

Calcium Content in Commercial UHT Milk in Poland

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Calcium is the main mineral component of milk and cottage cheese as well as late ripening cheeses. Its content in raw milk in cow milk in Poland, depending on environmental factors, including feeding and breed of cows, was described in the works of Barłowska et al. (2004, 2013), Król et al. (2010, 2016) and Brodziak et al. (2011). Calcium in milk occurs in the form of mineral calcium ions and in the organic form. It was found that 45% of Ca in milk occurs in the form of colloidal calcium phosphate (Guéguen and Pointillart, 2000). It is the main mineral component in mammals. About 99% of calcium is present in the skeletal system and teeth, mainly as hydroxyapatite [Ca₁₀(PO₄)₆(OH)₂].

The demand of cows for this element in the period of lactation is 100-200 g/day, according to milk yield and calving period related to the structure of the calf skeletal system (Strzetelski et al., 2014). Calcium absorbed in the small intestine is incorporated into the pathways of its metabolism. The process of Ca metabolism in organisms, reabsorption in the kidneys, its resorption in the bones and excretion is regulated by the parathyroid gland (EFSA, 2015). In human studies, calcium absorption in the gastrointestinal tract in infants was shown to be 61.3% (Abrams et al., 1997), in adolescents 45.6% (Lynch et al., 2007), and in adults 25% (Gibson, 2005) and it is lower in postmenopausal women (Heeey et al., 1989) and over 60 year olds (Nordin and Morris, 2011). We do not know whether the above data on the amount of calcium absorption depending on the age can be transferred to dairy cows but some similarities are possible. The main channel of calcium excretion during lactation is the mammary gland. With cow milk, depending on the size of its production, it is removed at the level of 10-15 to 30-40 g calcium/day, which is 15-25% of the amount consumed in the daily ration by the cow. A significant amount of calcium is necessary in the second lactation period of cows when the body, especially the fetal skeletal system, is being built. In the case of insufficient content of calcium in the cow's feeding ration, and with the age in humans, it is utilised through bone resorption, which leads to the bones weakening and skeletal system injuries, and, in cows, to a metabolic disorder known as postpartum fever. Calcium contained in milk and dairy products is characterised by high digestibility in the human diet, determined at the level of 90-95% (EFSA, 2015). The human demand for calcium is high for children and young people in relation to the skeletal structure and body mass. At the age of 22-24, the demand for calcium decreases although it remains at a high level. It increases again after the age of 50-55 due to the decrease in its digestibility. The consumption of milk and dairy products in Poland is estimated at around 150-160 litres per year, which means that it is significantly lower than in the Czech Republic, Germany, Great Britain and the USA, where it exceeds 180 litres per year (Eurostat, 2016).

The calcium content in the milk of cows depends on the breed, age, lactation period and the level of this element in the feeding ration. Its content in consumption milk from different manufacturers is a result of many factors: genetic, environmental and technological sourcing and processing of raw milk brought from dairy cows farmers. The calcium level in consumption milk throughout Poland and at the same time has not been studied so far.

The purpose of the study was to recognise the calcium content in consumption milk covering the entire area of the country, sold in large-format food stores in the form retaining the extended shelf life - as UHT milk.

Material and methods. Collection of milk samples

The research material consisted of randomly selected samples of UHT consumption milk with an extended shelf-life. 5-6 cartons of milk with different fat content (0.5 to 3.2%) were purchased in large-format food stores in each of the 16 provincial cities, which corresponded to 8 regions of the country (Tab. 1) and 13 producers of consumption milk in Poland. Two milk samples came from an unidentified country of the European Union, and one from France (Tab. 2). They were collected on three dates, on 13.05, 23.08 and 7.09. 2014. On the same day or the next day, milk samples were transported by car to the Central Laboratory of the National Research Institute of Animal Production (Aleksandrowice by Krakow), stored at 5°C, and analysed immediately for the calcium content. The results listed in the tables are the average results for those three dates of calcium content testing in milk in each region of Poland.

Table 1. Calcium content in consumer milk according to city/region of purchase

City of milk purchase	Number of samples	Calcium content (mg/l milk)				
			SD	CV%	min.	max.
Bydgoszcz	6	991	51	5,15	951	1033
Gdańsk	6	1020	50	4,90	983	1041
Katowice	6	1107	44	3,97	1050	1153
Kielce	6	1002	53	5,29	689	1118
Kraków	6	1006	30	2,98	1001	1090
Lublin	5	1089	32	2,94	1044	1120
Łódź	6	1060	51	4,81	1019	1154
Olsztyn	6	1001	11	1,10	1027	1054
Opole	6	1086	34	3,13	1040	1128
Poznań	6	1001	56	5,59	688	1119
Rzeszów	6	1097	43	4,27	1050	1151
Siedlce	6	1043	44	4,22	991	1101
Szczecin	6	1088	57	5,24	1014	1150
Wrocław	6	1156	48	4,15	1082	1200
Warszawa	6	1040	29	2,79	1009	1072
<i>Average</i>	95	1058				
<i>SD</i>			44			
<i>CV%</i>				4,12		
<i>Range</i>					688	1200

SD – standard deviation

CV – coefficient of variation

Analyses of Calcium content in milk

The calcium content in milk samples was determined by the hydrogenation method and the atomic absorption spectrometry technique (ASA model GBC, Avanta, Australia) after prior mineralisation. The samples were mineralised in a mixture of nitric acid and perchloric acid - in a microwave mineraliser (Ethos Plus, Milstone, Italy) in these flasks, in two mineralisation cycles, each lasting 20 minutes (AOAC, 2006).

