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Mediterranean forage resources and Pélardon cheese content of terpenes and fatty acids

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Abstract. Pélardon is a goats' milk PDO cheese produced in a Mediterranean area of southern France requiring a minimal use of rangelands. The aim of this work was to characterise the dominant strategies used by farmers to combine the use of natural resources provided by the region in order to feed the dairy goats and to define the links between these strategies and fatty acid and terpene composition of the cheeses. Thirty five cheeses were collected in spring and summer 2011 from 22 different farmhouse cheese-makers recruited to cover the diversity of farmers' feeding practices. The cheeses were analysed after 2 days' ripening and the farmers' feeding practices during the days prior to cheese-making were collected through an interview. Five main feeding strategies were defined according to the relative importance of rangeland and grassland grazing and the amount of hay and concentrates fed. These feeding strategies did not affect the cheese terpene content and composition whose main drivers are related to the botanical diversity of the rangelands and the grazing management of the goats by the shepherd. Cheese fatty acid composition varied mainly according to the importance of the grassland grazing and the supplementation with hay and concentrates. These results may help the farmer exploiting in an optimal way the diversity of the resources so that cheese characteristics reflect the richness of the "terroir" where they originate.

Keywords. Goat cheese – Terpenes – Fatty acids – Mediterranean forage resources.

Ressources fourragères Méditéranéennes et composition des fromages Pélardon

Résumé. *Le Pélardon est un fromage de chèvre AOP produit dans une zone Méditerranéenne du sud de la France. L'objectif de ce travail était de décrire comment les éleveurs combinent l'utilisation des ressources naturelles du territoire pour nourrir leur troupeau et étudier les liens entre ces combinaisons de pratiques et la composition de leurs fromages en acides gras et terpènes. Trente-cinq fromages fermiers ont été collectés au cours du printemps et de l'été 2011 dans 22 élevages sélectionnés pour couvrir la diversité des pratiques d'alimentation de la zone. Les fromages âgés de 2 jours ont fait l'objet des analyses et les principales pratiques d'alimentation des troupeaux au cours des jours précédant la fabrication des fromages ont été relevées lors d'une enquête. Les pratiques d'alimentation des éleveurs ont été classées en 5 stratégies variables selon l'importance relative du pâturage sur prairies et sur parcours, et selon les quantités de foin et d'aliments concentrés distribuées au troupeau. Ces stratégies d'alimentation n'ont pas eu d'impact significatif sur la teneur et la composition des fromages en terpènes qui dépendent principalement de la biodiversité des parcours et des pratiques de garde des éleveurs. La composition des fromages en acides gras a varié principalement selon l'importance du pâturage sur prairies et les quantités de foin et de concentrés offerts. Ces résultats pourraient aider les éleveurs à exploiter de façon optimale la diversité des ressources naturelles de leur territoire de façon à ce que les fromages reflètent au mieux la richesse du terroir où ils sont produits.*

Mots-clés. *Fromage de chèvre – Terpènes – Acides gras – Ressources fourragères Méditerranéennes.*

I – Introduction

For cheeses labelled with a protected designation of origin (PDO), understanding how the "terroir" influences the characteristics of the cheeses is an important issue. The natural resources provided by the region and the way the farmers combine their use to feed the animals is part of the definition of the "terroir". In the case of mountain cows' milk cheeses, some feeding practices like the use of permanent pastures have been shown to exert an important influence on cheese chemical composition and sensory properties (Martin *et al.,* 2005). In Mediterranean areas, a wide diversity of spontaneous and sown vegetation coexists. In those areas, the characterisation of the linkage between the natural resources and the characteristics of the cheeses may be particularly complex (Napoléone *et al*., 2012). This is the case for Pélardon, a small (100 g) goats' raw milk soft cheese produced in a Mediterranean area of southern France by 2 small dairies and 62 farmhouse cheese-makers. The aim of this work was: (i) to characterise the main strategies used by the farmers to feed the goats; and (ii) define the links between these strategies and the composition of the cheeses. We focussed on cheese fatty acids and terpenes, two families of compounds shown to depend little on cheese processing and to vary mainly according to animal feeding (Tornambé *et al.*, 2006; Chilliard *et al.*, 2007).

II – Materials and methods

Thirty five cheeses were collected in spring and summer 2011 from 22 different farmhouse cheese-makers recruited to cover the diversity of farmers' feeding practices. During a visit to the farm, the farmers were interviewed in order to describe the feeding management of the goats the day's prior cheese sampling. The focus was on the quantities and nature of the dry forages and concentrates given to the dairy goats, the time the goats spent grazing on grasslands and rangelands. Rangelands are made of very diverse wooden and herbaceous Mediterranean spontaneous vegetation. Its botanical diversity was classified as low, medium or high and the type of management of the goats on rangelands (free grazing or active shepherd management). Two 2-day-old cheeses were collected, frozen and sent to the laboratories for the analyses of volatile compounds by head-space gas chromatography coupled with mass spectrometry and fatty acids (FA) by gas chromatography. The data collected on-farm were used to classify the goats' diets in 5 feeding strategies identified by a graphical treatment of the data as described by Bertin (1977). The terpene and FA composition of the corresponding cheeses was then compared by an Anova (SAS software). A Principal Component Analysis was made using the 21 individual terpenes and 48 FA as active variables (SPAD Software). The data related to two additional "control" cheeses not PDO granted because goats were only fed indoors are reported but not included in the statistical analyses.

