

The Quality of Cheeses made from the Milk of Sheep Grazed on Natural Wet Mountain Meadows: Health-related Implications

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Abstract

The European Union advises extension of organic food farming due to its apparent health benefits. An analysis of the subject's literature unfolds growing interest in sheep milk application in the daily diet. It is rendered by the two factors: 1) its rich chemical composition and apparent health benefits 2) ease of collection and applicability in the production of dairy products. The purpose of this study was to analyze the physical and chemical properties of Polish acid and acid-rennet cheeses produced from the milk of sheep pastured in the natural environment. The content of monounsaturated and polyunsaturated fatty acids, linoleic acid, rumenic acid, and γ -linoleic acid was analyzed using gas chromatography coupled with mass spectrometry. The extent of microelements; Na, K, Ca, Mg, Zn, Mn, Fe, and Cu were analyzed flame detection method and electro thermal methods. Both types of cheeses may be classified as soft cheeses. There are both defined by the higher amount of linoleic acids that this observed in similar samples by other researchers. Both kinds of cheese are also a rich source of microelements with a concentration higher than this observed in cheeses from cow milk. This study points to sheep cheeses as an organic food that is desirable from the health-related point of view. It also proves sheep cheeses are a desirable alternative to cow cheese because they may exert better health-related response and may also be an alternative to Mediterranean diet in northern European countries.

Keywords

Sheep cheese; Acid cheese; Acid-rennet cheese; Fatty acids; Microelements; Diet

Conflict of Interests

The authors declare that they have no competing interest.

Introduction

The current policy of the European Union (EU) on organic food resulted in a rapid growth of retail and rendering the market at a level of €24 billion/year. There are, however, distinct differences in organic food consumption between member states of the European Union. The extreme cases are Bulgaria and Sweden; the former is defined by the lowest consumption of organic foods, the latter with the greatest. In the majority of Northern European countries animal products such as milk and dairy products, constitute nearly 20% of all organic products sold on the market [1]. Among milk-producing animals, sheep are the dominant reaching in 2014 the population level of 4,483,164 [2]. The husbandry of sheep influences not only dietary habits of Northern Europeans but also vast areas of ecosystems [3]. In Poland, the member state of the European Union sheep farming is among the leading element affecting the terrestrial ecosystem in the southern part of Poland; Beskid Sadecki, a region encompassing 670 km². For at least forty years there is a lucid reciprocal relation between the quality of milk and milk products from sheep grazed on natural mountain meadows and the ecosystem.

Since sheep milk and cheeses are defined by rich chemical composition and nutritional, and health benefits is an excellent raw material for organic food processing, its consumption grows gradually over the last 20 years.

Although the quality of cheese is defined, among others, by the stage of lactation an average consumer is more interested in its gustatory and dietary properties [4-6].

To assess health-related quality of the two most popular kinds of cheese, i.e., acid cheese and acid-rennet cheese-the name is a reflection of the curdling procedure-we analyzed general physical properties, fat content (quantitatively and qualitatively) and content of microelements in those cheeses.

Materials and Methods

Milk samples were collected in the Beskid Sadecki region of Poland, Figure 1. Cheese

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samples used in this study were produced by using milk collected in the 4th, 5th, 6th, and the seventh month of lactation with an exact interval of thirty days between sample collection and during the pasture feeding season. Acid and acid-rennet cheeses produced in the two local factories in the respective month were collected and submitted to the battery of the analytical tests.

In each sample parameters defining the consumption quality of the cheeses were analyzed: 1) water content, 2) dry weight, 3) total fat, and 4) protein content. All those parameters were analysed using Milko-Scan apparatus (Foss Electric, Hillerød, Denmark).

The profile of fatty acid profile was assessed using gas chromatography-mass spectrometry system (Thermo Scientific). The following parameters were analyzed: 1) the amount volatile fatty acids ($<C_{10}$) (VFA), 2) the amount of monounsaturated fatty acids (MUFA), 3) the amount of polyunsaturated acids (PUFA), 4) the amount of linoleic acid [(LA), (9Z,12Z)-9,12-Octadecadienoic acid], 5) the amount of rumenic acid [(RA), (9Z,11E)-Octadeca-9,11-dienoic acid5]], and 6) the amount of γ -linoleic acid [(GLA), (all-cis-6,9,12-octadecatrienoic acid)].

The content of Na, K, Ca, Mg, Zn, Mn, Fe, Cu were evaluated using atomic absorption spectroscopy. In brief, the analysis consisted of mineralization performed in the MarsXpres microwave oven (MARS Xpress CEM) followed by flame detection for Ca, Na, K, Zn, Mg and electro thermal method for Mn, Fe, and Cu. All the analyses were done on AA240 FS Varian spectrometer.

