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Free fatty acid composition of regionally-produced Spanish goat cheese and relationship with sensory characteristics

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Abstract

A study was made of free fatty acid composition and sensory characteristics (odour and taste) in regionally-produced Spanish goat cheeses. The most abundant FFAs were oleic, palmitic, stearic, capric and myristic acid which together accounted for roughly 85% of total FFAs. These cheeses generally underwent a lower degree of lipolysis than did other goat cheeses. Panellists judged the cheeses as having considerable odour and flavour intensity. However, both total FFA content and sensory attributes varied considerably among cheeses due, in all likelihood, to differences in ripening time and to production by different manufacturers. Principal component analysis generated three principal components (PC) that accounted for 70% of total variance; the variables that best correlated with them were long-chain and medium-chain free fatty acids (PC1), brine odour, bitterness and goat milk odour (PC2) and short-chain free fatty acids (PC3).

Keywords: Goat cheese; Free fatty acids; Sensory analysis

1. Introduction

Although output is lower than that of cow's and ewe's milk cheeses, there is a long tradition of goat cheese production in Mediterranean countries. In Spain, where virtually all the milk obtained from goats is used for cheese-making, only two of the twenty-eight cheeses produced (Anonymous, 1990) enjoy Denomination of Origin status. In the La Mancha region, goat cheeses have not been accorded that status, perhaps because, despite a reasonable output, they have been overshadowed by the highly-popular and widely-produced Manchego cheese. Here, goat cheeses are made with the milk of the goats from local herds using a technology similar to that employed in the manufacture of Manchego cheese. The physicochemical and sensory characteristics of these goats cheeses have been studied (Cabezas, Poveda, Sánchez, & Palop, 2005).

Cheese made from goat's milk is greatly appreciated because of its particular organoleptic characteristics. Lipolysis plays an essential role in the sensory properties of cheese; some free fatty acids (FFAs) have been shown to contribute directly to the aroma characteristics of many types of cheese, or indirectly as precursors of aroma components (Forss, 1979). The fatty acids hexanoic, octanoic and decanoic acids have long been considered responsible for the characteristic aroma of goat cheeses, giving rise to the popular terms caproic, caprilic and capric acids. Additionally, certain branched-chain FFAs contribute, by themselves, to the goaty flavour of cheese (Le Queré, Pierre, Riaublanc, & Demaiziéres, 1998; Rahmat & Richter, 1996).

A number of authors have studied the free fatty acid fraction of certain Spanish goat cheeses, including Vera (Fontecha, Peláez, Juárez, Requena, & Gómez, 1990), Majorero (De la Fuente & Juárez, 1993; Fontecha

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et al., 1990), and others (Buffa, Guamis, Pavia, & Trujillo, 2001); however, no previous studies have addressed lipolysis in goat cheeses made in the La Mancha region. The aim of this work was to study the free fatty acid profile of regionally-produced Spanish goat cheeses and its relationship with sensory characteristics.

2. Materials and methods

2.1. Cheese samples

Sixteen goat's milk cheeses were acquired directly from several local producers in the provinces of Ciudad Real, Toledo and Albacete in the La Mancha region of Spain. Cheeses were made from pasteurised goat's milk, following the Manchego cheese manufacturing technology (BOE, 1995), which includes enzyme coagulation, cutting, pressing and salting, and with modifications concerning the ripening time (from several days to 1 or 2 months). The precise ripening times of cheeses were not provided by the producers. Cheese sample preparation, prior to analysis, was performed as previously described (Cabezas et al., 2005).

2.2. FFA analysis

FFAs were analysed by gas chromatography. Samples for chromatographic analysis were processed using the method proposed by Metcalfe and Wang (1981) as modified by Juárez, De la Fuente, and Fontecha (1992). Lipid extraction was carried out on an acidified cheese slurry using diethyl ether; methylation of the fatty acids was performed with 20% TMAH (tetramethyl ammonium hydroxide) in methanol. The TMAH soaps (in the lower layer) were neutralised before injection and pyrolised to methyl esters in the chromatograph injector. Two extractions were carried out per sample. Chromatography conditions have been described elsewhere (Poveda, Pézez-Coello, & Cabezas, 1999).