III – Results and discussion

A total of 21 monoterpenes were identified in the cheeses. As already reported by Napoleone *et al.* (2012), the most abundant terpenes was α-pinene followed by limonene, β-pinene, p-cymene, 3,7-dimethyl-1,6-octadiene and camphene. The variability and the amount of terpenes in the cheese were particularly important but variable according to the compounds; from 92 to 22 000 fold higher in the richest cheeses compared to the poorest. The variability of the FA was also very high; saturated FA (SFA) ranged from 62 to 77, monounsaturated FA (MUFA) from 18 to 32 and polyunsaturated FA (PUFA) from 4 to 6 g/100 g Total FA (TFA). Linolenic acid and CLA ranged from 0.7 to 1.4 and 0.3 to 1.1 g/100 g TFA respectively.

The practices of the farmers were also very diverse: the quantities of hay and concentrates ranged from 0 to 2.5 and 0.1 to 1.2 kg/d/goat respectively. The daily duration of grazing on grasslands and rangelands ranged from 0 to 10 h/d and from 0 to 12 h/d respectively. Five distinct

feeding strategies were identified according to the amount of hay and concentrates fed to goats and the duration of grazing on grasslands or rangelands (Table 1). Two feeding strategies were characterised by a long grazing on rangelands without grasslands and differed according to the amount of hay fed. In two other feeding strategies, the grazing on grasslands and rangelands was equivalent and differed according to the amount of hay and concentrate. The last strategy was based on pasture on grassland supplemented by hay and concentrates.

Table 1. Description of the feeding strategies and associated cheese FA and terpenes composition

Type of pasture	Rangelands		Rangelands & grasslands		Grasslands	S*	RSD	*Control*
Hay & concentrate	**-**	**+**	**-**	**+**	**+**			***+***
Number of cheeses	7	11	7	6	4			*2*
Rangelands h/d	6.0b	5.0b	3.5ab	3.4ab	0.1a	*	2.69	*0*
Grasslands h/d	0.1a	0.1a	4.2b	3.7b	4.9b	***	1.69	*0*
Hay kg/d	0.5a	1.8b	0.4a	1.5b	1.3b	***	0.40	*2.5*
Concentrate kg/d	0.6a	0.7ab	0.6a	1.0b	0.7ab	*	0.23	*0.8*
α-pinene	6.6	6.3	6.4	6.3	5.7	NS	0.65	*5.5*
Camphene	5.3	5.2	5.3	5.2	4.6	NS	0.63	*4.6*
β-pinene	5.7	5.5	5.5	5.5	5.0	NS	0.50	*4.6*
p-cymene	5.3	5.4	5.3	5.3	5.0	NS	0.42	*4.6*
Limonene	5.8	5.8	5.6	5.6	5.4	NS	0.45	*5.3*
α-thujene	4.3	4.7	4.8	4.6	3.5	NS	0.87	*3.1*
γ-terpinene	4.6	4.9	4.9	4.7	4.1	NS	0.68	*3.2*
∑ Saturated FA	70.23	70.44	70.21	67.70	68.66	NS	3.34	*76.68*
6:0	2.75b	2.77b	2.70ab	2.47a	2.46a	*	0.23	*2.73*
8:0	2.97	3.00	2.84	2.56	2.59	+	0.36	*3.03*
16:0	24.88	24.31	24.27	24.56	24.93	NS	1.86	*29.92*
18:0	11.19	11.52	12.50	11.69	11.47	NS	1.55	*6.98*
20:0	0.33b	0.29ab	0.32b	0.27ab	0.24a	*	0.05	*0.21*
22:0	0.14d	0.11bc	0.13cd	0.10ab	0.08a	***	0.02	*0.09*
∑ Monounsat. FA	23.73	23.99	24.08	26.53	25.74	NS	3.14	*18.50*
*c*9-16:1	0.46ab	0.48ab	0.42a	0.53b	0.52b	*	0.06	*0.60*
*c*9-18:1	18.69	19.17	18.88	21.15	20.46	NS	2.44	*15.00*
*c*15-18:1	0.22ab	0.20ab	0.23b	0.20ab	0.19a	+	0.03	*0.16*
*c*11-18:1	0.44ab	0.54bc	0.41a	0.58c	0.56bc	**	0.09	*0.44*
*t*11-18:1	1.34	1.10	1.61	1.40	1.56	NS	0.45	*0.47*
∑ Polyunsat. FA	5.41	4.94	5.08	5.15	4.95	NS	0.44	*4.03*
*t*11*c*15-18:2	0.15ab	0.08a	0.16b	0.11ab	0.15ab	**	0.05	*0.08*
20:4n6	0.15	0.14	0.12	0.12	0.11	+	0.02	*0.12*

