., 1993; Auldist et al., 2002, 2004; Coulon et al., 2004; Todaro et al., 2004; Casandro et al., 2005; Knowles et al, 2006; Malacarne et al., 2006); although other surveys have not shown significant differences between breeds (Verdier-Metz et al., 1998). The different chemical components of milk determined a greater suitability for coagulation properties and cheese yield. Most of this effect can be related to differences in casein content among breeds and to casein genetic polymorphism; particularly the frequency of κ-B variant (Coulon et al., 2004). Milk coagulating properties are also strongly correlated to milk acidity parameters (Macheboeuf et al., 1993; Ikoneen et al., 2004), so it is necessary to take into account the genotype influence. Verdier-Metz et al. (1998) showed that higher milk pH from Tarentaise cows induced longer clotting time and Malacarne et al. (2006) found better rennet coagulation properties related to higher values of titratable acidity milk from Italian Brown cows. The differences in coagulation are not all explained by κ casein variants and acidity values, these are probably due to other milk characteristics, such as the micellar structure or the proportion of α_s-caseins or β-caseins (Verdier-Metz et al., 1998), that are affected by breed and also within breed (Coulom et al., 2004).

The physicochemical characteristics are influenced by breed, but higher percentages of fat or protein in milk do not always lead to cheeses with a superior level of these chemical compounds. Under the same conditions, Modicana cows produce milk richer in fat and protein than Friesian cows, but cheese obtained with the milk from this local breed had more fat but less protein than others made with Friesian milk (Todaro et al., 2004).

Many of the variations in cheese characteristics are due the differences in milk composition and when milk is not standardized, the effect of breed in cheese chemical composition is more evident. Additionally, cheese yield differences disappeared when milk was standardised to a constant solid ratio (Auldist et al., 2004). However, not all differences are explained by cheese composition; breed had shown a significant effect in some textural, colour and sensorial properties in cheeses with non statistical differences in gross chemical values, especially taste intensity that was more intense in local breeds than in Holstein cows (Verdier-Metz et al., 1998; Coulom et al., 2004).

Fat yield and composition used to be more affected by feeding practices and the influence of technological factors are very low (Chilliard et al., 2006), but there are also differences in the fatty acid profile between breeds (White et al., 2001; Auldist et al., 2004; Coulom et al., 2004). In other trials, volatile cheese compounds were not affected by genotype (Verdier-Metz et al., 1998).

Many years ago, Ronningen (1965) showed that the characteristic "goat" flavour was linked to animal breed and that cheeses made with Norwegian goat milk showed a stronger taste than others made with Saanen goat milk (Skjevdal, 1979).

Gross milk composition of the Nubian goat breed in Egypt was significantly higher (in fat, total protein, casein and total solids) than that of the Alpine goat. This variation affected cheese yield, but did not change cheese composition and sensorial scores, only oleic acid and total unsaturated fatty acids were affected with higher scores for Alpine milk (Soryal et al., 2005). Far away in India, Alpine Beetal´s milk had higher CLA than Saanen Beetal´s milk (Kumar & Kansar, 2005). Contrary to these results, other authors in experimental conditions (Tsiplakou et al., 2006) did not find a breed effect on sheep milk fat CLA content.

In the Atlantic Ocean, other authors (Fresno et al., 2001) found significant differences between Majorera and Tinerfeña goats milk; chemical composition only affected the soft cheese, although sensory properties showed many differences between soft, semi-hard and hard cheeses. Later studies with other Canary goat breeds demonstrated significant gross chemical differences. Cheeses made with Palmera milk presented better values for fat and

protein, the fatty acid profile was very similar although sensorial features had many differences (Álvarez et al., 2007).

A complete study (Pizzillo et al., 2005) was undertaken with five Italian goat genotypes (Girgentana, Siriana, Maltese and Local). Breed was shown to affect milk composition in pH, fat and protein/fat ratio, and while whey composition was depended on dry matter and protein/fat ratio. When milk was transformed into ricotta cheese more differences were found: fat, dry matter, lactose and protein/fat ratio. Breed had a limited influence in textural and colour properties, cheeses made with Siriana goats milk had higher score for "goat taste" and greater granulosity. Contrary to results in the Egyptian experiment, the fatty acid profile was affected and the high level of mono and poly unsaturated acids present in cheese made with Girgentana goat can be used in favour of the use of this breed.

All this research to demonstrate the significance of a breed in cheese yield and quality are of special importance concerning branded products, including market strategies. Their success can be seen with the initiative of a producer group of Parmigiano-Reggiano cheese who created a new niche market for cheese produced only with milk from Reggiana cows which commands a price that is about 50 % higher than the normal product (Roest & Menghi, 2000). Many local breeds would not be in danger of extinction if a Protected Designation of Origin (PDO) or a Protected Geographical Indication (PGI) included, as part of their specification requirements, that only a particular autochthonous genotype could be involved. Examples are shown in the cases of the Canary goat's breeds Majorera and Palmera with *Queso Majorero PDO* and *Queso Palmero PDO*, and the Portuguese goat breed Serrana Transmontana with *Queijo de cabra transmontana PDO*.

Different studies have demonstrated that it is not possible to isolate all the factors that contribute to a specific characteristic of a cheese: animal species and breed, animal feeding and other management practices, raw or pasteurized milk, as well the type of cheese making process including ripening conditions (Le Jaouen et al., 2001), except under experimental conditions, because the quality of the final product is the result of all these interactions.

As a final consideration, all these regional specific cheeses linked to a breed and a geographical area can be considered as cases of rural development, it is always necessary to remember that behind them there is the effort and know- how of farmers and cheesemakers. In the other extreme, there are the consumers that demand high specificity, exclusivity and better product definition.

Rennet effect

In the past, cheese-makers have used rennet paste preparations for curdling milk that were produced by macerating the stomachs from suckling ruminants according to the local uses. Nowadays most of the cheeses are made with commercial rennet and these artisan pastes are only used in some ovine and caprine raw milk cheeses (Bustasmante et al., 2000; Fresno et al., 2005), mainly in Italy (Provolone, Pecorino Romano and Pecorino Sardo), Spain (Idiazabal, Palmero, Majorero and other Canarian cheeses) and Greece (Kefalotyri, Feta) Other traditional clotting agent is vegetable rennet (Sanjuan et al., 2002) used in Spain (Torta del Casar, Serena, Pedroches and Queso de Flor de Guia), Portugal (Serra d'Estrela and Serpa)

The most important reasons for changing from natural rennet coagulants (animal or vegetable) to commercial products (such as commercial animal rennet, vegetable aqueous rennet, microbial origin rennet and recombinant chymosin) are related to microbial safety and the needs of standardized cheese. All types of rennet can be useful depending on the type of cheese:

a) Industrial cheeses without any PDO or PGI: milk normalisation and pasteurisation allows the standardization of cheeses making process and the final chemical and sensorial characteristics. Milk coagulation should be done with standard rennet and culture starters. Over the past few decades recombinant chymosin has been widely used and some of the researches completed did not find differences in rheological or sensorial characteristics of the cheeses (Núñez et al., 1992).

b) Industrial or semi-industrial cheeses included in a quality label (PDO or PGI): in these cases cheese must comply with the specification requirements. For these products it should be necessary to obtain rennet pastes and strain starter cultures from the traditional cheeses in order to reproduce the characteristics of the protected cheeses. Much research has been done on these topics with reference to Majorero PDO goat cheese (Requena et al, 1992; Calvo & Fontecha, 2004; Calvo et al, 2007; Castillo et al, 2007). Other research had been done by Hernández et al, (2001) concerning the use of commercial lipases to obtain the characteristic "natural rennet paste" flavour of Idiazábal PDO sheep cheese. It is necessary to take into account that, before being used by cheesemakers, research results must be validated by the official tester panel of the Regulatory Council of the Protected Origin Denomination or Geographical Indication.

c) Traditional raw handmade cheeses, with PDO or PGI (this can also be a recommendation for non protected cheeses, but it depends on production objectives of cheesemakers): in these cases traditional rennet (animal or vegetable) should be employed and no starter culture should be added. Rennet pastes must be prepared in traditional method; it is recommended that a test be done for total milk coagulation activity and microbiological analysis. The latter should be done to ensure that it conforms to the legal microbiological standard (in Spain, BOE nº 26/02/96). During kidding period(s) abomasus can be collected, prepared and conserved, so they will be used throughout the year. For each PDO cheese some research support will be necessary to determine the lipolytic and proteolytic activity throughout storage and the conditions under which they are kept (Bustamante et al, 2000; Virto et al, 2003). Another aspect to control includes the age at slaughtering, the diet of suckling animals, paste preparation and slaughtering conditions (Pireda & Addis, 2003; Addis et al, 2005 a,b; Sandillo et al, 2005).