2.3. Descriptive sensory analysis ISO 6564 (1985)

The odour and taste attributes of the 16 test cheeses were analysed using a panel of 10 tasters previously trained in the sensory analysis of cheese (González-Viñas, Poveda, & Cabezas, 2001; González-Viñas, Poveda, García Ruíz, & Cabezas, 2001). Attributes were evaluated using a 10-point scale (0: poorest; 10: best). Samples for sensory analysis were cut into 1.5 cm cubes and placed in closed Petri dishes for 2 h before evaluation. Each panellist was served four different cheeses per tasting session, which were coded with a three digit code (letter-number-letter) and presented in random order. All cheeses were tasted in two separate sessions. The following sensory properties were evaluated: (a) odour: odour intensity, goat milk, lactic acid, brine, butter and stable odour; (b) taste: acidity, sweetness, saltiness, spiciness, bitterness, goat milk taste, flavour persistence and flavour intensity.

2.4. Statistical analysis

Principal component analysis (PCA) and Pearson correlation coefficients were applied using the programme SPSS for Windows, version 11.5 (SPSS Inc. Chicago, IL, USA).

3. Results and discussion

Table 1 shows mean values and standard deviations for individual FFA concentrations in the sample cheeses, in increasing order of total FFAs.

The most abundant FFAs were oleic ($C_{18:1}$), palmitic ($C_{16:0}$), stearic ($C_{18:0}$), capric ($C_{10.0}$) and myristic ($C_{14:0}$) acids, which together accounted for roughly 85% of total FFAs. Butyric acid was the main short-chain FFA present (mean: 5.6% of total FFAs) and capric acid was the chief medium-chain FFA (8.9% of total FFAs). These results agree with those reported by Gómez, Fernández-Salguero, and Marcos (1987) for Ibores cheese, by Nájera, Barrón, and Barcina (1993) for Majorero and US goat cheeses, and by Franco, Prieto, Bernardo, González Prieto, and Carballo (2003) for Babia-Laciana cheese.

The degree of lipolysis undergone by the sample cheeses here was comparatively low, as might be expected, since ripening tends to be relatively short. However, total FFA content varied considerably between samples ranging between 2397 and 6644 mg/kg. This variation may be due to differences in the duration of ripening, differences in processing between the factories of origin and, perhaps, differences in the initial level of lipolysis in the milk used in cheese manufacture. Morgan, Bodin, and Gaborit (2001) reported that the initial degree of lipolysis in goat's milk influenced lipolysis levels in fresh cheeses. Fontecha et al. (1990) found total FFA values of between 5090 and 31,984 mg/kg in artisanal Majorero cheese, while De la Fuente, Fontecha, and Juárez (1993) reported a total FFA concentration of 9912 and 20,794 mg/kg for Vera and Majorero cheeses, respectively; Fresno, Tornadijo, Carballo, Bernardo, and González Prieto (1997) obtained a total FFA content of 44,529 mg/kg in Valdeteja cheese ripened for 120 days. These values are generally higher than those obtained here, probably because Majorero, Vera and Valdeteja cheeses are made with raw goat's milk, and it has been reported that milk pasteurisation leads to a decrease in lipolysis in goat cheeses (Morgan et al., 2001). On the other hand, Buffa et al. (2001), in a study of pasteurised goat cheese, found total FFA concentrations similar to those obtained here.

Table 1
Mean values and standard deviations of individual FFA concentrations (mg/kg) in Spanish goat's milk cheese in increasing order of total FFA concentrations

