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Physical and physico-chemical parameters of Greek cheeses

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Some physical and physico-chemical parameters of 15 different Greek cheeses were assessed. Cheeses differed as to the origin (cow, sheep and goat), they had different texture (soft, semi-hard and hard) and they were from different regions in Greece. The aw values in observed samples ranged from 0.799 (in semi-hard cheese Kefalotiri) to 0.889 (in soft cheese Katiki Domokou); while the average value of water activity in the samples was 0.851. Water content of the samples was 24.0 to 73.6 %. Dry matter in cheese thus constituted from 26.4 to 76 %. Fat content in dry matter was from 34.27 to 62.11 %. NaCl concentration in cheeses ranged from 0.82 over 5.15 %. Colour data for the monitored cheeses were analyzed colorimetrically and expressed by CIElab colour range as parameters L*, a*, b*.

Keywords: Greek cheese, water activity, pH, dry matter, fat, NaCl, colour.

INTRODUCTION

Cheeses include the traditional Greek foods and their production has a long tradition and describes it already Homer [1]. Greeks in cheese consumption ranks third in the world (behind France and Iceland) with a consumption of 23.4 kg per capita per year (it is more than twice as Slovakia with 10.3 kg per capita) [2]. Greek terrain and climate conditions are suitable for breeding sheep and goats as well as cattle, which also contribute to the wide variety of produced cheeses [3]. The most popular Greek cheese is a soft white cheese feta, which is ripened and stored in brine. According to Greek standards [4] only pure sheep‘s milk or a mixture of sheep‘s and goat‘s milk may be used for the feta cheese production. (usually up to 30 % goat‘s milk in the mixture.) It is well known that as Greek cheese and the name of feta is included in the register of protected denomination of origin (PDO) of the European Union.

In general, the quality of the cheese is affected by a number of parameters and the most primarily evaluates the basic composition: water content, fat content, pH, salt content and water activity. Water in cheese plays a relevant role for the curd consistence and the bacterial metabolism, and consequently for the processes during cheese ripening. The influence of the water content and the water activity on the cheese quality is very complex. Cheese contains beside high molecular proteins also low molecular compounds which are partly produced during ripening or as in the case of NaCl, are added during manufacturing. The low molecular soluble compounds (especially sodium chloride) have the biggest influence on the water activity in cheese [5-7].

Determining the values of water activity, pH and salt content belong to relevant data necessary for assessing the health safety and quality of the cheese [8-11].

The fat content in cheese is an important parameter, because in addition to significantly affect the sensory quality of the cheeses [12] involved also their thermo-physical properties (meltability, flowability, stretchability and oiling-off) especially in semi-hard cheese [13].

Natural colour of fattiest cow’s cheeses, and those from cows grazed on open pasture, tend to be yellower than cheese made from winter milk because of beta carotene. Beta carotene is a fat-soluble yellow pigment contained in grass. Some cheeses made from other animals’ milk are white because they don't store beta carotene in their fat the way cows do, but they convert it to colourless vitamin A [14]. One of validation criterion for milk products made from sheep and goats’ milk can be also colour [15, 16]. Of variations in quality may also draw attention to changes in colour of the cheese.

The aim of presented work was to estimate some physical and physico-chemical properties of typical cheeses from the other countries together with our foreign students and to ascertain what the differences in those properties are.

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EXPERIMENTAL

Assessed were 15 kinds of different cheeses, which differed as to the origin (cow, sheep and goat), they were from different regions in Greece and had a different texture (soft, semi-hard and hard). Cheese samples were purchased commercially in Greece in the months of October-November 2013. Moved to Slovakia in travel refrigerator and kept in the original packaging, respectively, vacuum-packed till the analysis and stored in the refrigerator at appropriate temperatures.

The samples were determined by the value of water activity, pH, water content (moisture), fat content and salt concentration. Colour of cheeses was evaluated by colorimetric method. Two cheeses from each product were sampled, all samples were analyzed in triplicate and results were given as a mean value.