The outline of data collection and analysis procedure is depicted in Figure 2. Although the quality of cheese is defined, among others, by the stage of lactation an average consumer is more interested in its gustatory and dietary properties [4-6]. Therefore, for statistical purposes, all the data were pooled, and the distribution of a sample comprising of 20 elements was analysed using numerical (Shapiro-Wilk) and graphical approach (histogram and quantile-quantile graph). The statistical differences were assessed using a t-test for dependent samples. The logic behind employing such an analytical strategy has its ground in the fact that both types of cheeses, i.e., acid and acid-rennet cheese, were produced from the same batch of milk. Since each pair of the study sample is mixture independent and dependent predictors, the test allowing for rejecting internal group variability was employed. The data are presented as an arithmetic mean and standard deviation of a mean. Statistical hypothesis was tested at the significance α level equal to 0.05, 0.01, and 0.001 and are depicted in Tables as * for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$.

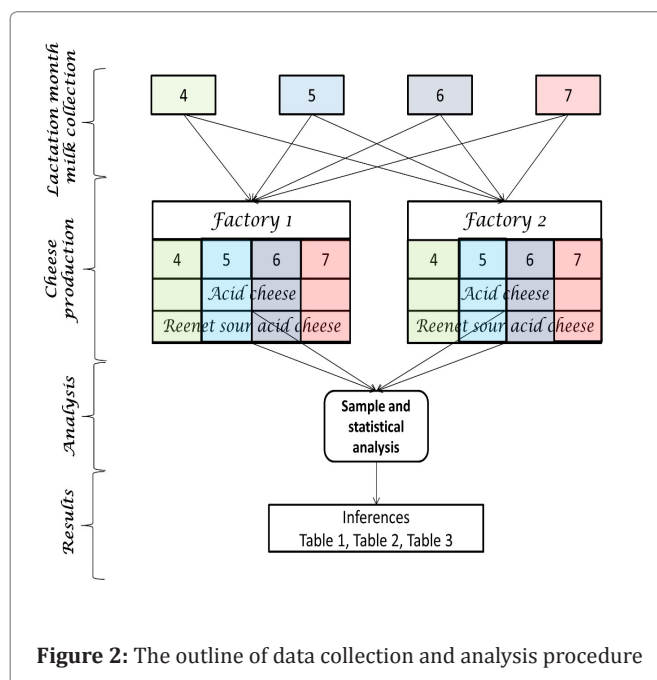


Figure 2: The outline of data collection and analysis procedure

Results

Tables 1-3 comprise the results of an analysis of the consumption quality of specific cheeses. Physical parameters for both kinds of cheese and corresponding statistical inferences are presented in Table 1. The average fatty acids content as a function of cheese with the corresponding statistics is shown in Table 2. Microelements content as a function of a cheese type and the corresponding statistical inferences are gathered in Table 3.

An analysis of Table 1 reveals the similar amount of total fat and fat in dry mass for both kinds of cheese. However, there is a statistically significant difference in water content at the p -level < 0.001 and in protein content at p -level < 0.05 .

An analysis of Table 2 shows a greater content of LA in the sample of acid cheeses than this observed for acid-rennet cheeses. The levels PUFA and GLA are significantly greater, at $p < 0.01$, in the acid-rennet cheeses.

Discussion

FAO/WHO Standard A6 [7] for soft cheeses requires the water content to be greater than 69 g/100 g mass for soft cheeses and less than 69 g/100 g mass for semi-soft cheeses. Statistical analysis unfolds that both types of cheeses may be classified as soft cheeses at the $p < 0.05$. However, at $p < 0.01$ the acid cheese can be classified as soft cheese and the acid-rennet cheese as a semi-hard cheese. Accordingly, referring the same standards battery [7], both kinds of cheese may be classified as high-fat products.

The review of the literature resulted in only one report undertaking the problem of analysis of fatty acid content in sheep cheese (the study on cheese fatty acid composition in sheep fed on Mediterranean fresh forages) [8]. Although the reported levels of LA and GLA are slightly greater than those presented in our study, i.e., the content of LA varies between 2.66 and 2.84 g/100 g of total mass and GLA between 1.64 and 1.83 g/100 g of total mass the averages correspond very well with data presented in Table 2. Our findings also confirm the results of the study of Steinhart and co-workers indicating that ruminants milk products are characterized by a high level of conjugated linoleic acids: rumenic and γ -linoleic acids [9].

A recent study indicates that a diet rich in CLA improves health-related quality of life [10]. This observation in connection with the studies on the reciprocal relations between cheese consumption and progress of diseases such as cancer, atherosclerosis, and diabetes in humans unfolds lucid advantages of sheep acid-rennet cheese consumption [11-13].