Sample	FFA (mg/kg)									Total
	C_4	C_6	C_8	C_{10}	C_{12}	C_{14}	C_{16}	C_{18}	$C_{18:1}$	
10	44 ± 10	20 ± 4	28 ± 0	109 ± 1	81 ± 0	195 ± 2	766 ± 2	307 ± 4	847 ± 19	2397 ± 23
4	313 ± 5	127 ± 3	79 ± 4	172 ± 3	61 ± 10	137 ± 3	630 ± 23	255 ± 9	688 ± 39	2460 ± 84
12	36 ± 8	13 ± 1	28 ± 4	136 ± 20	94 ± 3	191 ± 11	739 ± 9	291 ± 10	948 ± 16	2475 ± 45
13	65 ± 23	45 ± 17	64 ± 17	233 ± 34	124 ± 0	231 ± 1	914 ± 74	340 ± 4	990 ± 85	3006 ± 74
7	94 ± 0	64 ± 0	63 ± 0	211 ± 1	119 ± 1	238 ± 2	1013 ± 8	400 ± 3	1068 ± 5	3268 ± 18
6	59 ± 15	54 ± 5	70 ± 3	242 ± 25	131 ± 7	284 ± 29	1026 ± 90	385 ± 30	1142 ± 135	3393 ± 241
16	160 ± 1	106 ± 5	117 ± 1	360 ± 3	135 ± 14	272 ± 19	880 ± 40	358 ± 23	1149 ± 9	3536 ± 80
14	183 ± 4	83 ± 7	92 ± 7	294 ± 24	135 ± 13	319 ± 43	1072 ± 109	446 ± 36	1342 ± 134	3966 ± 378
5	314 ± 18	131 ± 0	97 ± 4	309 ± 18	124 ± 7	254 ± 10	970 ± 28	364 ± 4	930 ± 45	3493 ± 98
1	366 ± 6	201 ± 4	129 ± 1	381 ± 7	162 ± 10	366 ± 3	1189 ± 22	466 ± 17	1202 ± 25	4462 ± 89
2	161 ± 0	95 ± 7	114 ± 1	462 ± 5	205 ± 1	489 ± 9	1603 ± 25	493 ± 9	1302 ± 16	4922 ± 60
11	200 ± 5	110 ± 1	190 ± 1	419 ± 1	237 ± 1	729 ± 5	1550 ± 6	350 ± 173	1231 ± 65	5014 ± 182
8	759 ± 95	256 ± 4	220 ± 1	710 ± 27	248 ± 29	386 ± 11	1054 ± 18	403 ± 2	1285 ± 9	5320 ± 62
3	266 ± 1	174 ± 1	167 ± 0	564 ± 31	223 ± 17	516 ± 39	1631 ± 73	617 ± 33	1938 ± 182	6096 ± 377
15	217 ± 13	141 ± 13	263 ± 8	873 ± 16	285 ± 3	525 ± 3	1510 ± 17	631 ± 7	2242 ± 73	6687 ± 5
9	920 ± 54	553 ± 31	334 ± 27	1056 ± 34	319 ± 0	409 ± 2	1149 ± 13	430 ± 30	1474 ± 52	6644 ± 237

Total FFA contents for cheese samples 10, 4, 12, 13, 7, 6, 16, 5, and 14 were comparable to that obtained in Manchego cheeses ripened for between 15 and 150 days, with total FFA concentrations lower than 4000 mg/kg (Poveda, Pézez-Coello, & Cabezas, 2000); however, the remaining samples presented values higher than those found in Manchego cheeses.

Mean scores and standard deviations for taste and odour attributes are shown in Tables 2 and 3, respectively. Sample cheeses also varied considerably in terms of taste and odour profiles. Panellists judged most of the cheeses as having considerable odour intensity and flavour intensity.

Principal component analysis (PCA) was applied to individual FFAs and sensory attributes in order to determine which variables accounted for most variance among samples. The first three principal components (PC) accounted for 70% of total variance (TV). Fig. 1(a) and (b) show the projection of cheese samples on the plane defined by PC1 and PC2, and PC1 and PC3 respectively. The variables showing the highest correlation with PC1 (accounting for 42.38% of TV) were long-chain and medium-chain free fatty acids: $C_{16:0}$ (0.948), $C_{18:0}$ (0.872) and $C_{14:0}$ (0.864). PC2 (16.29 % TV) was highly correlated with the sensory variables brine odour (0.851), bitterness (0.843) and goat milk odour (0.793), while PC3 (11.40% TV) correlated best with the short-chain free fatty acids $C_{6.0}$ (0.960) and $C_{4:0}$ (0.926).

Pearson correlation coefficients between FFA concentrations and sensory attributes were calculated. Butyric acid correlated with bitterness ($P < 0.01$), brine odour ($P < 0.01$) and goat milk odour ($P < 0.05$), with correlation coefficients of 0.673, 0.616 and 0.539, respectively. Short-chain free fatty acids are known to contribute actively to cheese flavour and aroma (Brennand, Ha,

Table 2
Mean scores and standard deviations of taste attributes in Spanish goat's milk cheese