Water activity. Water activity of cheese was estimated by non-destructive method using the LabMaster-a_w apparatus with electro-resistive sensor (from Novasina, Switzerland).

For LabMaster instrument calibration set of originally humidity standards (SAL-T 11, 33, 53, 75, 90 and 97 %) was used. Finely chopped cheese samples were sequentially measured in duplicate in plastic containers (10 ml) along with preheating of the next sample. The resulting a_w value, the selected measurement temperature (25 °C) and time measurements were read from the device LCD display.

pH. pH values were measured with a sharp needle Sen Tix pH-electrode (WTW, Germany) directly in cheese. Combined glass/calomel electrode was thoroughly calibrated with two buffer solutions at pH 4.01 and 7.00. The measurement was repeated consecutively using three different test points. Between each measurement was the electrode wiped to remove cheese, soaked in ethanol/ether (50/50), rinsed with water and wiped.

Water content. The water content (moisture) in cheese was determined by the method of drying to a constant weight at 102 °C (± 2 °C) in the drying oven UFP 500 (Memmert, Germany). Grated cheese (5 g) (m_c) was uniformly distributed at the surface of aluminium dish containing sand (20 g) both being dried in the oven until constant weight (24 hours) at 102 ± 2 °C (m_1). The dish with cheese were then dried and weighed in the same conditions (m_2):

$$\text{Dry mater}\ (\%\ \text{cheese}) = \frac{m_2 - m_1}{m_c} \times 100$$

$$\text{Moisture}\ (\%\ \text{cheese}) = 100 - \text{dry matter}$$

Dry matter was determined in triplicate per sample [17].

*Fat content.*The fat content was determined by simple and rapid Gerber-Van Gulik method. Method is based on the digestion of proteins and non-fat components by concentrated sulfuric acid and the separation of fat from the aqueous phase after centrifugation in special glass butyrometers (Van Gulik). In the butyrometer was charged 3.0 g of grated cheese, than were added 3 ml of distilled water and 10 ml of sulfuric acid (density 1522 kg.m^3). The sample was dissolved in a water bath at 65 °C and 1 ml of amyl alcohol was added to aid the separation of fat and aqueous phases. The sample in butyrometer was homogenized by over-rotation until complete dissolution. Finally, more sulfuric acid was added in order to bring upper fat layer in the measurement zone, again tempered to 65 °C for 5 minutes and centrifuged at Gerber centrifuge for 5 minutes at 1200 rpm and 65 °C. After centrifugation, the weight percentages of fat present in the cheese were read on the butyrometer scale [18].

*NaCl.*The amount of NaCl was determined by Mohr argentometric method [19]. Grated cheese (10.0 g) was stirred in the mortar with 10 ml distillate water, transferred quantitatively into 100 ml volumetric flask and filled up to the mark. Homogenous solution was filtered. In the titrimetric flask was 10 ml of filtrate diluted with 30 ml water and 1 ml of potassium chromate indicator was added. Mixture was titrated with silver nitrate (c = 0.1 mol/litre) till orange colour appeared. The percentage mass fraction of sodium chloride content was calculated from the volume of the silver nitrate solution in millilitres according the formula:

$$\frac{w_{\text{NaCl}}}{\%} = 0.585 \cdot a \cdot f$$

(Where: a = ml of 0.1 mol/l $AgNO_3$; f = factor of 0.1 mol/l $AgNO_3$).

Colour. Colour selection of cheeses was measured by colorimeter CM 410 (Konica Minolta, USA) with C type of illumination and expressed by rectangular CIELab colour range as 3 parameters L*, a*, b* which can accurately characterize various shades of colour and brightness. In the space CIELab L* expresses the brightness values, a* and b* are the chromaticity coordinates. L*

Table 1. Mean value of water activity, pH and sodium chloride content in cheese.