There has been some research conducted to compare rennet pastes with commercial ones:

Effects in fat fraction: traditional rennet pastes, compared with commercial animal rennet, increase the concentration of total FFA, but also show a significantly higher percentage of short-chain FFA, (Larráyon et al, 1999; Bustamante et al, 2000; Virto et al, 2003; Moatsou et al, 2004; Fontecha et al, 2006).

Effects in protein fraction: using a comparable amount of total milk coagulating activity, lamb rennet was as proteolitic as bovine rennet in Canestato and Idiazabal cheeses (Santoro & Faccia, 1998; Bustamante et al, 2003), other results show higher levels of proteolysis in Idiazabal (Vicente et al, 2000) and Roncal (Irigoyen et al, 2002) cheeses; in contrast, Candreli et al, (1997) found that traditionally prepared kid rennet pastes gave significantly lower levels of soluble nitrogen. The casein fraction was affected by the type of rennet in Roncal cheese (Irigoyen et al, 2000) and Idiazábal cheese (Bustamante et al, 2003) and were not affected in other experiments involving other Idiazábal cheeses (Vicente et al., 2000). Vicente et al. (2001) found significant differences in total and individual concentrations of free amino acids, while Bustamante et al, (2003) only found evidence of variations in a few free amino acids. These differences between these results can be due to

differences in the raw ovine milk composition and the cheese manufacturing plant (although both were manufactured for the PDO Idiazábal cheese label). Variations in rennet effect may also be due to the rennet characteristics, the analysis method, factors involved (ripening time, season etc.), the size sample and also statistical analysis.

Effects in Sensory evaluation: The increase of lipolysis origin cheeses with higher intensity scores for strong sensorial attributes with the characteristics of pungent and "natural rennet" flavour or "pecorino" or goat taste (Woo & Lindsay, 1984; Candreli et al, 1997; Bustamante et al, 2000; Virto et al, 2003). In Idiazabal cheese, odour and flavour descriptors were affected (except acid flavour descriptor), but not texture parameters (Virto et al, 2003). In goat cheeses, colour and instrumental texture was affected by type of rennet; cheeses made with natural paste shown to be more easily broken, than cheeses made with commercial rennet which were harder and more elastic (Fresno et al, in press).

In some other traditional cheeses milk is clotted with vegetable rennet, dry flowers, (in the past wild flowers and now wild or cultivated), thistles (*Cynara L.,spp*, mainly *Cynara Cardunculus*, *Cynara humilis* and *Cynara scolymus*) but also other vegetable species such as papaya (*Carica papaya*), pineaple (*Ananas comosum*), fig-tree (*Ficus carica*), *Solanum dobium*, *Opuntia ficus indica*, *Diffenbachia maculate*, and spices from *Eurphorbia*, like *E. serrata*. These products contribute to the specific characteristics of some local cheeses. There are some studies that demonstrate the effects of this coagulant in chemical composition of cheeses but sensory studies are limited. No effect in chemical composition had been found in sheep milk such as Portuguese cheeses (Sousa & Malcata, 1997), Flor de Guía, Spanish cheese from mixed milk from the Canary Islands (Álvarez et al, 2001), sheep milk cheese made in Australia (Shao Jian et al, 2003) or Los Pedroches cheese made with sheep milk (Tejada & Fernández Salguero, 2003). However, some differences were reported by Sanjuán et al, (2002) in another study about Los Pedroches cheese and Núñez et al, (1991) about La Serena cheese. Most authors suggest that there is greater proteolysis in vegetable rennet (cyprosin) than in animal rennet (chymosin). Cheeses made with cardoon used to be creamier, softer and with differences in bitterness, less bitter in Australian cheeses (Shao Jian et al, 2003) and more so in Canarian cheeses (Álvarez et al, 2001). Other researches has been done concerning the comparison of different spices of *Cynara spp* in cheese characteristics (Viroque et al., 2000) and about the characterization of different cardoon, wild or cultivates (Viroque & Gómez, 2005) and it uses in cheesemaking.

As a final refection, the choice of rennet should depend on the desired characteristics of the cheese. Traditional coagulants contribute to a genuine texture, taste and flavour. New rennet or cultures in branded products must be well validated by the official panels of the protected cheeses before they are introduced in cheesemaking.

Smoke effect

Smoking, together with drying and salting, is one of the oldest food preservation techniques (Barylko-Pikelna, 1977). Smoke has an antioxidant and a bacteriostatic action; it also dries the rind of the cheeses and contributes to their conservation (Ahmad, 1993). In modern food technology smoking is no longer considered as food preservation practice and the primary purpose of this technique is to give the product a characteristic taste, texture and appearance. Where smoked products are concerned, the most important feature of consumer choice is the distinctiveness in the sensory properties (Mohler, 1980).

In the past (Fresno et al, 2004), and also in some present cheeses (Drozdz, 2001), smoking was done on a shelf hanging above the fire in the shepherd's hut. Later, with the introduction of electric or gas kitchens, cheese-makers used mini kilns or smoking chambers

and the smoke was generated with different woods or vegetable products of the region. Cheese factories use modern smokehouses that use different smoke generators such as friction smoke and wet smoke generators.

Smoked foods are sometimes suspected of containing contaminants as polycyclic aromatic hydrocarbons (PAH), harmful to human health (Guillén et al, 1997); and for this reason the food industry has started to use smoke flavourings (Guillén et al, 2000), although some European countries, as Spain, forbid the use of smoke cheeses.

Some studies have been made on the presence of PAH in traditional smoked cheeses and their results show that they do not exceed the limit fixed (Garcia Falcón et al, 1999; Anastasio et al, 2004; Guillén & Sopelana, 2004; Guillén et al, 2004a,b; Guillén et al, 2005). It can therefore be deduced that smoking is an interesting practice if the pyrolisis temperature is controlled and the smoking chamber is clean. Furthermore, other authors have found higher concentrations (Bosset et al, 1998; Pagliuca et al, 2003). It is necessary to note that contamination is higher in the rind than in the interior of the cheeses and the rind is not normally consumed.

Smoking techniques play important role in the development of new products (Mc Ilveen & Vallely, 1996a,b; Bárcenas et al, 1998), smoke flavourings are frequently used as novel flavours for products not previously smoked (Ojeda et al, 2002). Comparison between natural and liquid smoked cheeses had been completed (Atasever et al, 2003).

Many traditional cheeses are currently, or used to be smoked; the vegetable matter, temperature and humidity of the smoke and the physicochemical characteristics of the cheese are the main factors that can modify the characteristics of the cheese.

Under experimental conditions, smoking materials did not have a significant effect on pH or total fat, protein and dry extract (Álvarez et al, 2005). During the smoking process there is an increase of lipids and proteins in the cheese rind, (Ahmad, 993) while moisture decreases (Álvarez et al, 2005)

Vegetable matter used for smoking has a significant effect in the volatile components of cheeses and can be of interest as marker compounds for the identification of the different cheeses (Guillén et al, 2003). In traditional Palmero PDO cheese smoked with needles of canary pine (*Pinus Canariensis*), more than 320 components that play an important role in the flavour were detected. This cheese is the only PDO cheese that had regulated the use of different smoking materials in their making practice: dry needles and dry wood of canary pine (*Pinus Canariensis*), dry segmented prickly pear cactus (*Opuntia ficus indica*) and shell of almonds (*prunus dulcis*).

Smoking has an important effect in sensorial properties of cheeses. Surface colour is one of most attribute affecting the consumer acceptance of smoked cheese (Riha & Wendorff, 1993a). Colour is related with pH and moisture of cheeses, temperature and time of smoking process (Möhler, 1980, Riha & Wendorff, 1993b) and the vegetable matter used for smoking (Ruiter, 1979). Canarian experimental cheeses smoked with six different products showed differences in rind colour (Álvarez et al, 2004), that were also appreciated by a consumer panel (Fresno et al, 2006a). Smoke also produces changes in textural properties of cheeses; higher smoke temperature origins softer and melted cheeses (Mc Ilveen & Vallely 1996). Vegetable matter also has an effect in sensorial analysis of texture (Fresno et al, 2006b). The odour and taste of cheese is affected by the smoking process, not only due to the volatile compounds of the smoke but also because the different reactions between the smoke and the cheese chemical components, these differences can be observed by trained panels (Fresno et al, 2005).

As a conclusion, the possibilities of smoking cheeses and all the variation of different sources can be used to characterize the traditional smoked cheeses and the different sensorial properties which could help them to improve their market position. The use of local matter for smoking can help to link this product to the place in which they are made. New cheeses with different flavours can be developed using traditional smoking practices (or smoke flavouring in countries where they are allowed).