* S = statistical significance; +P<0.10. *P<0.05. **P<0.01. ***P<0.001. NS: non-significant.
Data within the same row not sharing a common superscript are different (P<0.05).
Terpenes are expressed in log (arbitrary units) and FA in g/100gTFA.

None of the cheese terpenes differed significantly according to the feeding strategies because of the very high variability in the data. Nevertheless, 17 terpenes were numerically higher (from 2 to 18-fold) in the 4 feeding strategies including rangeland grazing in comparison to those that did not (grassland and control). Within the feeding strategies including rangelands, the amount of terpenes was comparable, regardless of the duration of the grazing on rangelands or the amount of hay and concentrates fed, certainly because grazing goats are very plant selective.

The concentrations of 6:0 and 8:0 were decreased by increasing grazing on grasslands with the same amount of hay distributed. This result, in accordance with Chilliard *et al.* (2007), is linked to a putative inhibitory effect of 18:3n-3 against mammary *de novo* synthesis of FA. The *c*9-16:1 concentration was the highest in the feeding strategies including grasslands pasture and high amounts of hay and concentrate in the diet. The highest *c*11-18:1 concentration was observed

with high amounts of hay and concentrates. The *t*11*c*15-18:2 concentration was numerically lower in feeding strategies including high amount of hay and concentrate in the diet, suggesting that 18:2n-6 from concentrate could limit the ruminal biohydrogenation (RBH) of 18:3n-3 (Chilliard *et al.,* 2007). The 20:0 and 22:0 were the highest when goats grazed rangelands and when hay supplementation was low. The 20:4n-6 concentration tended to increase with the duration of rangeland grazing rich in aromatic plants. We can suppose that secondary metabolites of these plants could limit the RBH of this FA.

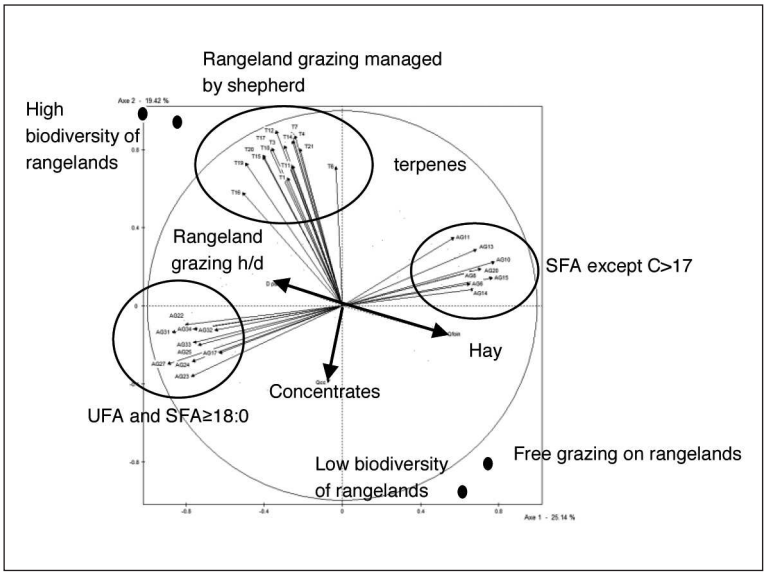

Fig. 1. PCA on cheese FA and terpene composition and projection of the farmers' practices.

The first plot of the PCA (Fig. 1) shows the independence between the FA, mainly correlated with PC1 (most SFA on the positive side of the PC and most UFA on the negative side) and the terpenes mainly correlated with PC2. Cheese terpenes, that reveal the ingestion of aromatic plants rich in secondary metabolites (Tornambe *et al.,* 2006), were the highest when rangelands were the most diverse and when rangeland grazing was managed by the shepherd.

IV – Conclusions

The results of this trial showed that the main drivers of the Pélardon cheese composition of FA are the grazing on grasslands and the amount of hay and concentrates fed. The feeding strategies we defined didn't reveal the ingestion of plants rich in terpenes as those commonly found in Mediterranean rangelands. When grazing on rangelands, the drivers of this ingestion seem to be mainly the shepherd's management of goats and the rangeland biodiversity and in a lesser extent, the quantitative duration of the grazing and the amount of hay and concentrates fed. These results may help the farmers to exploit in an optimal way the diversity of the local resources so that cheeses' characteristics reflect the richness of the "terroir".

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