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Analytical Methods

Differentiation of geographical origin of cream products in Poland according to their fatty acid profile

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ABSTRACT

Fatty acid (FA) composition of bovine milk fat from cream samples, originating from three regions of Poland (one mountainous and two lowland ones) and collected within 2 years, was analysed aiming at identifying the region of production by applying principal component analysis (PCA). From the 44 FAs identified by gas chromatography, two groups were discerned: seasonally variable ($n = 17$) and non-seasonal ($n = 7$). The biplots showed that different FAs could serve as markers of geographical origin of cream samples. The CLA, vaccenic acid, C18:3*9c12c15c*, total C18:1*trans* and C18:3*9c12c15c* $n-6$ (GLA) were found indicative of mountainous regions, and the short-chain saturated FAs (SCFA; C4:0–C11:0) – of the lowland ones. The Opole province was characterised by a high content of linoleic acid. It was concluded that the origin of a cream sample could be fairly well identified by gas chromatography combined with chemometric analysis of milk fat FAs.

1. Introduction

The geographical origin of food products can serve as an indicator of their quality and authenticity in certification procedures. Therefore, both consumers and manufacturers attach great importance to it. Products of high quality are not only associated with freshness, specific sensory attributes and specific culinary qualities, but also with benefits for health, traditional production methods, care for environment and animal welfare, etc. From the producers' point of view, the clearly indicated product origin is associated with increased confidence in the quality and safety of products from given region or country, especially from rural areas. The local nature of a food product, correlated with its geographical location, is a result of both quality of the raw material used and of processing technology. The features of the raw material, which are an important factor determining the final product, depend on the environmental conditions in a specific geographical area (Monfreda, 2012). In order to determine the authenticity of a dairy product, the geographic origin of milk is to be known (Brescia, Monfreda, Buccolieri, & Carrino, 2005).

Since product origin is one of the decisive characteristics of foodstuffs, highly sophisticated analytical procedures are required to determine it. Chromatography is one of the techniques that have been successfully applied to food authentication via separation and determination of food components. A multicomponent analysis, as opposed to a single-marker approach, seems promising in establishing the geographical origin of food products (Galeano Diaz, Duran Meras, Sanchez Casas, & Alexandre Franco, 2005; Maçatelli et al., 2009).

The composition of bovine milk fat is affected by various factors, such as feeding regimen, seasonality, breed of cattle, age, lactation stage, milking system and frequency (Jensen, 2002; Kalač & Samková, 2010; Morales-Almaráz et al., 2010). Another factor of great importance is the geographical one; it determines the botanical composition of pasture plants and can thus influence the chemical composition of milk fat (Alonso, Brana, & Bada, 2004; Collomb, Bütikofer, Sieber, Jeangors, & Bosset, 2002; Faulkner, Brechany, Mabon, & Pollock, 1986; Frelich et al., 2009; Rutkowska & Adamska, 2011; Rutkowska, Adamska, & Bialek, 2012; Thorsdottir, Hill, & Ramel, 2004). Nowadays, two main cattle feeding regimens can be distinguished: seasonal and Total Mixed Ration (TMR). The seasonal, traditional system, is based on separate feeding of roughage and rations, providing the ability of their separate portioning. It is commonly used in farms in Polish mountains, where animal nutrition is based on high quality forage produced locally, with low content of silages and without concentrates. The cows from mountainous farms have access to pasture during spring, summer and autumn (Collomb et al., 2002; Frelich

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et al., 2009; Rutkowska, Adamska, et al., 2012). A more modern solution, recommended for breeding cows with high potential of production, is TMR. This system provides cows a steady access to a complete mixture of roughages, rations and vitamin-mineral concentrates in *ad libitum* amounts (Rutkowska, Sinkiewicz, & Adamska, 2012). Dairy cattle feeding, specific for given region, is one of the most important factors influencing raw milk composition and, consequently, the composition and quality of dairy products derived from it, such as cream, butter and various types of cheese. The results obtained in earlier studies show that fatty acid (FA) composition is a good descriptor for discriminating both raw materials and food products employing various factors (Castro Ferreira, Morgano, do Nascimento de QuierozBassi, & Mantowani, 2000; Dias et al., 2009; Gaspardo, Lavrencic, Levart, Del Zotto, & Stefanon, 2010; Kupcewicz, Stanek, & Janicki, 2011; Martinez, Standal, Axelson, Finstad, & Aursand, 2009).

The aim of the study was to explore the feasibility of chemical data, such as FA profile, to identify the origin of cream samples by applying the principal component analysis (PCA).