Statistical analyses

The results of analyses were elaborated by calculating the mean values for experimental factors (locality and region and milk producer), standard deviation (SD), coefficient of variation (CV) and range of deviations for the average value. The results of the analyses were compiled according to the place of purchase and the milk producer (dairy co-operative / dairy company).

Table 2. Calcium content in consumer milk according to milk producer

Milk cooperative	Number of samples	Calcium content (mg/l milk)				
		\bar{x}	SD	CV%	min.	maks./max.
Łowicz	14	1121	61	5,44	987	1171
Raciąż	3	1111	30	2,70	1091	1154
Grajewo	23	1070	55	5,14	683	1180
Radzyń Podlaski	1	1092	–	–	–	–
Sieradz	4	1163	72	6,19	1020	1150
Wysokie Mazowieckie	23	1040	93	8,94	689	1152
Nowy Targ	3	1040	37	3,56	1019	1074
Krasnystaw	1	1171	–	–	–	–
Gostyń	1	1029	–	–	–	–
Kościan	2	1029	19	1,85	1018	1033
Wyszyny	1	1001	–	–	–	–
Jabłonowo Pomorskie	1	904	–	–	–	–
Rypin	13	1071	49	4,58	1022	1152
Gdańsk	2	1040	60	5,77	1003	1081
EU/France	3	1009	63	6,24	951	1064
Average	95	1059				
SD			78			
CV%				7,4%		
Range					683	1180

Objaśnienia w tabeli 1. – Abbreviations in Table 1.

The results and their discussion

The average calcium content in consumption milk in Poland was 1058 ± 44 mg/l, with a coefficient of variation of 4.1% and a range of 688 to 1200 mg/l. The highest calcium content was found in samples of consumption milk from Wrocław: 1156 ± 48 mg/l, Zielona Góra 1142 ± 61 mg/l and Katowice 1107 ± 44 mg/l. The lowest amount was found in milk samples from Bydgoszcz: 991 ± 51 mg/l, Olsztyn 1001 ± 1 mg/l, Poznań 1001 ± 56 mg/l and Kielce 1002 ± 53 mg/l. Milk analyses showed very wide range of deviation in calcium content in milk - from 688 to 1200 mg/l (Tab. 1).

From among 13 milk cooperatives and dairy companies, the highest calcium content was found in consumption milk from the Dairy Cooperative in Krasnystaw; it amounted to 1171 mg/l. The lowest was found in a milk sample from Dairy Cooperative in Jabłonowo Pomorskie - 904 mg/l. The calcium content in 46 milk samples from the largest producers of consumption milk in Poland - the Dairy Cooperative MLEKPOL in Grajewo and the Dairy Cooperative MLEKOVITA in Wysokie Mazowieckie was 1070 ± 55 and 1040 ± 93 mg/l, respectively. Milk from both producers accounted for approximately 48.4% of collected samples of consumption milk in Poland. The calcium content in consumption milk samples originating from the European Union, including from France, was 1009 ± 63 mg/l.

The content of Ca in cow's milk was also determined for specific farms in a few regions of the country. In spring-summer and autumn-winter seasons, in 134 samples of Simmental cow's milk and 168 samples of mixed-breed cows's milk, the calcium content was 1010.0 ± 148.94 and 859.20 ± 203.31 mg/l, respectively (Barłowska et al, 2013). Significantly higher values were found in studies by Król et al. (2016), which differ to a considerable extent from the data shown in other works. The level of minerals, including Ca, was examined in the low-input production system (White-Necked, Polish Red and Simmental breeds), in total in 127 milk samples and in the intensive production system (Polish Holstein-Frisian breed), in total 63 samples of milk. The tests were carried out in the spring-summer and autumn-winter seasons, providing results averaged over the entire research period. The calcium content was, on average, 1810.05 ± 370.00 mg/l for both seasons, 1593.1 ± 369.3 mg/l in the low-cost system. The mentioned works did not specify whether and which calcium containing mineral mixtures were used in cow feeding. In both publications, the calcium content in milk was determined by the infrared reflection method using the Infrared Milk Analyser (Bentley). Mineral content was determined by the NIRS technique. We do not know how large database of calcium content in milk was used in the case of the instrument used in the research and whether it concerned only cow's milk or various types of dairy cattle. The reference method to the NIRS technique is the classical chemical method that was used in this work. Bagnicka (2007) in the review article on milk composition of cows, goat, sheep and buffalo milk gives the milk content of cows at the level of 1190 mg/1000 g of milk. Raw milk obtained from cows is processed in dairy plants. Commercial consumption milk in Poland has a diversified fat content at the levels of 0; 0.5; 1.5, 3.2% and is stabilised with the UHT technique. Minerals are not part of the fat, and therefore, the amount of fat in milk does not determine their content, including Ca content in milk.