Sample	Flavour intensity	Goat milk taste	Acidity	Sweetness	Saltness	Spicyness	Bitterness	Flavour persistence
1	4.2 ± 1.5	5.0 ± 1.4	6.8 ± 0.2	0.5 ± 0.1	2.3 ± 0.1	1.0 ± 0.2	5.2 ± 1.5	59 ± 0.6
2	6.8 ± 1.5	3.2 ± 1.8	4.7 ± 0.3	1.3 ± 1.3	4.8 ± 0.3	1.7 ± 1.8	2.9 ± 0.1	48 ± 0.7
3	6.7 ± 1.6	2.6 ± 0.8	4.8 ± 0.1	1.0 ± 1.1	5.0 ± 1.1	4.7 ± 0.4	5.1 ± 0.3	53 ± 0.2
4	7.8 ± 1.1	3.7 ± 0.7	4.9 ± 0.4	2.4 ± 1.3	5.6 ± 1.9	2.6 ± 0.8	3.0 ± 0.1	74 ± 0.9
5	7.1 ± 1.6	3.3 ± 0.2	3.7 ± 1.8	4.4 ± 1.6	8.2 ± 0.9	1.2 ± 1.3	2.6 ± 0.7	4.7 ± 1.1
6	4.8 ± 0.1	2.0 ± 0.1	2.7 ± 1.1	0.6 ± 0.3	7.7 ± 1.4	1.2 ± 0.4	3.1 ± 0.2	2.8 ± 0.7
7	4.7 ± 0.1	3.4 ± 1.9	1.7 ± 0.5	2.2 ± 0.4	3.3 ± 1.2	1.2 ± 0.1	2.6 ± 0.8	3.3 ± 0.3
8	5.5 ± 0.1	2.5 ± 0.8	5.8 ± 0.8	1.2 ± 0.8	2.4 ± 0.1	1.6 ± 0.8	7.5 ± 0.4	6.7 ± 1.4
9	7.2 ± 0.8	1.9 ± 0.1	4.4 ± 0.4	4.9 ± 1.9	3.6 ± 1.5	4.8 ± 0.6	6.5 ± 14	7.0 ± 0.6
10	5.6 ± 0.1	1.8 ± 0.9	4.3 ± 0.9	0.3 ± 0.0	5.3 ± 0.4	1.0 ± 0.3	1.2 ± 0.8	4.0 ± 0.4
11	5.7 ± 0.2	1.6 ± 0.6	4.8 ± 0.7	0.4 ± 0.1	6.2 ± 0.4	1.6 ± 0.1	3.1 ± 0.8	5.1 ± 0.4
12	2.5 ± 1.6	1.7 ± 0.1	1.0 ± 0.7	1.4 ± 0.0	2.3 ± 1.0	0.2 ± 0.1	0.6 ± 0.6	1.9 ± 0.7
13	2.1 ± 0.6	1.1 ± 0.8	1.1 ± 0.7	2.6 ± 1.4	1.5 ± 0.4	0.3 ± 0.4	0.4 ± 0.6	1.4 ± 0.2
14	4.1 ± 0.0	1.5 ± 0.5	1.9 ± 0.8	0.7 ± 0.4	4.4 ± 0.1	0.5 ± 0.5	2.1 ± 0.1	3.8 ± 0.7
15	6.6 ± 0.6	1.0 ± 0.6	3.8 ± 0.3	0.4 ± 0.1	3.2 ± 1.4	1.6 ± 0.8	6.0 ± 0.6	4.2 ± 0.4
16	5.8 ± 0.3	1.1 ± 0.6	2.2 ± 0.6	0.2 ± 0.1	2.0 ± 0.4	2.1 ± 0.2	5.6 ± 0.4	4.2 ± 0.5

Table 3
Mean scores and standard deviations of odour attributes in Spanish goat's milk cheese

