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Casein content in milk from Eastern Poland and its changes over 5 years

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The study included 8,850 milk samples collected over a 5-year period from about 900 cows kept on 50 farms in Eastern Poland. The number of samples collected in each successive year from 2006 to 2010 was 1,688, 1,512, 2,942, 1,984 and 724. Five intervals were used in evaluating the variability in casein content: I – ≤2.00%; II – 2.01-2.40%; III – 2.41-2.80%; IV – 2.81-3.20% and V – over 3.20%. Casein content ranged from 1.57% to 4.00% in the milk samples evaluated. The lowest average casein content, 2.51% (P≤0.01), was obtained in the first year of the study, and the highest average percentage (2.68%) in the third year. For all the material evaluated the average percentage share of casein in total protein was 74.78%, ranging from 74.33% to 75.41% in different years (P≤0.01). The percentage of milk samples containing less than 2% casein decreased systematically during five years analysed, and from the second year the percentage of samples with content in the highest range (over 3.20%) decreased as well.

KEY WORDS: cow milk / casein / content variability

Poland is one of the leading milk producers in the European Union, ranking 4th among 28 countries, with average production of more than 12 million tonnes a year. The production of dairy products, especially rennet cheese, is increasing steadily. According to the FAO [6], in 2011 Poland was the sixth largest cheese producer in the world (650,000 tonnes).

The dairy industry, responding to consumer preferences, focuses on the production of fermented beverages and of both curd and rennet cheeses. This requires raw material with a high content of protein, and especially casein, which is important in processing due to its coagulation and water-binding capacity. Its content in milk averages about 2.5%, varying from 2.3% to 3.5% depending on the breed of cows, their diet, and the stage of lactation [2, 4, 12]. A study by Litwińczuk et al. (13) from the 1980s and 1990s

showed highly significant (P≤0.01) correlation coefficients between the content of casein and total protein, ranging from 0.53 to 0.78. For this reason the dairy industry mobilizes producers of raw milk (mainly through financial incentives) to increase its protein content, as low content of casein in milk significantly reduces cheese yield per unit volume, which in consequence raises the cost of production of dairy products. By reducing the amount of milk used to produce 1 kg of cheese by just 0.1 litres, 10 kg more cheese can be obtained from 100,000 litres of milk, and 3,000 more kg over the course of a year (300 days) [5]. The content of casein in milk also has a significant effect on its rennet clotting time [7, 17] and the firmness of the resulting clot [8, 17]. In the case of cow milk, a shorter coagulation time results in a firmer and more compact curd, and also reduces the loss of casein into the whey.

According to dairy industry data, despite the increase in total protein content in milk, the amount of raw milk used to produce a kilogram of cheese has not decreased in recent years, and has even increased slightly. This means that the proportion of casein in the total protein is decreasing. According to the literature published 20-30 years ago [11, 13], the share of casein in the total protein of cow milk was nearly 80% at that time.

The aim of the study was to determine possible changes in the content of casein in milk obtained in eastern Poland over a five-year period.

Material and methods

The research was conducted in 2006-2010. The research material consisted of 8,850 milk samples taken from about 900 cows from 50 farms in eastern Poland, each with 10 to 100 cows. Milk samples were taken twice a year, in the spring/summer and autumn/winter seasons. Samples from cows with diseased udders were excluded (positive result for the California mastitis test).

The herds included in the study were subject to use value assessment for dairy cattle and met the requirements for milk production set out in Commission Regulation (EC) No. 1662/2006 of 6 November 2006 amending Regulation (EC) No 853/2004 of the European Parliament and of the Council laying down specific hygiene rules for food of animal origin.

The content of casein in each milk sample was determined according to AOAC [1], and protein and fat with an Infrared Milk Analyzer (Bentley Instruments). The results were used to calculate the proportion of casein in the total protein and the protein-to-fat ratio.

Five ranges were used to evaluate the variation in casein content: I – ≤ 2.00%; II – 2.01-2.40%; III – 2.41-2.80%; IV – 2.81-3.20% and V – over 3.20%. The results are presented in graphs.

StatSoft Inc. STATISTICA ver. 6 was used for the statistical calculations. Analyses were based on a General Linear Model (GLM) – ANOVA procedure. The significance of differences between means was determined by the Tukey test for unequal sample sizes at p = 0.05 and p = 0.01.