№	Name	a_w	pH	NaCl, %
1	Graviera from Creta	0.821	5.580	2.46
2	Mastelo from Chios	0.871	6.350	2.22
3	Ladotiri from Mytilini	0.831	5.250	2.22
4	Feta from sheep	0.869	4.403	3.63
5	Feta from goat	0.863	4.325	3.63
6	Chaloumi monastiriou	0.881	5.574	1.58
7	Chaloumi from goat and sheep	0.863	5.648	3.04
8	Tiraki Tiniako	0.858	4.355	2.63
9	Kaseri from Mitilini	0.866	5.386	2.01
10	Touloumotyri	0.871	5.565	2.46
11	Dry Mizithra from Creta	0.840	5.216	2.45
12	Pecorino Karali	0.805	5.616	4.83
13	Gaviera from Tinos	0.835	5.665	3.25
14	Kefalotiri Karali from Epirus	0.799	5.366	5.15
15	Katiki Domokou	0.889	4.317	0.82

takes the value from 0 to +100 (from black to white). The values of a* and b* range from –60 to + 60, with –a*direction is greenish, +a* represent red direction, –b* is the blue direction and +b* direction is yellow. H° gives hue angle degree in CIE-LCH colour range [20].

RESULTS AND DISCUSSION

For analyzes have been used two samples of 15 different studied Greek cheeses and each one was estimated in triplicate. Mean values of water activity, pH and sodium chloride are given in Table 1. Determining the values of water activity, pH and salt content belong to relevant data necessary for assessing the health safety and quality of the cheese. Water activity is an important parameter in food technology optimisation to provide microbiological, chemical and physical stability of food. The a_w values in observed samples ranged from 0.799 (in semi-hard cheese Kefalotiri) to 0.889 (in soft cheese Katiki Domokou); while the average value of water activity in the samples was 0.851. The pH of the samples ranged from 4.317 to 6.350. NaCl concentration in cheeses ranged from 0.82 over 5.15 %. Most of the samples (73.3 %) had salt content between 2.0 and 4.0 %. (In two samples was higher salt content in the two lower.) In the sample with the lowest salt content and the highest a_w value was, in contrast, the lowest pH that just provides health safety of product [11].

Results presenting means levels of the water content, dry matter and fat content in the tested samples are shown in Table 2. Water content (moisture) in cheese ranged from 24.0 to 73.6 %. Dry matter in cheese thus constituted from 26.4 to 76 %. Presence of fat in the samples ranged between 12.0 - 43.5 %. Also fat content in cheese dry matter was calculated and expressed in the result table. Fat content in dry matter was from 34.27 to 62.11 %.

Table 2. Mean values of moisture, dry mater and fat content in cheese.

№	Name	Dry matter, %	Moisture, %	Fat, %	Fat in dry matter, %
1	Graviera from Creta	64.2	35.8	22.0	34.27
2	Mastelo from Chios	61.6	38.4	32.0	51.95
3	Ladotiri from Mytilini	76.0	24.0	43.5	57.24
4	Feta from sheep	48.4	51.6	25.0	51.65
5	Feta from goat	48.4	51.6	30.0	61.98
6	Chaloumi monastiriou	58.8	41.2	28.0	47.62
7	Chaloumi from goat and sheep	56.2	43.8	27.0	48.04
8	Tiraki Tiniako	62.6	37.4	37.5	59.90
9	Kaseri from Mitilini	62.0	38.0	30.5	49.19
10	Touloumotyri	56.8	43.2	31.5	55.46
11	Dry Mizithra from Creta	64.4	35.6	40.0	62.11
12	Pecorino Karali	65.0	35.0	31.5	48.46
13	Gaviera from Tinos	66.0	34.0	30.0	45.45
14	Kefalotiri Karali from Epirus	66.2	33.8	32.5	49.09
15	Katiki Domokou	26.4	73.6	12.0	45.45

Table 3. Colour parameters of inner parts in assessed cheese samples.