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Changes in microbiological, rheological, chemical and sensory qualities of soft goat milk cheeses during frozen and refrigerated storage

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Summary

Quality of goat milk cheeses can be influenced by a multitude of conditions including chemical, physical, microbiological, rheological and organoleptic changes before, during and after manufacture. Microbial, rheological, chemical and sensory qualities of commercial US soft caprine milk cheeses were investigated during different frozen and refrigerated storage treatments. Three different lots of commercial soft goat cheeses were purchased, and subdivided into 3 equal portions per lot. One portion was stored at 4°C as the nonfrozen control, and the other two were immediately frozen (-20°C) for 0, and 3 months, then subsequently thawed the next day at 4°C and stored at 4°C for 0, 14 and 28 days. Changes in microbial populations were enumerated for total aerobic, *E. coli* and coliform, yeast and mold, and *Staphylococcus aureus* using 3M petrifilm techniques. Rheological properties were determined for meltability, texture profile analyses (TPA), dynamic analysis, and torsion analysis. Descriptive sensory properties were evaluated by a trained panel. Flavors and tastes were scored on a 10-point Spectrum intensity scale. No significant differences were found in microbial profiles between fresh and frozen-thawed cheeses for 4 wk storage, while total aerobic counts tended to decrease. *E. coli*, coliform, and *Staphylococcus aureus* in soft cheeses were non-detectable <1.0 (log cfu/g). The frozen-thawed cheeses had significantly lower rheological properties relative to fresh control. Frozen-thawed ones tended to have lower torsion values than the fresh, while both groups had similar torsion values in 3 mon frozen cheeses. Lipolysis of the cheeses increased with the extended refrigeration storage at 4°C. After 2 weeks storage at 4°C, cooked/milky, diacetyl, and milkfat flavors decreased while yeasty and oxidized flavors increased in soft goat cheeses ($P<0.05$). The fresh soft cheeses had a sensory quality shelf life of less than 1 month at 4°C. Freezing had little effect on the sensory quality, while subsequent refrigeration after-thaw showed a gradual deterioration on cheese quality.

Keywords: *Soft goat cheese, freezing, refrigerated storage, food quality, sensory property*

Introduction

Extension of shelf-life for caprine milk cheeses is greatly important for the sustainability and profitability of the dairy goat industry due to the seasonality of goat milk production (Park et al, 2002). It is desirable to explore the feasibility of extended storage of goat cheeses for later marketing, including frozen-storage.

Consumers are conscious about the safety of dairy foods including goat milk and its cheeses due to their susceptibility to microbial contamination. Despite intense hygienic efforts, contamination of raw milk by pathogenic microorganisms cannot be completely eliminated. Most

dairy product outbreaks have been transmitted via raw or improperly pasteurized milk (Griffiths, 1989; Johnson et al, 1990).

Rheology is one way to quantify the texture of food and have some correlation to sensory texture scores (Hamann, 1988). Texture profile analysis (TPA) uses a double compression method to mimic chewing and provides researchers with information on the hardness, springiness, and cohesive nature of the cheese (Bourne, 1978; Tunick et al., 1993). Small strain dynamic analysis applies repetitive small strain to the sample to evaluate viscoelastic properties of the cheese (Hamann, 1988; Ma et al.,1996). Specific texture attributes have been less frequently related to liking of cheeses such as Cheddar.

Sensory properties of goat milk cheeses would be important determining factor for consumer acceptability and marketability of the products. Most of the sensory and textural attributes in cheeses increase during ripening. Grading and judging can be extensively used by the dairy industry for quality evaluation of all dairy products (Bodyfelt at al., 1988). Sensory quality such as total aroma intensity was well correlated by chemical indices such as organic acids and volatiles (Califano and Bevilacqua, 1999).

Although numerous varieties of goat milk cheeses are produced and consumed worldwide, a paucity of research data has been available on microbiological, rheological and sensory qualities of commercial caprine cheeses during extended frozen and refrigerated storage in the perspectives of consumer and scientific validation. Therefore, the objectives of this report are to: (1) determine microbial, rheological, chemical and sensory characteristics of nonfrozen, 0 and 3 months frozen-stored and then refrigerated soft goat milk cheeses, and (2) investigate if any relationships exist among these food quality indices with respect to storage quality and shelf-life for extended and year-round marketing of the products.

Materials and Methods

Preparation of soft goat milk cheese sample

Three batches of commercial soft goat milk cheeses were purchased, and the cheeses were manufactured using a modification of the method of Le Jaouen, (1987). Goat milk was pasteurized at 145°F (62.8°C) for 120 minutes and by slow coagulation and natural draining, then hanging the cheese in cheesecloth for three days in cool room (22°C) before packaging. The cheeses were packaged in 1 pound rod shapes with polyolefin shrink wrap, then shipped to the analytical laboratories in an ice pack box via overnight delivery service.

Experimental design and treatments

Three lots of the commercial plain soft goat cheeses were assigned to three different storage treatments. Each lot of the goat cheeses was divided into 3 equal portions. One subgroup (fresh nonfrozen) of the each variety was stored in a refrigerator at 4°C for 0, 14 and 28 days. The other 2 subgroups were immediately frozen (-20°C) for 0 and 3 months, subsequently thawed the next day at 4°C, and then stored in the same way as the nonfrozen control samples. Each lot of the soft cheeses was divided into different quantities and sent to different laboratories, and subjected to microbiological, lipolytic, organic acids, rheological and sensory analyses.

Analyses of food quality parameters

1. Microbiological Analysis:

3M Petrifilm plates techniques were used to enumerate microbial populations as recommended by the manufacturer (3M Products, 1999). An 11 g of cheese sample and 99 ml diluent (phosphate buffer, KH_2PO_4 0.0425 g/L, adjusted to pH 7.2) were blended in autoclaved blender cup, and then serially diluted in the same buffer.

Total bacterial counts; The Petrifilm aerobic plate count (APC) was obtained using Petrifilm plate count medium with incubation at 32°C for 48 hours. Petrifilm plates having heterofermentative lactic acid bacteria were enumerated on a standard colony counter (Bantex Model 920A).

E. coli and coliforms were enumerated using Petrifilm *E. coli*/coliform count (EC) plates with incubation at 35°C for 24 hours. Yeast and molds were determined by using Petrifilm yeast and mold count plates with incubation at 22°C for 3-5 days.

Staphylococcus aureus was determined by plating on Petrifilm Rapid *S. aureus* count plates with incubation at 35°C for 24 hours, then the plates were transferred to another incubator at 62°C and incubated for 1-4 hours. The Petrifilm with inserted reactive disks were incubated for 1-3 hours at 35°C. Typical *S. aureus* colonies were enumerated on the Petrifilm plates using the same colony counter (Bantex Model 920A).

2. Chemical analysis:

Acid degree values (ADV), pH and organic acids were analyzed for all samples. The ADV refers to measure of the amount of free fatty acids present in a fat sample, which is a quantitative index of hydrolytic lipolysis in dairy products. ADV was assayed by the Standard Methods for the Examination of Dairy Products (Richardson, 1985).

Organic acids of the cheese samples were extracted, filtered through 0.45 μm membrane, and analyzed using a Hewlett Packard Liquid Chromatography (LC-1100 Series) by the methods of Bevilacqua and Califano (1989) and Park and Lee (2006).

3. Rheological analysis:

Texture profile analyses (TPA) of samples were conducted using a Sintech universal testing machine. Hardness, springness, and cohesiveness were calculated *Torsion* data was collected using a torsion operating at 2.5 rpm. Sample plugs were cut and milled to the appropriate capstan shape. Samples were placed in the Gelometer and the shear stress, shear strain, and shear rigidity (stress/strain) at the point of fracture was measured.

Small strain dynamic analysis was conducted using a Rheometrics Dynamic Analyzer, (Model RDA-700, Rheometrics Scientific, Piscataway, NJ). Elastic (G') and viscous (G") moduli and complex viscosity ($\tilde{\eta}^*$) were recorded.

4. Sensory Evaluation:

A sensory panel (n=7, 6 females, 1 male) evaluated the cheeses using a previously published lexicon for cheese flavor adapted for goat cheeses (Drake et al., 2001). University staff and students who were interested, had available time, and liked cheese were selected as panelists. Panelists had each received 150 h training on aroma and flavor evaluation of cheeses, including soft goat cheeses. Flavor and taste intensities were scaled using a 10-point intensity scale with the Spectrum™ method (Drake et al., 2001).

Statistical analysis

Experimental data were analyzed for analysis of variance, correlations between parameters, and least squares mean comparison among treated goat cheeses as described by Steel and Torrie (1960). All data were also analyzed using General Linear Model of SAS program (SAS, 1990).

