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Discrimination between cheeses made from cow's, ewe's and goat's milk from unsaturated fatty acids and use of the canonical biplot method

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ABSTRACT

In this work we used the canonical biplot (CB) method to discriminate between cow's ewe's and goat's cheese through their content of unsaturated fatty acids. The variables employed for this discrimination were as follows: unsaturated fatty acids C14:1; C16:1; C17:1; C18:1; C18:1 *cis*; C18:1 *trans*, C18:2, ΣC18:1 and Σunsaturated. We used pure cheeses or mixed cheeses whose minimum content of the main milk was 75%, the rest being present at 25%. Nine groups or populations of cheeses were defined, comprising pure cow's (C100), ewe's, (S100) and goat's (G100) milk cheeses and mixtures of 75% cow's milk plus 25% ewe's (C75S), mixtures of 75% cow's milk with 25% goat's milk (C75G), mixtures of 75% ewe's milk plus 25% cow's milk (S75C), mixtures of 75% ewe's milk and 25% goat's milk (S75G), mixtures of 75% goat's milk and 25% ewe's milk (G75S), and mixtures of 75% goat's milk and 25% cow's milk (G75C). All cheeses were allowed to ripen for a period of six months. The canonical biplot method permitted the discrimination of the 9 groups of cheeses.

1. Introduction

Milk and dairy products, mainly cheeses, are usually associated with high levels of long-chain saturated fatty acids (Wood et al., 2004). However, unsaturated fatty acids vary considerably in milk and exhibit between 1 and 6 double bonds (from monoene to hexaene). The qualitative and quantitative presence of fatty acids (FA) in milk may contribute to differentiating the type of cheese in question (Ha and Lindsay, 1991).

The nutrient values of cheeses and their technological characteristics, such as the composition of the different FA, are affected by many factors, such as breed (Collomb et al., 2002), season (Luna et al., 2007; Collomb et al., 2008), stage of lactation (Kelly et al., 1998; Signorelli et al., 2008; Lurueña-Martínez et al., 2010), diet (Sampelayo et al., 2007; Chilliard et al., 2000; Ferlay et al., 2006; Chion et al., 2010) and the source species (cow, ewe, goat) (Lucas et al., 2008). Studies addressing the general process of cheese making have shown that the FA profile affects the characteristics of the cheese (Buchin et al., 1998).

Thus, the texture of a cheese depends on the degree of unsaturation of the FA and a higher degree of unsaturation is correlated with a smoother texture (Bugaud et al., 2001). Regarding flavour, increases in rancidity are related to the release of free FA, mainly due to a high content of butyric acid (Collins et al., 2003), whereas higher amounts of short-chain FA are associated with a more bitter flavour (Gobbetti et al., 2002). Accordingly, changes in the FA profile may sometimes be accompanied by a change in the flavour of cheeses (Chilliard and Ferlay, 2004; Chilliard et al., 2005).

Cheese plays an important role in human nutrition and it has recently been acknowledged as a natural source of oleic acid, short- and medium-chain FA and conjugated linoleic acid (CLA) (Dawczynski et al., 2010). Although the most important of these is oleic acid, which forms 75% of the FA in the category, it is also possible to detect linolenic acid, which is a precursor of eicosapentaenoic acid (C20:5, ω3; EPA) and of docosahexaenoic

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acid (C22:6, ω3; DHA) (Kouba and Mourot, 2011), linoleic acid, a precursor of arachidonic acid (C20:4, ω6), and the conjugates of linoleic acid, of great nutritional interest. Identification of the species that originally produced the milk represents a considerable problem for food analysts and law enforcement authorities, who must guarantee that milk and other dairy products are unadulterated and accurately labelled. Cheeses made from goat's and ewe's milk contain high levels of short- and medium-chain fatty acids in comparison with cheeses made with cow's milk (Chen et al., 1979; Gnädig et al., 2004).

In recent years, several analytical techniques for detecting mixtures of milks from different species have been developed. These include electrophoretic techniques (Gobbetti et al., 2002; Dziuba et al., 2004); isoelectric focusing (IEF) (Kim and Jimenez-Flores, 1994) and capillary electrophoresis (Cartoni et al., 1999; Miralles et al., 2000), and high-performance liquid chromatography (HPLC) (Ferreira et al., 2001; Veloso et al., 2004), together with immunological methods and, more recently, species-specific PCR (Maudet and Taberlet, 2001; Bottero et al., 2003) and near-infrared spectroscopy (NIRS) (González-Martín et al., 2007; Soto-Barajas et al., 2013)

Table 1
Fatty acid composition: mg/g cheese.