Sample	Odour intensity	Goat milk odour	Lactic acid odour	Brine odour	Butter odour	Stable odour
1	5.3 ± 0.6	6.2 ± 1.8	4.3 ± 1.3	4.5 ± 0.8	0.4 ± 0.1	0.4 ± 0.1
2	8.1 ± 0.4	1.4 ± 0.1	1.5 ± 0.5	4.9 ± 0.7	1.3 ± 1.2	1.0 ± 0.1
3	6.3 ± 1.6	1.9 ± 0.4	2.0 ± 0.7	2.6 ± 1.6	6.1 ± 1.8	1.1 ± 0.5
4	8.1 ± 0.6	1.8 ± 1.5	2.7 ± 13	2.4 ± 0.1	2.2 ± 0.7	2.4 ± 0.8
5	8.1 ± 1.5	1.5 ± 1.4	1.9 ± 1.2	2.4 ± 0.7	2.5 ± 0.8	1.5 ± 1.3
6	2.9 ± 0.1	1.5 ± 0.2	1.1 ± 0.8	1.5 ± 0.5	3.3 ± 1.3	0.4 ± 0.2
7	2.5 ± 1.1	1.3 ± 0.1	0.9 ± 0.1	1.5 ± 0.5	3.4 ± 1.4	0.7 ± 0.1
8	4.8 ± 1.9	4.4 ± 1.3	1.5 ± 0.1	6.6 ± 0.0	1.9 ± 0.6	0.8 ± 0.2
9	7.5 ± 0.1	4.4 ± 1.3	2.0 ± 0.4	6.6 ± 1.1	1.3 ± 0.6	1.3 ± 0.1
10	4.2 ± 0.1	1.8 ± 0.4	1.9 ± 0.6	2.2 ± 0.8	2.0 ± 1.1	0.8 ± 0.1
11	4.0 ± 0.2	2.0 ± 1.1	1.1 ± 0.4	2.8 ± 1.7	1.6 ± 0.0	0.4 ± 0.1
12	2.2 ± 0.4	0.8 ± 0.1	1.9 ± 1.2	0.8 ± 0.8	3.2 ± 0.7	0.2 ± 0.3
13	1.8 ± 0.5	0.5 ± 0.3	1.4 ± 0.3	0.7 ± 0.3	2.8 ± 0.2	0.1 ± 0.1
14	1.0 ± 0.2	0.3 ± 0.1	1.3 ± 0.2	1.4 ± 0.9	4.2 ± 1.0	0.2 ± 0.1
15	5.2 ± 0.2	0.7 ± 0.0	3.7 ± 0.1	4.8 ± 0.3	1.3 ± 0.5	0.3 ± 0.0
16	4.3 ± 0.3	1.2 ± 0.3	4.2 ± 0.4	1.4 ± 0.1	4.3 ± 0.8	0.2 ± 0.1

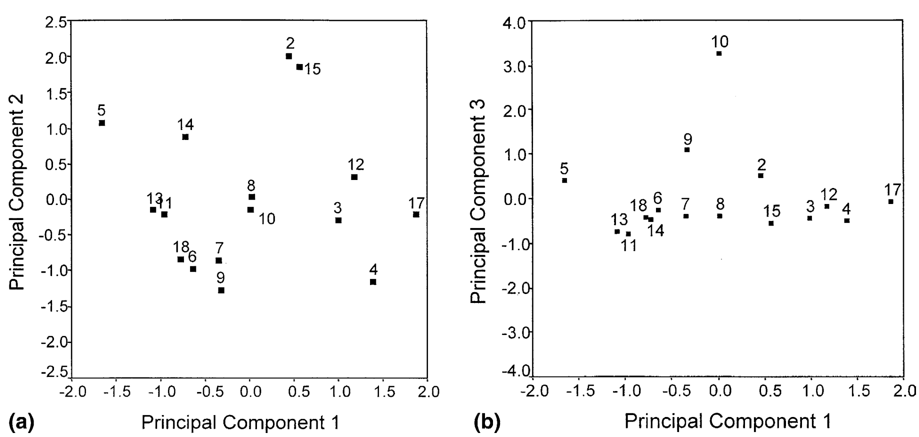

Fig. 1. Projection on the plane defined by the first three principal components (PC) of goat cheese samples on the basis of the FFA concentrations and the sensory attributes. (a) PC1 and PC2. (b)PC1 and PC3.

& Lindsay, 1989). Gómez-Ruiz, Ballesteros, González-Viñas, Cabezas, and Martínez-Castro (2002) reported a correlation between FFAs and certain odour attributes in Manchego cheeses.

4. Conclusions

The FFA profile of regionally-produced Spanish goat cheese was similar to that reported for other goat cheeses, oleic, palmitic, stearic and capric acid being the most abundant. The degree of lipolysis undergone by goat cheeses in the La Mancha region was fairly low compared to those of other goat cheeses.

Long-chain free fatty acids and the sensory attributes bitterness, brine odour and goat milk odour were the variables that most contributed to sample differentiation.

However, the cheeses tested varied considerably in terms of both total FFA content and sensory attributes, probably due to differences in ripening time and processing by different manufacturers. If these cheeses are to be awarded Denomination of Origin status, the goat's milk used for cheesemaking will need to be standardised, and both manufacturing and ripening processes will need to be subjected to more exhaustive controls.

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