Hess et al. (2015), in a paper discussing the health effects of consuming milk and dairy products, says that the content of calcium in consumption milk is at the level of 276 mg/244 g, which corresponds to 1131 mg of calcium/kg of milk. Rozenberg et al. (2016), in the work on nutrients of milk and dairy products, says that the content of calcium in full-fat milk (with the fat content of 3.7%) is at the level of 1190 mg/1000 g. In the light of the results of calcium content monitoring in consumption milk in Poland the obtained values are consistent with the results of Barłowska et al. (2013), as well as data found in foreign literature (Atkinson et al., 1995, Hess et al., 2015, Rozenberg et al., 2016). The research results obtained in this work indicate that the calcium content in consumption milk in Poland is balanced depending on the region of its sale and the place of its production. The coefficient of variation (CV) for calcium content in milk for 13 Polish regions was 4.1%, and for 15 milk producers 7.4%. The results obtained suggest that the amount of calcium excreted in cow milk is stable and does not change in a wider range. The calcium content in mammalian milk is regulated by homeostasis and does not depend on calcium intake in the feeding ration (Olausson et al., 2012).

Milk is the main source of Ca in dairy products. Rozenberg et al. (2016) determined its content in dairy products in the European Union (Belgium) at 721 mg/100 g in Cheddar ripening cheese, 183 mg/100 g in low-fat yoghurt, 128 mg/100 g in vanilla ice-cream and 86 mg/100 in the cottage type zero-fat cheese. The same authors calculated that by consuming 240 ml of milk daily, 42 g of cheese and 85 g of green vegetable leaves we consume the total of 289 mg of calcium per day.

According to the WHO/FAO (2004) data, the demand for adults for calcium is 1000 mg/day, and above the age of 65, it increases to 1300 mg/day. With age, the absorption of calcium in the digestive tract decreases. For children up to 1 year, the demand for calcium is 400 mg/day, from 1 to 3 years - 500 mg, from 4 to 6 years - 600 mg, from 7 to 9 years - 700 mg/day, and from 10 to 18 years - 1300 mg/day.

In the light of these data calcium contained in milk and dairy products should provide about 20% of the daily demand of an adult person for this element. Insufficient calcium intake in the daily diet has health consequences in humans, especially in the case of the skeletal system, as well as diseases of the circulatory system (Uusi-Rasi et al., 2013) and in the incidence of breast cancer in women (Chen et al., 2010).

Summary and Results

Summing up, it can be concluded that the calcium content in consumption milk in Poland is at a level similar to that described in domestic and foreign literature, and, on average, it amounts to 1058 ± 44 mg/l milk. Its content in consumption milk, depending on the region of Poland and the producer, is stable and variable within the range of 4.1 to 7.4%. It means that when consuming 250 ml of milk (including dairy products), we consume about 250 mg of calcium daily, which is about 25% of the adult's demand and 19% of people over 65 years of age demand.

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CALCIUM CONTENT IN COMMERCIAL UHT MILK IN POLAND

Summary

The aim of the study was to determine calcium content in consumption milk in Poland. Samples for analyses were collected in three periods (spring, summer and autumn) from large-format food stores located in 16 provincial cities, which corresponded to 8 regions of Poland. The milk samples originated from the 13 largest manufacturers of consumption milk. The study material consisted of UHT pasteurized milk with extended shelf life. In each store, 5 to 6 1-litre containers of milk with 0.5 to 3.2% fat were randomly chosen and purchased. A total of 95 milk samples were gathered, including 3 samples of milk from France and unidentified European Union countries. The results were reported according to location of purchase and milk producer (dairy cooperative/dairy company). The average milk calcium content was 1058 mg/l with a standard deviation (SD) of ± 44 mg/l and variation coefficient of 4.12% (range from 688 to 1200 mg/l). The highest calcium content was found in the milk from Wrocław (1156 ± 48 mg/l) and in the milk from the Dairy Cooperative in Krasnystaw (1171 mg/l), and the lowest in the milk from Wyszyny in Wielkopolska (1001 mg/l). Calcium content in 46 samples of milk from the largest producers of consumption milk in Poland (MLEKPOL Dairy Cooperative in Grajewo and MLEKOVITA Dairy Cooperative in Wysokie Mazowieckie) was 1070 ± 55 and 1040 ± 93 mg/l, respectively. The milk from these two plants formed 48.4% of the collected samples of consumption milk.

Key words: consumption milk, calcium, region, manufacturer, variability coefficient