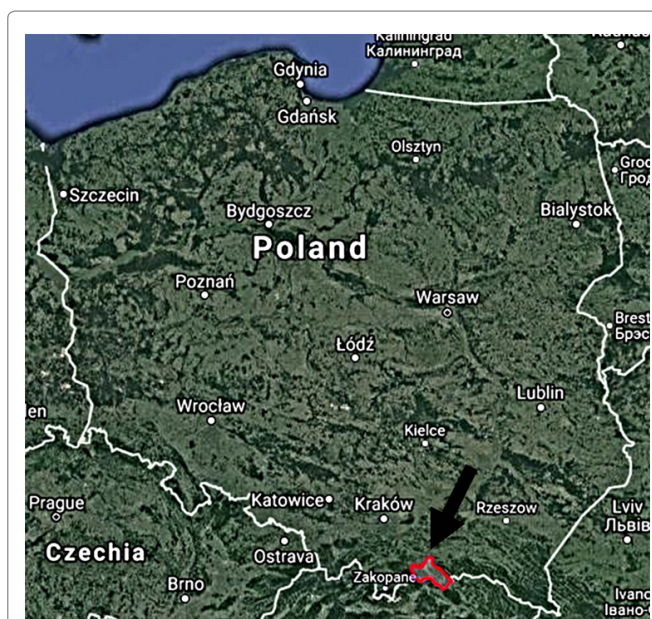


Figure 1: Geographical placement of the Beskid-Sadecki region, Poland

Parameter	acid cheese Mean $\pm$ std	acid-rennet cheese Mean $\pm$ std	Statistical inference
Water content	59.8 $\pm$ 7.22	53.1 $\pm$ 8.42	***
Water content in non-fatty matter	74.6 $\pm$ 9.11	67.1 $\pm$ 8.05	**
Fat content	19.9 $\pm$ 2.44	20.9 $\pm$ 2.84	N
Fat content in dry matter	49.6 $\pm$ 5.33	44.6 $\pm$ 5.49	N
Protein content	18.9 $\pm$ 2.04	19.9 $\pm$ 2.51	*

Table 1: Basic indicators of chemical quality of acid and acid-rennet sheep cheese. The data are represented as a mean and standard deviation of a mean. * stands for $p < 0.05$; ** for $p < 0.01$, and *** for $p < 0.001$. N-lack of statistically significant differences

Parameter	acid cheese Mean $\pm$ std	acid-rennet cheese Mean $\pm$ std	Statistical inference
VFA	22,71 $\pm$ 3,55	21,46 $\pm$ 3,81	NA
MUFA	17,96 $\pm$ 3,06	18,83 $\pm$ 2,80	NA
PUFA	7,79 $\pm$ 1,05	9,51 $\pm$ 1,31	***
LA	2,18 $\pm$ 0,31	2,16 $\pm$ 0,19	**
RA	3,88 $\pm$ 0,55	3,91 $\pm$ 0,61	NA
GLA	0,68 $\pm$ 0,04	2,25 $\pm$ 0,25	***

Table 2: Fatty acids profiles of acid and rennet-acid cheeses from sheep milk. The data are represented as a mean and standard deviation of a mean. * stands for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$. N-lack of statistically significant differences

Parameter	acid cheese Mean $\pm$ std	acid-rennet cheese Mean $\pm$ std	Statistical inference
Na (mg/kg)	400,64 $\pm$ 84,35	453,60 $\pm$ 85,35	NA
K (mg/kg)	1266,95 $\pm$ 154,63	1368,44 $\pm$ 135,44	NA
Ca (mg/kg)	1079,49 $\pm$ 897,88	4869,60 $\pm$ 220,06	***
Mg (mg/kg)	161,68 $\pm$ 22,55	245,22 $\pm$ 33,54	***
Zn (mg/kg)	7,197 $\pm$ 1,05	16,21 $\pm$ 2,52	***
Mn (μ g/kg)	658,50 $\pm$ 21,05	513,99 $\pm$ 22,58	***
Fe (μ g/kg)	1227,39 $\pm$ 264,11	1414,15 $\pm$ 124,15	***
Cu (μ g/kg)	439,26 $\pm$ 18,46	523,87 $\pm$ 54,16	***

Table 3: Microelement content in acid and rennet-acid cheeses from sheep milk. The data are represented as a mean and standard deviation of a mean. * stands for $p < 0.05$, ** for $p < 0.01$, and *** for $p < 0.001$. N-lack of statistically significant differences

Although Nudda et al. [14], showed that the content of GLA is season independent and is a derivative of the quality of pasture the average values presented in his study correlate with the data presented in our report.