Table
Content of milk components in successive years of the study

Year	n		Fat (%)	Protein (%)	Casein (%)	Percentage of casein in total protein (%)	Protein-to-fat ratio
2006	1688	$\bar{x}$	4.13^{a}	3.37^{A}	2.51^{A}	74.46^{A}	0.85^{ABC}
		SD	0.92	0.41	0.33	4.81	0.20
2007	1512	$\bar{x}$	4.26^{b}	3.60^{C}	2.67^{BC}	74.33^{A}	0.88^{D}
		SD	0.96	0.51	0.41	5.28	0.24
2008	2942	$\bar{x}$	4.16^{ab}	3.55^{BC}	2.68^{C}	75.41^{B}	0.86^{C}
		SD	0.56	0.42	0.37	5.38	0.09
2009	1984	$\bar{x}$	4.24^{b}	3.54^{BC}	2.62^{B}	74.35^{A}	0.84^{AB}
		SD	0.54	0.42	0.32	4.90	0.09
2010	724	$\bar{x}$	4.27^{b}	3.43^{A}	2.57^{AB}	75.32^{AB}	0.82^{ABC}
		SD	0.68	0.43	0.29	5.82	0.13
Total	8850	$\bar{x}$	4.20	3.51	2.62	74.78	0.86
		SD	0.73	0.44	0.36	5.18	0.16

a, b – differences significant at P≤0.05; A, B – differences significant at P≤0.01

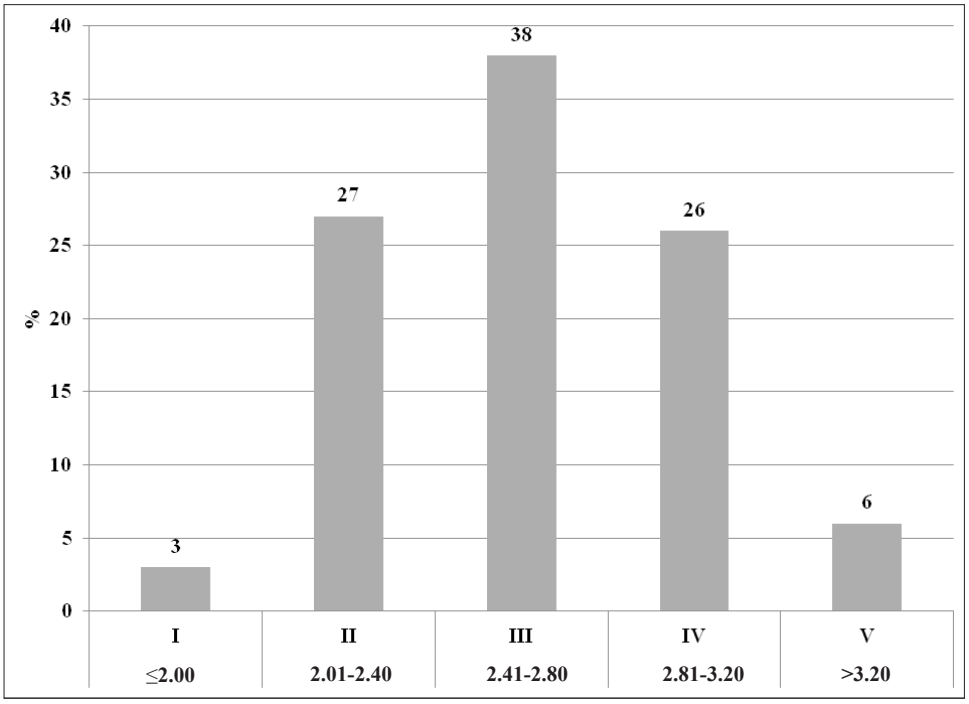

Fig. 1. Percentage of milk samples with casein content in each interval

Results and discussion

The average fat, protein and casein content in the nearly 9,000 milk samples tested during the 5-year period was 4.20%, 3.51% and 2.62%, respectively. The lowest mean content of fat (4.13%), protein (3.37%), and casein (2.51%), which made up a relatively low proportion of the total protein (74.46%), was noted in the first year (Table). In the next year (2007), a significant increase ($P \leq 0.01$ and $P \leq 0.05$) was observed in the concentration of these constituents in the milk (fat 4.26%, protein 3.60%, casein 2.67%), as well as the lowest proportion of casein in the total protein (74.33%), but also the most favourable protein-to-fat ratio, at 0.88. The highest content of casein (2.68%), as well as the significantly highest ($P \leq 0.01$) proportion of casein in the total protein (75.41%), was found in the milk obtained in the third year of research (2008). This is likely due to highly favourable feed conditions and, above all, price relationships for milk production in Poland in 2008. The fact that the number of milk samples tested was highest that year (about 3,000) may also have had an effect. A study by Jasińska et al. [9] conducted in