Results and Discussion

Freezing did not have significant impacts on total aerobic bacterial counts (TPC), nor on mold counts, while it reduced yeast count significantly (Table 1). Yeast counts tended to increase with aging time, while mold counts increased at 14 day then decreased for nonfrozen control cheese. The initial TPCs between the control and frozen storage groups were not significantly different, but the TPCs were decreased during the 28 days refrigerated aging period for both nonfrozen and frozen storage treatments. This reflects a die-off of TPCs from the lactic culture bacteria used in the manufacture of the cheese, as well as the secondary microflora from the milk and other possible contaminants during processing. Wendorff (2001) reported similar observations with frozen stored ovine milk, where standard plate counts and coliform counts decreased with extended storage time and microbial storage stability was greater with lower freezing temperatures.

Table 1. Total bacteria, yeast and mold counts (log cfu/g) and pH in commercial soft goat cheeses stored fresh nonfrozen and frozen-thaw, then aged at 4°C for 4 wks.

Storage Treatment	Aging 4°C (day)	N	TPC Mean	TPC SD	Yeast Mean	Yeast SD	Mold Mean	Mold SD	pH Mean	pH SD
Fresh nonfrozen	0	9	8.93	0.68	4.80	0.40	3.20	0.17	5.79	0.177
	14	9	6.00	0.61	5.83	0.40	3.37	0.63	6.07	0.177
	28	9	5.87	0.74	6.17	0.68	3.17	0.29	6.03	0.177
Frozen-Thaw	0	9	8.30	0.46	4.03	0.91	3.00	0.00	5.95	0.177
	14	9	5.80	0.96	4.36	1.72	3.17	0.29	6.00	0.177
	28	9	6.17	0.75	5.86	1.36	3.10	0.17	5.95	0.177

TPC: Total plate (bacteria) count; SD: Standard deviation

E. coli, coliform, and *Staphylococcus aureus* in the soft goat cheeses were non-detectable <1.0 (log cfu/g). These results indicate that the commercial soft caprine cheeses may not have a food safety concern in consumer perspective, and no sign of the post-processing contamination of harmful bacteria in the products.

The experimental soft cheeses were too fragile to conduct torsion analysis. Frozen-thawed soft cheeses tended to have lower torsion values than fresh ones, while the 3 month frozen group had similar torsion values or slightly higher than the fresh (Table 2). The differences were small due to high standard deviation, whereby this trend did not hold for TPA results from 0 to 14 and 28 days. However, it did hold for viscoelastic properties such as G', G", and η* values (Table 2). The soft goat cheeses showed slight variation in TPA hardness and chewiness. Cervantes et al. (1983) reported that Mozzarella cheese was not significantly affected by freezing and thawing after one week of frozen storage, as assessed by compression, beam bending and sensory evaluation.

Table 2. Summary of mean rheological index values for fresh, frozen-thawed and 3 month frozen stored plain soft goat milk cheese.

Treats	Aging	Hard[a]	Spring[b]	Cohes[c]	Chew[d]	G'	G"	η
Fresh	Day 0	10.63	10.01	0.10	9.33	15.86	5.28	1.75
	Day 14	13.50	10.05	0.11	13.67	17.03	5.48	1.79
	Day 28	10.83	10.16	0.07	8.67	17.53	5.73	1.84
Frozen-Thaw	Day 0	7.46	10.20	0.08	5.33	15.03	5.05	1.59
	Day 14	11.57	10.25	0.15	14.33	12.02	4.08	1.34
	Day 28	11.63	10.67	0.11	13.67	11.37	3.69	1.20
3 Month Frozen	Day 0	12.27	9.93	0.12	14.33	16.24	5.50	1.72
	Day 14	12.27	10.65	0.10	12.67	16.68	5.61	1.76
	Day 28	11.83	10.40	0.10	11.33	16.70	5.44	1.76

[a]Hardness; [b]Springness; [c]Cohesiveness; [d]Chewiness
G': Elastic modulus (kPa); G": Viscous modulus (kPa); η: Complex viscosity (kPa.s)

Table 3. Comparison of effects of nonfrozen and frozen storage and refrigeration aging at 4°C for 4 weeks on sensory property scores of plain soft goat cheeses.[1]

Flavor characteristics	0 day			14 days			28 days		
	Fresh	Frozen-thaw	3 Mo frozen	Fresh	Frozen-thaw	3 Mo frozen	Fresh	Frozen-thaw	3 Mo frozen
Cooked/milky	2.3a	2.3a	2.3a	2.0b	2.0a	2.3a	1.7c	1.7c	2.0a
Whey	2.0a	2.0a	2.0a	1.6b	1.7a	2.1a	1.0c	1.0b	1.5b
Milkfat	3.0a	2.9a	2.5a	2.5b	2.5a	2.4a	1.8c	1.9b	1.9b
Waxy/animal	3.0a	3.1a	2.5a	3.0a	2.9a	2.6a	2.8a	2.8a	2.6a
Brothy	0.5b	0.7b	0.7b	1.0a	0.9a	1.0a	1.0a	1.0a	1.0a
Yeasty	0.0c	0.0c	0.0c	1.0b	1.0b	0.5b	3.8a	2.0a	2.0a
Diacetyl	1.5a	1.1a	0.9a	1.0b	0.5b	0.5b	0.2c	0.2c	0.5b
Sweet	2.0a	2.0a	2.0a	1.9a	1.5b	1.5b	1.0b	1.0b	1.1b
Sour	3.7a	3.7a	3.8a	3.7a	3.8a	4.0a	3.0b	3.0b	3.8a
Salty	3.3a	3.3a	3.1a	3.5a	3.5a	3.1a	2.5b	2.8b	2.8b
Oxidized	0.3c	0.3c	1.0c	1.1b	1.7b	1.9b	2.8a	2.8a	2.8a
freshness	7.5a	7.0a	7.5a	5.0b	5.1b	6.5b	3.0c	3.2c	5.4b

[1]Data taken from Park and Drake (2005)

Both of the initial nonfrozen and frozen-thaw cheeses for 0 day refrigeration at 4°C were significantly softer and less chewy than the cheeses stored at frozen temperature for longer periods (3 months and beyond). In overall, freezing had a little effect on the rheological properties measured using TPA. Martin-Hernandez et al. (1990) observed no difference in the hardness (0.35 to 0.37 kg/g) of rennet-set brine-salted caprine milk soft cheese after 4 months frozen storage. Verdini and Rubiolo (2002) also reported that 2 mo of frozen storage had no effect on the rheological properties of bovine milk Port Salut Argentina (soft) cheese.

Sensory evaluation scores indicated that the differences among the 3 storage treatment groups were generally not significant. However, aging under refrigeration caused declining most of the flavor scores including cooked/milky, diacetyl, milkfat flavors, brothy, waxy, sweetness, sourness, saltiness and freshness for 2 weeks aging at 4°C, while yeasty and oxidized flavors increased ($P<0.05$) (Table 3). The sensory quality of the shelf life fresh soft cheeses appeared to be less than 1 month at 4°C.

Some sensory scores and rheological properties were significantly ($P<0.05$ or 0.01) correlated each other (Table 4). Sour flavor had significant r values with chewiness, elastic modulus and cohesiveness. Sweetness was negatively correlated with springness ($P<0.01$), and saltiness was positively with complex viscosity ($P<0.01$), while r values between all other parameters appeared to be not significant.

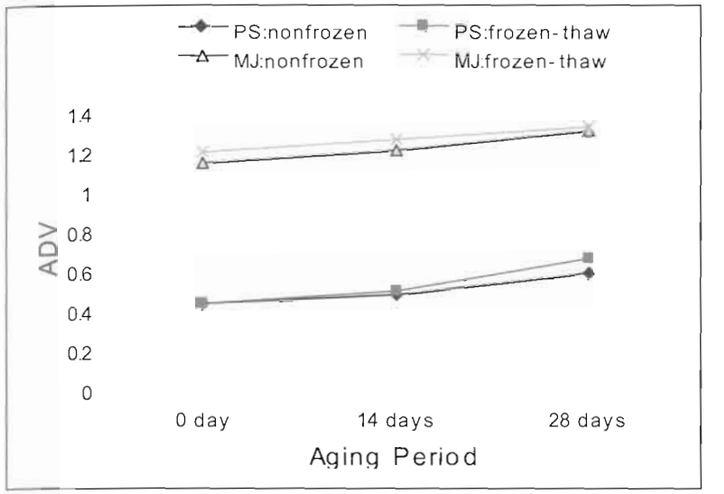
Table 4. Correlations (r) between sensory and rheological properties of fresh and 3 mon frozen-stored soft goat milk cheeses.[1]

Sensory property	Rheological property	r	Significance level
Sweet flavor	Springness	-0.9975	0.0453
Sour	Chewiness	0.9991	0.0270
Sour	Elastic modulus	0.9999	0.0054
Salty	Complex viscosity	0.9999	0.0011

[1]Pooled data of 27 cheese samples.