2. Materials and methods

2.1. Sampling

A total of 63 samples of cream containing 12% of fat (half-cream) were collected during two consecutive years (2010–2011) from dairy plants located in three different regions of Poland: Wielkopolska (n = 23) Bieszczady Mountains (n = 22), Opole (Opolskie) province (n = 18). On average, two samples per month were collected. Fewer samples were taken from Opole province due to the flood and its aftermath in that area during spring and summer months in 1 year. Cream was produced by the same technique in all the regions studied. Samples were taken directly from dairy sites and transported in a cooled box to the laboratory.

The cream manufacturing process involved the separation of fat from milk through centrifugation at high speed (usually 7500 rpm). The next step was deodorisation, running at 90 °C at a pressure of 50 kPa. That process involved removing defaulting gases and odours of the feed or of technological origin. Cream is then heat-treated (95 °C) to obtain microbial purity and to destroy lipases, which can cause lipid deterioration resulting in off-flavour and shelf-life reduction.

2.2. Description of analysed regions

The collected samples of cream originated from two lowland regions (Wielkopolska and Opole province) and one mountainous region (Bieszczady; see Table 1). In the studied regions animals were managed differently. In the Wielkopolska province, seasonal, traditional way of feeding was used in about 70% of farms. Cows were fed mainly corn silage, hay and grain concentrates ration as a supplement, and instead of pasture they received also some amount of fresh-cut alfalfa as green fodder. In the remaining 30% of farms in that area, animal were fed by the TMR regimen.

Because of the fact that farms feeding large numbers of cows by TMR constitute over 70% of milk suppliers in the Opole province, that feeding regime is the most popular among them. In that particular region, cows received mainly corn silage, grass silage and grain concentrates, their access to pasture being extremely limited. That system is favourable for cows with high milk production potential, the highest in that region. This way of cattle feeding is most popular in areas of intensive cultivation and animal husbandry, e.g. in the Opole province.

In mountainous farms in the Bieszczady region, the traditional, season-depending system of feeding is commonly used. It is based on separate feeding of roughage and rations, with low content of silages and without concentrates. In that region, only small farms (19 cows on average) existed, the animal feeding being seasonal and based on pasture during the season. Because forages are produced locally, they are of high quality.

The Polish Holstein Friesian breed (PHF) was the only one in lowland areas but in the mountainous region constituted only 28% of cattle there, the dominating breed (55%) being Siementhal cows (Table 1). The pasture season covered the period from May 15 till October 30.

2.3. Fatty acid analysis

Lipids from cream samples were extracted and determined using the Röse-Gottlieb method (AOAC No 905.02). Methyl esters of FA (FAME) were prepared according to AOCS Official Method Ce 2-66 (by transmethylation of fat samples using a mixture of 95% H_2SO_4 and methanol). Gas chromatographic (GC) analyses were performed using an Agilent 6890N (USA) chromatograph equipped with flame ionisation detector (FID) with split/splitless injector operated with a split ratio of 1:50. FAMEs were analysed on Rtx 2330 Restek capillary column with stationary phase of high polarity (100 m × 0.25 mm I.D., film thickness 0.1 μm). Oven temperature was initially set at 120 °C for 40 min, then ramped to 155 °C at 1.5 deg/min and held for 50 min, then ramped again at 2 deg/min to 210 °C and held for 35 min. Injector and detector temperatures were maintained at 250 °C, the carrier gas (helium) flow rate being 0.9 ml/min. For identification and recoveries of FAME the butter reference standard (CRM 164; Commission of the European Communities, Community Bureau of Reference, Brussels, Belgium) and Supelco 37 No. 47885-U standard (Sigma Aldrich)

Table 1
Characteristics of analysed regions.

Characteristic	Lowland		Mountain region
	Wielkopolska	Opolskie	Bieszczady
Localisation and altitude (m)	Central 75–150	South-East 100–260	Mountain 600–1000
Feeding regimen of cows[b]	Seasonal – 70% of farms TMR – 30% of farms	TMR – 70% of farms Seasonal – 30% of farms	Seasonal feeding
Average size of herds [numbers of cows][a]	43	67	19
Breed of cattle reared in the region[a]	94% PHF 6% other breeds	96% PHF 4% other breeds	55% Simmental 28% PHF 17% other breeds
Average annual milk yield (kg)[a]	7095	7718	5211
Average content of fat (%)[a]	4.05	3.99	4.02
Average content of proteins (%)[a]	3.36	3.28	3.26

[a] According PFCBDF (2010, 2011) data.
[b] Information obtained from dairies.