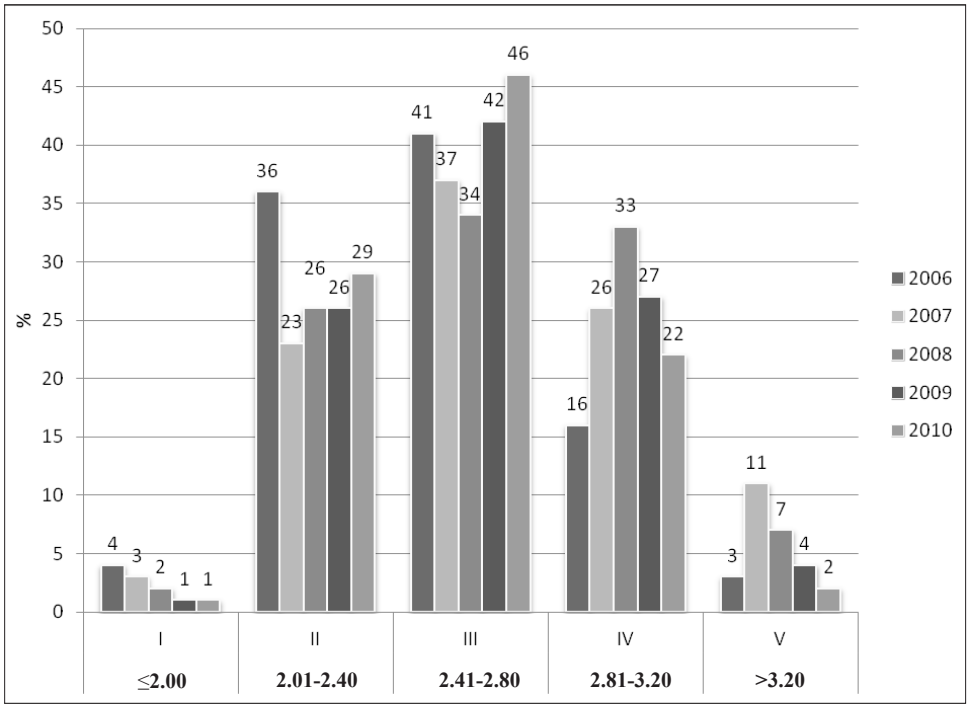

Fig. 2. Variability in the percentage of milk samples in each casein content interval over the 5 years of the study

2009-2010 in West Pomerania showed that the protein content in bulk milk from 3 large farms ranged from 2.75% to 3.39%, and casein content from 2.10% to 2.59%. Data from the Polish Federation of Cattle Breeders and Dairy Farmers [15] indicates that the protein content in the milk of the active cow population has increased steadily since 2006, on average by 0.01% per year.

In the last decade in eastern Poland, especially Podlasie (where some of the milk samples were taken), significant changes have taken place in the structure of dairy farming. There has been an increase in the number of farms focused on intensive milk production, where modern feeding systems are used (TMR and PMR), which has led to increased milk yield and improved milk composition. However, there is still a large percentage of small dairy farmers using traditional feeding systems, which, as indicated by numerous studies [3, 10, 16, 18], has a significant effect on the seasonality of production.

The analysis of casein content in nearly 9,000 milk samples showed that it ranged from 1.57% to 4.00%. It should be emphasized that the casein content of as many as 70% of the samples was more than 2.40%, which is important information for the dairy industry (Fig. 1). In successive years of the study (Fig. 2), the percentage of milk samples with very low casein content (below 2%) steadily decreased, i.e. from 4% in 2006 to 1% in the last two years (2009 and 2010). A more detailed analysis of the data indicates that only in the first year of the study (2006) did the proportion of milk samples with casein content up to 2.40% reach 40%. In the next 4 years (2007-2010) it was much lower, within the range of 26-30%.

Wedholm et al. [17] reported casein content in milk ranging from 2.57% to 2.76%, with a very high share of casein in the total protein (81-82%). A study carried out more than 30 years ago by Litwińczuk et al. [14] found much higher average casein content in the milk tested, at 2.83%, and its share of the total protein was higher as well, at 81.3%. In a study by the same team in the late 1990s [11], the mean casein content in the milk was lower (2.54%), as was its share in the total protein (78%). Referring to our own research from 2006-2010, we can conclude that the recent increase in the protein content of milk has been mainly due to the increase in the content of whey proteins and non-protein nitrogen. As a consequence, the proportion of casein in the total protein has decreased from about 78% at the end of the 20th century to about 75%. This is unquestionably a very unfavourable phenomenon for the dairy industry.

In conclusion, during the five years analysed (2006-2010), the proportion of milk samples with a very low content of casein, i.e. less than 2%, steadily decreased. A similar trend was observed for samples with the highest content, i.e. over 3.20%. It should be stressed, however, that except for the first year of the study (2006), 70% and more (73-74%) of the milk samples evaluated contained more than 2.4% casein.

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