The advantages of the organic food products, such as sheep cheese produced in the southern region in Poland, are also supported by the study of Khanal et al. [15], who indicated full public acceptance of technologically CLA-enriched cow cheese. Taking this into account one may infer that organic food “naturally” comprising a high level of CLA should be readily accepted by consumers on the international

market, as is in the case in Poland. An additional advantage of organic sheep cheeses is their high energy content which is derived from the significant amount of fatty acids. Opposite to reprocessed sugar-rich foods, sheep cheese does not induce blood clotting and is likely to augment hypertension as well as may inhibit bacterial growth in the gastrointestinal tracts and have bactericidal effects. The latter observation was recently confirmed by the two study [16,17], which showed that short-chain fatty acids [formic acid (C1), acetic acid (C2), propionic acid (C3), butyric acid (C4), isobutyric acid (C4), isovaleric acid (C5), hexanoic acid (C6)], medium-chain fatty acids [octanoic acid (C8), capric acid (C10), lauric acid (12)], and long-chain fatty acids [myristic acid (C14), palmitic acid (C16)], exert antimicrobial activity against *Streptococcus mutans*, *Streptococcus gordonii*, *Streptococcus sanguis*, *Candida albicans*, *Aggregatibacter actinomycetemcomitans*, *Fusobacterium nucleatum*, and *Porphyromonas gingivalis*.

An additional advantage of a sheep-cheese is in the high content of LA; an essential fatty acid of ceramides. LA also involved in the maintenance of the transdermal water barrier of the epidermis [18]. It has been shown that the daily recommendation of these acids should be on the order of 12 g/d and 17 g/d for women and men, respectively [19]. Thus, enrichment of a daily diet with sheep cheese allows for easy reaching that thresholds.

Health importance of sheep cheese is consumption is also supported by the study of Zaltano and co-workers [20], who showed that Greek cheese contains up to 1.9% CLA. The results presented in this study shows clearly that sheep rennet-acid cheese is a much richer source of CLA thus by conjecture we may assume that it will exert similar if not better results. This statement was confirmed by the latest report on physical properties of sheep milk [21].

A comparison of the reference data provided by the Dietary Reference Intakes (DRIs) [22]; Na (1.0-1.5 g/d), K (3.0-4.7 g/d), Ca (700-1300 mg/d), Mg (80-420 mg/d), Zn (3-11 mg/d), Fe (3-15 mg/d), Cu (340-900 μ g/d) and Mn (1.2-2.3 mg/d) for children, women, and men age 1 to 72 years, with data presented in this study, Table 3, clearly shows that a sheep cheese should be employed as a useful dietary supplement.

An analysis of microelements reveals that acid-cheese is defined by significantly less of Na, K, Ca, Mg and Zn, Fe, and Cu and statistically greater amount of Mn than this observed in acid-rennet cheese. A comparison of our results with those a few focused on cheeses produced by analogous procedures shows a similar amount of magnesium [23,24].

The reported zinc content with the study on in Croatian hard sheep cheeses points to the latter as a significantly richer source of zinc 35-40 mg/kg [25]. Analysis of copper content shows the value similar to the only two reports on this subject [24,26].

Although the cheeses examined in the study are defined by a high amount of sodium it is negligible from a dietary point of view [22]. Thus, increased consumption of sheep cheeses will not elicit Cardiovascular Diseases (CVD) that are driven, among others, by increased consumption of salt (NaCl) [27]. Additionally, increased consumption of sheep milk dairy products may exert some positive effects. Just to mention a few: they are rich in magnesium which is successfully employed as an effective means of fighting with Cd and Pb toxicity [28]. Dairy calcium stimulates a proper bone structure development and maintenance in children and adults [29]. Iron delivered, among others, with dairy products iron participates in a wide variety of metabolic processes such as oxygen transport, Deoxyribonucleic Acid (DNA) synthesis, and electron transport [30].

It was also shown that sheep's milk and milk products are an excellent source of trace elements such as Ba, Cr, Cu, Hg, Mg, Mn, Ni, and V because the content of these elements in sheep milk is greater than in cow milk [31].

Conclusion

The proper dietary habits are among the primary sources of the good health-related quality of life. In the recent years, much attention has been directed towards Mediterranean diet which comprises

among other of a significant amount of cheeses [32]. In this study, we show the health-related advantages of consumption of organic food such a sheep cheeses, which are the source of essential fatty acids and microelements. We have shown that both types of sheep cheeses, i.e., acid cheese, and acid-rennet cheese contain a higher amount of required microelements than this observed in cow milk cheese. Also, the content of derivatives of linoleic acid makes this food a desirable alternative to cow cheese which may exert better health-related response.

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