Figure 1. Acid degree values (ADV) on nonfrozen and frozen-thawed goat milk cheeses aged at 4°C for 4 weeks (Park and Lee, 2006).

Freezing did not affect the initial stage of pH and ADV in the goat cheeses. However, ADVs gradually increased as the refrigerated storage extended up to 4 weeks, indicating that lipolysis elevated with the extended refrigeration storage at 4°C (Fig. 1).



In the light of organic acid contents, tartaric, citric, uric and propionic acids were increased after 3 months frozen-storage, while formic and malic acids were decreased. Differences between treatments were significant ($P<0.05$ or 0.01) for acetic, propionic, and unknown peaks 6 and 8 (probably propionic isomers) acids. Several unknown organic acid peaks appeared in the HPLC chromatogram, but the standards for those peaks were not available, while some of them were in significant quantities.

Table 5. Correlation coefficient (r) between selected sensory property scores and levels of different organic acids for the experimental soft goat cheeses.[1]

	Tartaric acid	Formic acid	Malic acid	Acetic acid	Citric acid	Propionic acid
Goaty/waxy	-0.999**	0.983	0.984	0.637	-0.912	-0.505
Sour	0.992	-0.997*	-0.873	-0.715	0.863	0.410
Salty	-0.595	0.746	0.252	0.999**	-0.234	0.373
Whey	0.940	-0.850	-0.999**	-0.316	0.998*	0.783
Brothy	0.564	-0.383	-0.831	0.298	0.842	0.998*
Milkfat/lactone	-0.846	0.719	0.984	0.106	-0.986	-0.897

*Significant at $P<0.05$; **Significant at $P<0.01$

[1]r values were calculated between the pooled means of sensory scores and those of organic acids for each experimental units (Data taken from Park and Drake, 2005).

Some of correlations between organic acids and sensory scores were significant ($P<0.05$ or 0.01), including r values between tartaric acid and goaty/waxy flavor, formic acid and sour taste, acetic acid and saltiness, citric acid and whey, malic acid and whey, malic acid and cooked milky flavor, propionic and brothy flavor, and some unknown acids (2 unknown peaks) and milk fat lactone flavor (Park and Drake, 2005; Table 5).

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Impact of the use of chest-nut (*Castanea sativa*) leaves on sensory characteristics of Mothais sur feuille French goat cheese

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Summary

Mothais sur feuille is a soft lactic cheese made with raw goat milk and traditionally ripened on a chest-nut leaf. The legitimacy of the use of a chest-nut leaf during the cheese processing has been questioned and sometimes abandoned due to sanitary regulations. The impact of setting a chest-nut leaf under the "Mothais sur feuille" cheese on microbiological, physicochemical and sensorial characteristics of the products was studied for the PDO recognition process of the context of French goat cheese. The microbiological assays revealed that there was an absence of pathogens on the leaves, indicating that the leaves were collected in good hygienic conditions. A high variation of yeast and mould counts was observed according to the harvesting areas. Subsequent results showed that the leaf has to be placed in early cheese manufacturing process (before ripening) to induce significant benefits on sensory characteristics of the cheese. Sensory analysis evidenced greater typical flavour and thinner rind and fondant texture. In addition, boiling the leaves in a water bath as a sanitary treatment was tested not only to ensure microbiological quality against pathogens but also to examine alteration bacteria such as *Pseudomonas*. Sanitary treatment did not reduce benefits gained by the leaf. These results show the importance and the technological role of chest–nut leaf, either treated or non-treated, in the manufacturing processes of "Mothais sur feuille" goat cheeses.

Keywords : goat milk cheese, chest-nut leaf, flavour, Mothais sur feuille, heat treatment

Introduction

Mothais sur Feuille cheese is a traditional raw goat milk cheese produced in Poitou-Charentes, France. It is a disc of 10-12 cm diameter weighing 180-200g. Known since 1840 at least on local markets, a PDO recognition procedure has been engaged (Le Jaouen, 2005). This fondant soft lactic cheese is presented on a chest-nut or, more rarely, on plane tree leaf, which constitutes one of its main characteristics. More than decorations, leaves may constitute a protected ripening surrounding such as for French goat cheese Banon, totally packaged in chest-nut leaves. Leave can also serve as a blotting paper as for Mothais sur Feuille cheese. Finally, some of them may have antiseptic properties such as *Laurus nobilis* on French ewe milk cheese (Froc, 2002). Nevertheless, few data concern technological interest, microbial profiles and sanitary treatment of leaves. Works are more consequent on wood to prove its usefulness in flavour development of cheeses. For instance, use of wooden container « gerle » during milking for Salers, a French cow milk cheese, or use of wooden mould for Piacentinu cheese, a Sicilian ewe milk cheese (Carpino et al, 2007), or use of wooden shelf during ripening for hard cheeses (Boulanger, 2006) enhances their typical flavours. The purposes of this study were to (1) characterize and ensure hygienic quality of chest-nut leaves, and (2) prove the role of chest-nut leaves in manufacturing process of Mothais sur Feuille goat cheese.

Material and methods

Preparation of leaves samples

Chest-nut leave samples were collected from four different cheese producers to characterise microbial composition of the leaves, especially in the case of use of raw leaves. Harvesting and storage conditions of the leaves for these four producers were representative of the most frequent uses (according to a previous survey). The samples were collected at two periods in January and March, 2002.
The effect of heat treatment (90°C/1 min) of leaves on their microbiological composition was studied using the samples from two producers among the four ones, and the impact of heat treatment of the leaf on cheese quality was evaluated on samples from 1 producer among the 4 (cheeses were made with a same batch of leaves).

Experimental treatment of leaves in cheese making:

In order to appreciate leaf benefit and impact of sanitary treatment, five different treatments were applied for manufacturing process of the Mothais sur feuille goat cheese as follows: No leaf (control: C) placed after the day of mould removing (D), Untreated leaf placed early on the 2^{sd} day after mould removing (D2) or after ripening stage on the 10th day after mould removing (D10), and Heat-treated leaf also placed on D2 or D10. The same milk was used and all cheese making steps were strictly identical for all the 5 batches.

Analytical methods for microbiological, chemical and sensory assays:

Microbiological analyses were performed on heat treated of non-treated leaves, raw milks, fresh cheeses (D2) and ripened cheeses (D17) just before sensory analysis. The main microorganisms analysed were: total bacteria count (IDF 100B:1991), psychrotrophic bacteria (IDF 101A, 1991), *Pseudomonas* spp and *Ps. fluorescens* (NF V04-504), yeast and moulds (IDF 94B), +coagulase *Staphylococcus* (NF V08-057-2), coliforms (NF V08-050 for cheeses, coli ID Biomerieux at 30°C for leaves), *E. coli* (rapidE from Biorad SDP – 07/1-07/93 for cheeses and coli ID Biomerieux at 37°C for leaves). *Listeria monocytogenes* (SDP 07/3-01/98 for cheese, ALOA from AES, V03-100 for leaves) and *Salmonella spp* (SDP 07/2-06/96 for cheeses and ASAP V08-013 and V08-052 for leaves) were applied. Leaves (mix of 10 leaves) were infused in NaCl tryptone diluents and submitted to stirring with a Stomacher apparatus before analyses.

The moisture of leaves (mix of 10 leaves) was determined. Biochemical analyses were conducted on goat milk and cheeses (mixes of 2 cheeses) according to Gaborit et al (2001). Dry matter and pH were determined on fresh cheeses just after mould removing, and on ripened cheeses at the 12th day after mould removing (D12) and at the 17th day after mould removing (D17) which corresponds to ½ shelf life of cheese. Fat and lipolysis were analysed on ripened cheeses.

Sensory analyses were conducted with a trained panel specialised for goat milk cheeses at ENILIA (according to AFNOR V09-105 norm) on D17 cheeses. 36 descriptors (14 for flavour, 7 for odour, 9 for texture and 6 for aspect) were evaluated on a 0-10 scale. Moreover, a professional panel (mainly cheese makers) evaluated D17 cheeses and D38 (6 week old) cheeses.

Results and discussion

Microbial characteristics and variability of chest-nut leaves:

Table 1. Microbiological profile of chest-nut leaves (4 producers) harvested at 2 periods.