№	Name	L*	a*	b*	ΔL	H°
1	Graviera from Creta	80.01	-3.46	30.67	0.41	96.44
2	Mastelo from Chios	87.21	-3.71	18.74	0.02	101.20
3	Ladotiri from Mytilini	87.61	-5.76	28.67	0.21	101.36
4	Feta from sheep	91.34	-2.44	14.47	0.32	99.57
5	Feta from goat	94.08	-2.50	11.91	0.25	101.86
6	Chaloumi monastiriou	90.93	-4.09	25.63	0.12	99.07
7	Chaloumi from goat and sheep	88.74	-2.77	18.28	0.08	98.62
8	Tiraki Tiniako	92.76	-1.86	18.79	0.06	95.65
9	Kaseri from Mitilini	79.87	-3.19	25.16	0.25	97.23
10	Touloumotyri	92.36	-4.21	17.23	0.21	102.73
11	Dry Mizithra from Creta	82.45	-2.83	24.06	0.43	96.71
12	Pecorino Karali	84.87	-3.77	22.21	0.39	99.63
13	Gaviera from Tinos	82.27	-1.75	21.72	0.13	94.61
14	Kefalotiri Karali from Epirus	87.57	-1.55	13.63	0.06	96.47
15	Katiki Domokou	93.95	-3.75	14.88	1.64	104.15

The colour characteristics of all samples were monitored in the inner part of cheeses. Mean L*, a*, b* parameters of the cheeses are presented in Table 3. Colour of cheese depends on type of used milk and fat content. L* parameter values ranged in 79.87 - 94.08. Standard deviations (ΔL) ranged in individual samples in 0.02 - 1.64. Intensity of greenish was expressed in a* values from -5.76 to -1.55. Values of the parameter b*, which reflects the intensity of the yellow colour in assessed cheeses is ranged in 11.91- 30.67. Hue angle degree H° ranged in 94.61- 104.15. The measured results can be used when comparing different technologies in cheese production or innovation as it was used, for example by Clareto et al. for comparing cheeses in which the fat was partially substituted with other ingredients [21]. The colour of the cheese surface and of the cheese inner parts is usually characteristic. During cheese ripening L*, a*, b* values did not change significantly [22].

When comparing the measured results with our other work in which we analyzed various Slovak cheeses it can be concluded, that most different were water activities. Greek cheeses a_w value were generally lower compared with similar Slovak cheese samples [23]. The aim of presented work was to estimate some physical and physico-chemical properties of typical cheeses from the other countries together with our foreign students and to ascertain what the differences in those properties are. The first work of this group is now presented, which is dedicated to the most important and specific Greek cheese.

Different 15 kinds of Greek cheese samples were determined by the value of water activity, pH, water content (moisture), fat content and salt concentration. Colour of cheeses was evaluated by colorimetric method. Each determination was carried out in triplicates and results were given as a mean value.

When comparing the measured results with our other work in which we analyzed various Slovak cheeses it can be concluded, that most different were water activities. Greek cheeses a_w value were generally lower compared with similar Slovak cheese samples.

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ФИЗИЧНИ И ФИЗИКОХИМИЧНИ ПАРАМЕТРИ НА ГРЪЦКИ СИРЕНА

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(Резюме)

Оценени бяха някои физични и физико-химични параметри на 15 различни вида гръцки сирена. Сирената се различаваха по произход (краве, овче и козе), те се характеризираха с различна текстура (меко, полу-твърдо и твърдо) и бяха от различни райони на Гърция. Стойностите на водната активност в изследваните образци вариране от 0,977 (в полутвърдото сирене Кефалотири) до 0,889 (в мекото сирене Катики Домокоу), а средната стойност на водната активност в образците беше 0,851. Водното съдържание на образците беше от 24,0 до 73,6 %. Така сухото съдържание съставлява от 26.4 до 76 %. Масленото съдържание в сухата фаза беше от 34,27 до 62,11 %. Съдържанието на NaCl вариране от 0,82 до 5,15 %. Цветните данни за наблюдаваните сирена бяха анализирани чрез колориметрия и изразени в CIElab цветна система чрез параметрите L*, a*, b*.