Sample	C14:1	C16:1	C17:1	C18:1	C18.1 cis	C18.1trans	Σ C18:1	Σ Unsaturated
0C100	0.37	1.77	0.44	4.54	42.39	2.77	49.67	52.25
0O100	0.26	1.60	0.34	6.86	34.77	7.22	48.02	50.21
0V100	1.37	2.42	0.47	4.39	26.58	3.44	34.33	38.59
0C75O	0.40	1.77	0.35	4.88	36.46	3.63	45.27	47.79
0C75V	0.88	2.16	0.47	4.37	38.02	3.33	45.37	48.87
0V75C	1.77	3.07	0.57	4.20	36.03	2.74	43.94	49.35
0O75V	0.60	2.09	0.38	6.80	32.23	8.90	46.52	49.60
0V75O	1.07	2.22	0.44	4.57	27.23	5.62	36.95	40.69
1C100	0.55	2.47	0.60	6.17	54.32	3.83	64.62	68.23
1O100	0.29	1.89	0.35	8.17	46.03	8.11	60.56	63.10
1V100	1.74	2.70	0.55	4.20	31.72	3.96	39.80	44.79
1C75O	0.56	2.30	0.46	6.02	39.13	4.50	50.06	53.38
1C75V	1.07	2.73	0.62	5.50	45.61	3.55	55.45	59.88
1V75C	2.89	4.76	0.98	6.20	41.98	4.22	54.07	62.70
1O75V	1.06	3.20	0.58	9.92	45.08	39.73	66.11	70.95
1O75C	0.50	2.23	0.37	7.53	35.15	7.18	49.45	52.55
1V75O	2.10	3.96	0.80	7.77	43.74	10.16	60.49	67.35
2C100	0.39	1.62	0.36	4.09	38.60	2.30	44.64	47.01
2O100	0.27	1.91	0.36	7.96	38.62	8.31	53.58	56.13
2V100	1.65	2.56	0.55	3.87	25.55	4.45	33.52	38.28
2C75O	0.34	1.48	0.27	4.37	32.88	3.11	40.51	42.60
2C75V	0.74	1.80	0.36	3.74	32.73	2.07	38.65	41.55
2V75C	1.46	2.45	0.41	3.48	29.69	2.24	36.03	40.35
2O75V	0.63	1.96	0.32	6.19	29.33	5.68	41.35	44.26
2O75C	0.50	2.30	0.38	8.19	38.72	7.22	54.50	57.67
2V75O	1.30	2.49	0.45	5.07	28.92	5.86	39.45	43.68
3C100	0.53	2.29	0.53	5.62	58.27	3.24	66.88	70.23
3C75O	0.45	1.96	0.37	5.54	35.64	4.08	49.95	52.72
3C75V	1.05	2.50	0.54	4.94	40.74	3.52	48.94	53.03
3C75V	1.67	2.80	0.50	3.93	32.14	2.70	39.38	44.35
3O75V	0.83	2.55	0.43	8.26	41.68	9.72	58.10	61.91
3O75C	0.37	1.96	0.29	7.22	35.02	7.75	48.16	50.78
3V75O	2.11	3.81	0.71	7.46	47.15	9.17	62.25	68.87
4C100	0.48	2.09	0.48	5.15	50.24	2.80	58.25	61.30
4O100	0.29	2.09	0.41	8.86	43.56	8.06	60.16	62.96
4V100	1.84	2.89	0.63	4.49	29.61	5.03	38.71	44.07
4C75O	0.43	1.93	0.37	5.40	39.04	4.15	49.00	51.71
4C75V	0.89	2.19	0.45	4.48	40.33	2.82	47.91	51.45
4V75C	1.73	2.96	0.52	4.16	33.91	3.20	41.85	47.07
4O75V	0.78	2.55	0.42	8.24	39.75	8.75	56.45	60.20
4O75C	0.50	2.43	0.39	8.50	40.84	7.78	57.46	60.78
4V75O	1.83	3.42	0.64	6.77	40.63	7.75	54.49	60.38
5C100	0.51	2.45	0.58	5.91	44.91	3.57	54.16	57.70
5O100	0.23	1.58	0.28	7.14	37.38	6.83	50.30	52.38
5V100	1.50	2.33	0.48	3.71	26.27	3.93	33.60	37.92
5C75O	0.65	3.17	0.65	8.32	48.52	6.25	64.77	69.23
5C75V	1.08	2.83	0.63	5.56	38.76	3.48	48.82	53.35
5V75C	2.42	4.38	0.86	5.99	40.08	4.10	52.24	59.90
5O75V	0.85	2.89	0.49	8.57	34.90	10.28	53.50	57.73
5O75C	0.70	3.28	0.58	10.78	51.64	10.03	72.23	76.78
5V75O	1.22	2.34	0.39	4.93	30.83	5.81	40.82	44.77
6C100	0.52	2.30	0.56	5.83	52.57	3.49	61.82	65.20
6O100	0.25	1.82	0.35	8.01	39.33	7.34	54.43	56.85
6V100	2.01	3.07	0.67	4.45	30.99	6.48	40.53	46.28
6C75O	0.68	3.07	0.61	7.79	57.57	5.92	72.09	76.45
6C75V	1.50	3.66	0.82	6.65	41.46	4.11	65.94	71.92
6V75C	2.96	5.02	0.93	6.34	52.70	4.82	65.14	74.05
6O75V	0.68	2.26	0.38	7.70	34.51	8.96	49.70	53.02
6O75C	0.63	3.03	0.57	10.19	51.73	10.41	71.61	75.85
6V75O	1.49	2.84	0.53	5.89	33.25	8.08	45.34	50.20