	Unit	Geometric mean			Min	Max
		Total	Period 1	Period 2		
Total bacteria count	CFU/g	$2.2\ 10^6$	$6.7\ 10^6$	$7.2\ 10^5$	$3.9\ 10^4$	$4.9\ 10^7$
Psychrotroph	CFU/g	$5.3\ 10^5$	$2.6\ 10^5$	$1.1\ 10^6$	$1.3\ 10^4$	$3.6\ 10^7$
Pseudomonas	CFU/g	$1.8\ 10^4$	$8\ 10^5$	$4.1\ 10^3$	Absent	$3.7\ 10^6$
Ps. fluorescens	CFU/g	$3.0\ 10^1$	$1.1\ 10^1$	$7.7\ 10^1$	Absent	$3.4\ 10^4$
Yeasts + Moulds	CFU/g	$2.6\ 10^5$	$5.1\ 10^5$	$9.0\ 10^4$	$6.5\ 10^3$	$3.1\ 10^6$
Yeasts	CFU/g	$6.5\ 10^1$	$4.2\ 10^3$	Absent	Absent	$4.0\ 10^5$
Blue moulds	CFU/g	$4.1\ 10^3$	$1.3\ 10^4$	$1.3\ 10^3$	Absent	$5.9\ 10^5$
Coliforms	CFU/g	$3.0\ 10^2$	$9.3\ 10^4$	Absent	Absent	$4.8\ 10^6$

The psychrotrophes, yeast and moulds were the most abundant microorganisms (Table 1). The mean moisture of leaves was 13% and ranged between 9% and 15%, these two extremes corresponding to the lower and higher microbial contents, respectively. A great variability was also observed among the four producers, probably related to the harvesting and storage conditions. It is particularly accentuated for *Pseudomonas fluorescens* and coliforms, presenting very high population (>500 000 CFU/g for 2 samples) when present (only 50% of the samples). No pathogen was found. Differences also occurred between types of mould (red, black moulds, *Mucor*...) between the four batches. Moreover, lower microbial populations were noted for the second sampling period for yeasts, coliforms and *Pseudomonas* (Table 1).

Impact of sanitary treatment on microbiological composition of leaves

Among three tested sanitary treatments, boiling water bath (90°C/ 1 min) was the most efficient one and was useful for the producer. The boiling water bath, enabling a 3 to 6 log reduction of each micro- organism group (figure 1), ensure hygienic quality of the leaves. This is useful for alteration of microorganisms and may be necessary in the case of presence of pathogens, which were nevertheless absent from all tested samples.

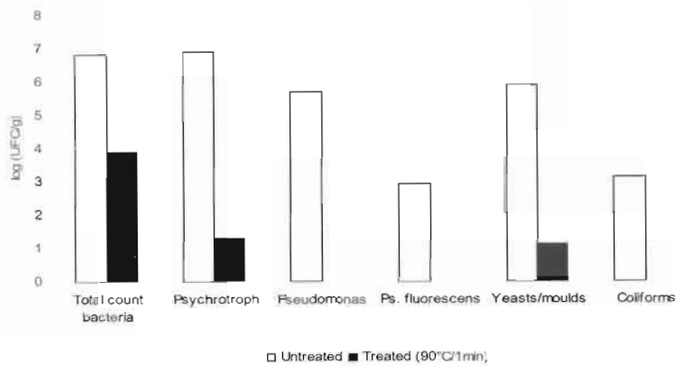

Figure 1. Efficiency of heat treatment to reduce microbial presence of chest-nut leaves.

Impact of the usage of leaves on cheese quality:
Cheeses with a leaf applied on the 2nd day after mould removing showed higher moisture content than the other cheeses (Table 2). This only difference was reduced thereafter.

Table 2. Biochemical composition of cheeses

	D12 (end of ripening)		D17 (sensory analysis)			
	pH	Dry matter (%)	pH	Dry matter (%)	Moisture in non-fat cheese (%)	Lipolysis (g Oleic Acid/100g Fat)
Untreated (D2)	5.11	39.8	5.28	43.0	73.0	0.69
Treated (D2)	5.06	39.7	5.38	41.5	74.5	0.68
Untreated (D10)	5.17	43.8	5.39	43.3	73.0	0.52
Treated (D10)	5.16	43.5	5.51	44.2	71.8	0.84
Control	5.24	43.0	5.52	44.1	72.2	0.93

Microbiological composition of cheeses was not affected by the use, the time of setting, and heat treatment of the leaves (boiling vs. non-boiling). The only difference concerned *Pseudomonas*, in lower proportion for untreated leaves placed at 2 days after mould removing. It could be related to a competition between *Pseudomonas* from the milk and microorganisms of the leaf. For cheese makings, initial contamination of leaves was quite low (as for the second sampling period of previous trials) which could explain these low differences.

Chest-nut leaf had an impact on sensory profile of cheeses when it was set early in the process. It induced more typical and persistent flavours of cheeses, especially for 6 week old cheeses evaluated by the professional panel. Trained panel found significantly higher yeast odour and flavour intensities for D2 cheeses (figure 2). Hazel nut and undergrowth flavour intensities, detected by the professional panel, were slightly higher for D10 cheeses. The texture was significantly more fondant with a lower rind thickness for D2 cheeses. The high moisture content for D2 cheeses enabled microbial enzymes production and could explain the higher fondant texture observed for D17 cheeses having same dry matter content. The same conclusions were drawn for treated or untreated leaves.

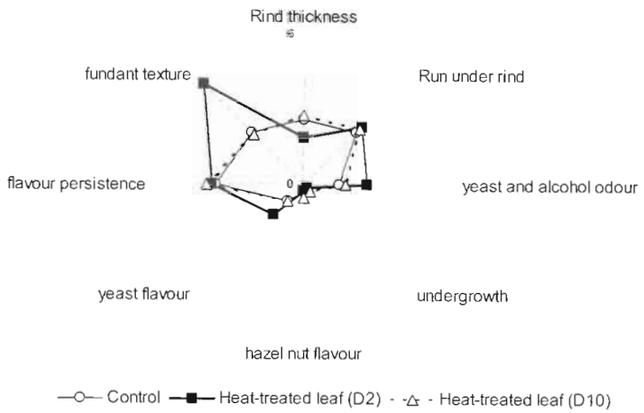

Figure 2. Sensory profiles (with trained panel) of cheeses with chest-nut leaf set at D2 or D10 after mould removing and control (without leaf).

Conclusions

A high variation in yeast and mould counts of chest–nut leaves was observed between different harvesting areas and storage conditions. In this study, no pathogen was found on leaves harvested according to specifications (including harvesting and storage conditions and self checking), even when total bacteria count was high. The leaf induces a greater typical flavour, thinner rind and fondant texture, especially when it is placed early during the process. Sanitary heat treatment did not reduce benefits gained by the leaf. Use of leaves with higher total bacteria count but without pathogens of the products in this cheesemaking might have enhanced differences in cheese flavour. These results may suggest the technological role of chest–nut leaf, treated or not, in the process of "Mothais sur feuille" goat cheese manufacture.

Acknowledgements

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Sensorial characteristics of Majorero P.D.O. cheese

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Summary

The sensorial attributes of cheese play a major role in product acceptability and influence the success of the product in the market. Majorero P.D.O. cheese is a goat milk cheese with limited production from the Canary Islands. It is very important to maintain the authenticity of the traditional cheese that makes it different from other goat cheeses. This study is included in a regional Project (DOQUECAN) for Canarian P.D.O. cheeses valorisation. The objective is to make an exhaustive description of sensory characteristics of Majorero P.D.O. cheeses. Cheeses from six representative producers were analyzed by a panel specifically trained for Majorero cheese. Texture, odour, flavour and taste were carried out from 15 days to 90 days ripening. Ripening time affected most sensory parameters analysed. As the cheeses matured and became drier they became rougher and more elastic. The odour and aroma intensity increased during ripening. This increase is associated with a progressive reduction of lactic descriptors as well as butter and dried fruit descriptors raised.

Keywords: goat cheese, P.D.O., sensorial analysis

Introduction

Majorero goat cheese is a typical product of Fuerteventura one of the seven Canary Islands (Spain) and is manufactured from Majorera goats' milk according to the specifications of its Denomination of Origin Regulatory Board. The quality of this cheese was recognised when it obtained the Majorero Cheese Designation of Origin in 1996. It was the first Canary Island cheese and the first Spanish goats' cheese to obtain this distinction.

Fuerteventura island has a rich farming tradition, and goats are very important to their economy. This cylindrical fat cheese could be consumed fresh (8-20 days of ripening) or semihard (20-80 days of ripening), weighing from 1 to 6 kilograms. Its surface is white in fresh cheeses changing to ivory colour in older cheeses. In the ripening process, cheeses could be re-covered by typical products as oil, cayenne pepper and ground toasted cereal. Its dough is compact when cutting, with a creaminess texture and slightly acid and pungent taste. They present a goat's milk characteristic flavour in fresh cheeses, developing to a more complex flavour in older cheeses.

Clearly, the sensorial quality of the food is what the consumer can identify and value (Issanchou et al., 1997). Although it may not totally govern acceptability, it is used as a decision tool in technological and economic aspects of acceptability. The sensory quality of a product or the degree of satisfaction which its consumption produces is the factor which attaches most value added to a product, and can only be evaluated using the sensorial analysis. Although the objectivity of sensorial analysis may be in doubt, it is the only direct method that is valid to measure organoleptic characteristics of a product (Piggot, 1995).

This paper is included in a strategic Project of the Canary Government for increasing the characterization and differentiation of Canarian P.D.O. cheeses, including studies of changes that occur during ripening and consumer preferences evaluations.

Material and methods

With the concurrence of professionals (veterinarians, farmers, cheese makers, and marketing agents), 6 cheese factories were selected for the quality and regularity of Majorero cheese production. A total of 72 Majorero goat cheeses were manufactured (12 from each cheese maker) to study sensorial characteristics during ripening. Cheeses were picked after 15, 30, 60 and 90 d of ripening. Three cheeses from each producer were used to study the organoleptic profile. Cheese samples were coded with a letter representing the respective dairy plant where they were manufactured, and a number. During ripening, the cheeses were stored in a ripening chamber at 10 to 12°C and 85 to 90% relative humidity. All of the samples were ripened by the respective manufacturers; for each time, cheeses were sent to the laboratory in refrigerated boxes and analyzed immediately to monitor changes.

Sensory analysis was carried out 2, 15 and 60 days after elaboration. Samples, coded with 3-digit random codes (Meilgaard et al., 1991), were presented balanced (Suriyaphan et al., 2001) to avoid the effect of the presentation order. The methodology employed has been previously described, with odour and flavour attributes in accordance with those described by Berodier et al., (1996), and texture following the guidelines published by Lavanchy et al., (1999). A panel of seven formally trained and highly experienced judges were used, who already work in collaboration with the Majorero P.D.O cheese sensory panel. Furthermore, before the beginning of this experiment, five extra training sessions with Majorero P.D.O. cheeses were performed.

The cheese samples presented were portions 1.5 cm thick x 1.5 cm wide x 5-8 cm long, with the rinds cut away. The size and shape of all pieces were identical. Two portions per sample were served; one to evaluate texture and the other to evaluate odour and flavour (Lavanchy et al., 1999). Serving temperature was 20±1 °C (Engel et al., 2000). Judges rinsed their mouth between the two samples using unsalted crackers, Granny-Smith apples and water with very low level of mineralization to remove any aftertaste.

The sensorial analysis was developed in a special room of the ICIA, following the instructions given by the Regulation UNE 87-004 (1979). Seventeen sensory attributes, nine for texture (roughness, surface moisture, elasticity, firmness, friability, adhesivity, solubility, moisture into the mouth and granulosity), eight for odour and flavour (acidity, saltiness, pungent, sweetness, bitterness, taste persistence, odour and flavour intensity) were scored on a structured scale from 0 to 7. In addition, each assessor was allowed to describe the odour and flavour of each sample by selecting descriptors from the following main family list: milky, vegetable, fruity, toasted, animal, floral, spiced and others (soapy, rancid and pungent in the nose).

For sensory variables, the effect of ripening time was analysed using the General Linear Model ANOVA procedure with SPSS for Windows version 13.0.

Results and discussion

The sensorial evaluation of Majorero cheeses are shown in Table 1 for texture attributes. Ripening time affected five of nine texture characteristics. Roughness and granulosity increased ($P<0.001$) throughout the maturation period, on of the values stabilising in the last thirty days. However, conversely, superficial and mouth moisture and elasticity decreased

(P<0.001) until ninety days of ripening. Fresh cheeses were more elastic than hard cheeses. This may be because of the higher fat content of 90 day cheeses (Gwartney et al., 2002; Kheadr et al., 2002).

- Nonetheless, firmness, friability, adhesivity and solubility values were very similar for the different types of cheeses. It is important to note that, contrary to other Majorero experimental cheeses (Álvarez, 2003), when Majorero P.D.O. cheeses became drier they did not became firmer and more crumbly. Comparable results were described by Piggot and Mowat, (1991), who did not detect those changes in texture in Cheddar type hard cheese.

Table 1. Sensorial texture characteristics of Majorero cheese

	Ripening time (R)					
	15d	30d	60d	90d		
	LSM				RSD	Effect
Roughness	2.27^{a}	2.73^{b}	3.21^{c}	3.45^{c}	0.05	0.001
Superficial moisture	3.45^{b}	3.16^{b}	2.73^{a}	2.51^{a}	0.06	0.001
Elasticity	3.02^{c}	2.71^{bc}	2.41^{ab}	2.08^{a}	0.06	0.001
Firmness	3.24	3.39	3.42	3.68	0.07	0.176
Friability	3.74	3.86	4.02	4.07	0.11	0.703
Adhesivity	3.29	3.55	3.64	4.51	0.19	0.136
Solubility	5.04	5.03	4.73	4.88	0.06	0.244
Mouth moisture	4.01^{b}	3.16^{ab}	2.68^{a}	2.84^{a}	0.13	0.001
Granulosity	2.38^{a}	2.48^{a}	2.85^{b}	2.88^{b}	0.05	0.001

LSM: Least square mean.
RSD: Residual standard deviation.
[a-d] Within a row, means marked with different superscripts differ significantly (p<0.05).

Ripening time affected nearly all the odour and flavour parameters analysed (Table 2). As might have been expected, odour and flavour intensity and also taste persistence increased significantly throughout the ripening period, obtaining the highest values at ninety day. This increase is associated with a progressive reduction of lactic descriptors (Muir et al., 1997). Older cheeses had a greater variety of odours and flavours than fresh cheeses whereas 60 and 90 day cheeses presented butter and oil characteristics as well as hay and dried fruit.

The trigeminal stimulation increased with the ripening process. Bitterness rose until 60 days and then decreased reaching the lowest value in 90 day old cheeses. Lemieux and Simard, (1994), refer to a frequent correlation between bitterness and astringency that not appears in Majorero P.D.O. cheeses because they were not at all astringent. Sweetness started to appear slightly in cheese after 15 days but disappeared in older cheeses. On the other hand hard cheeses (60 and 90 days old) presented higher acid values with citric characteristics very common in this type of cheeses.

Conclusion

Odour and flavour characteristics were more affected than texture properties by ripening time. These sensorial results join together with chemical composition and physical properties will be used for a better and complete definition of Majorero P.D.O. cheeses at different ripening periods.

Table 2. Sensorial odour and flavour characteristics of Majorero cheese

	Ripening time (R)					
	15d	30d	60d	90d		
	LSM				*RSD*	*Effect*
Acidity	2.80^{ab}	2.61^{a}	3.10^{ab}	3.34^{b}	0.10	0.038
Saltiness	3.63^{a}	3.58^{a}	4.46^{b}	4.46^{b}	0.06	0.001
Pungent	0.00^{a}	0.00^{a}	0.44^{b}	0.46^{b}	0.04	0.001
Sweetness	0.31^{b}	0.00^{a}	0.00^{a}	0.00^{a}	0.03	0.001
Bitterness	0.61^{ab}	0.61^{ab}	0.68^{b}	0.32^{a}	0.04	0.009
Taste persistence	3.38^{a}	3.49^{a}	4.62^{b}	4.83^{b}	0.07	0.001
Odour intensity	2.13^{a}	3.84^{b}	3.94^{c}	4.48^{d}	0.09	0.001
Flavour intensity	3.57^{a}	4.08^{b}	4.17^{b}	4.72^{c}	0.05	0.001

LSM: Least square mean; RSD: Residual standard deviation.
[a-d] Within a row, means marked with different superscripts differ significantly (p<0.05).

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Colour and texture changes in Palmero P.D.O. cheese during ripening

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Summary

Palmero P.D.O. (Protected Denomination of Origin) cheese is a traditional Canarian cheese made with raw milk from the Spanish local breed of Palmero dairy goats. This study was a part of the regional project (DOQUECAN) which was focused on the valorization of Canarian P.D.O. cheeses. The objective of this study was to evaluate the changes in physical parameters (colour and texture) of Palmero P.D.O. cheeses during 90 days of aging. Forty-eight hand-made cheeses from 4 different producers were compared by determining mechanical parameters from the texture profile analysis (TPA) and colour parameters in terms of CIELAB and CIELCH colour space. The rheological and colour changes in the experimental cheeses were examined throughout 15 to 90 days of ripening. During the 90 days of ripening an increase in hardness, fracturability and chewiness occurred and elasticity decreased simultaneously. The L* internal value decreased significantly, while yellowness increased during cheese ripening. Croma and Hue angle changes were not clear.

Keywords: Palmero goat cheese, colour, texture, ripening.

Introduction

Nowadays, there is a great deal of interest in the definition of quality, especially with regard to the Protected Denomination of Origin (P.D.O.). In addition, there is an increasing need for the characterization of these cheeses including the study of changes that occur during ripening (Lebecque et al., 2001). Palmero cheese is a typical product of La Palma (Canary Isles, Spain) and it is manufactured from raw goat milk of "Palmera" breed according to the specifications of its Denomination of Origin Regulatory Board (UE 1241/2002). It is an uncooked, pressed cheese with a short ripening period of usually less than 60 days.

Texture and colour are important criteria for evaluation of cheese quality as these two parameters are important for consumers in making decisions on the purchase of the product (Casiraghi et al., 1985, Pinho et al., 2004).

Rheological and fracture properties are of great importance for the producer, the market and the consumer. They affect the perception in mouth, the use (cut, grating, spread and melted), the manipulation, packaging and formation of eyes. These properties differ depending on the type of cheese and its content of water, fat, salt, pH, protein degradation, the stage of maturation, and also depending on environmental factors such as temperature (Walstra and Peleg, 1991).

Colour is one of the characteristics which defines the quality of the product, and, according to Calvo, (2003), is the one that most influences the consumer's choice. Colour is the first feature to be perceived and determines the first judgment on the quality of the product (Otterstäter, 1999). Out of all the sensory qualities presented by a food, colour sometimes can even subjectively modify other sensory perceptions such as odour and flavour.

This paper is written as a part of the report for the strategic Project of the Canary Government for increasing the characterization and differentiation of Canarian P.D.O. cheeses, including studies of changes that occur during ripening and consumer preferences evaluations.

Material and methods

With the agreement of professionals (veterinarians, farmers, cheese makers, and marketing agents), 4 artisanal cheese producers were selected for the quality and consistency of Palmero cheese production. A total of 48 Palmero goat cheeses were manufactured (12 from each cheese maker) to study textural and colour parameters during ripening. Groups of 3 cheeses were picked up after 15, 30, 60 and 90 days of ripening. Three cheeses from each producer were used to study the textural and colour parameters. Cheese samples were coded with a letter representing the respective dairy plant where they were manufactured, and a sample ID number was assigned to all cheese samples. During ripening, the cheeses were stored in a ripening chamber at 10 to 12°C and 85 to 90% relative humidity. All samples were ripened by the respective manufacturers; for each aging time, cheeses were sent to the laboratory in refrigerated boxes and analyzed immediately to evaluate the changes.

Internal and external colours were recorded using a portable MINOLTA spectrocolourimeter (Minolta CR-400, Osaka, Japan). The L*, Croma, Hue Angle, a*, and b* colour measurements were determined according to the CIELCH and CIELAB colour space, were L* corresponds to light/dark chromaticity (changing from 0% dark to 100% light), colour intensity was recorded using the Croma value, Hue angle was used as a measure of colour tone, a* corresponds to green/red chromaticity (changing from -60% green to 60% red), and b* to blue/yellow chromaticity (changing from -60% blue to 60% yellow). The instrument was calibrated with a white tile before the measurements. Each colour test was performed on four replicates on the product surface and five replicates inside the cheese.

To analyze the texture, a Texture Analyzer (Texture Expert Exceed XT2i, Surrey, England) was used with a 50 mm cylindrical probe for the compression test. Six cylindrical samples were obtained from each cheese with the aid of a 40 mm stainless steel manual probe. A Texture Profile Analysis (TPA) was performed for each sample which basically consisted of a double compression. The speed of descent of the head (head/top part) was 2 mm/sec, with a degree of compression of 75 % of the height of the sample. This test gave six parameters: fracturability, hardness, adhesiveness, cohesiveness elasticity and gumminess. Sample temperature was 22±1°C.

For colour and texture variables, effect of ripening time was statistically analyzed using the General Lineal Model ANOVA procedure with SPSS for Windows version 13.0 (SPSS Inc., Chicago, IL, USA).

Results and discussion

Table 1 shows the values for textural attributes for Palmero P.D.O. cheeses derived from TPA analysis. All textural parameters of the cheeses were affected by ripening time ($p<0.001$) except cohesiveness that presented similar values for all different ripening periods. These results are in accordance with those reported by Bara Herczegh et al. (2002) and Irigoyen et al. (2002). Fracturability, hardness and gumminess increased along maturation as well as fat raised (Miguel et al., 2002). However, Pinho et al. (2004) studying "Terrincho" ewe's cheese, have shown that an increase in these parameters up to 30 days and afterwards a decrease to the end of the maturation. On the other hand, elasticity decreased till 30 days ripening and

kept constant till 90 days and adhesiveness decreased in the first two months of maturation and increased thereafter. These results could be related to the increasing of fat contents in the ripening process of the cheeses (Gwartney et al., 2002; Pereira et al., 2002).

Table 1. Effects of ripening on textural characteristics

	Ripening time					
	15d	*30d*	60d	90d		
	LSM				*RSD*	*Effect*
Fracturability	80.8^{a}	99.2^{b}	112.7^{c}	155.5^{d}	2.18	0.001
Hardness	125.0^{a}	163.1^{b}	197.3^{c}	262.9^{d}	3.78	0.001
Cohesiveness	0.10	0.11	0.11	0.11	0.00	0.104
Adhesiveness	1.95^{b}	1.77^{ab}	1.08^{a}	2.75^{c}	0.10	0.001
Elasticity	79.9^{b}	74.2^{a}	74.0^{a}	72.2^{a}	0.71	0.001
Gumminess	1017^{a}	1312^{b}	1603^{c}	1995^{d}	35.3	0.001

LSM: Least square mean.
RSD: Residual standard deviation.
[a-d] Within a row, means marked with different superscripts differ significantly ($p<0.05$).

The mean values for L*, Croma, Hue Angle, a* and b* parameters are shown in Table 2. Cheese colour was statistically affected ($P<0.05$) by ripening time. Only external Croma and b* and internal a* and Hue angle were not affected by this factor. Both external and internal lightness decreased along maturation according to Rohm and Jaros, (1996); this was more prominent on the surface than inside the cheese. The 30 and 60 days aged cheeses showed higher internal colour intensity while external colour tone was significantly ($P<0.05$) higher in fresh cheeses (15d). An increase in yellowness b* (i) was observed up to 60d of ripening; however, cheeses became less yellow at 90 d.

As was observed by other authors (Pillonel et al., 2002; Pinho et al., 2004), there was a decrease in lightness and a slight increase in both redness (a) and yellowness (b) during cheese ripening in the present study.

Table 2. Effects of ripening on external and internal cheese colour parameters

	Ripening time (R)					
	15d	30d	*60d*	*90d*		
	LSM				*RSD*	*Effect*
L* (e)	76.9^{c}	67.5^{b}	64.0^{b}	59.3^{a}	1.05	0.001
L* (i)	87.8^{c}	86.6^{b}	84.5^{b}	79.4^{a}	0.55	0.001
Croma (e)	22.9	24.2	26.2	26.1	0.49	0.051
Croma (i)	12.3^{a}	14.0^{bc}	14.1^{c}	12.8^{ab}	0.19	0.001
Hue Angle (e)	91.1^{c}	86.8^{b}	82.6^{a}	80.6^{a}	0.80	0.001
Hue Angle (i)	99.5	99.6	99.6	100.8	0.30	0.390
a* (e)	-0.29^{a}	1.58^{ab}	3.21^{bc}	4.35^{c}	0.37	0.001
a* (i)	-2.05	-2.33	-2.32	-2.34	0.70	0.397
b* (e)	22.9	24.1	25.9	25.7	0.47	0.071
b* (i)	12.1^{a}	13.8^{bc}	13.8^{c}	12.5^{ab}	0.19	0.001

LSM: Least square mean.
RSD: Residual standard deviation.
L* (e), Croma (e), Hue Angle (e), a* (e) and b* (e) correspond to parameters measured on cheese surface (external) and L* (i, Croma (i), Hue Angle (i), a* (i) and b* (i) correspond to parameters measured inside the cheese (internal).
[a-d] Within a row, means marked with different superscripts differ significantly ($p<0.05$).

Conclusion

These physical results join together with chemical composition and sensorial properties will be used for a better and complete definition of Palmero P.D.O. cheeses at different ripening periods. The differences observed in texture and colour parameters could be useful to estimate the ripening time with an objective method.

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