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# YIELD OF ACID CURD CHEESE PRODUCED FROM COW'S MILK FROM DIFFERENT LACTATION PERIODS

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## ABSTRACT

**Background.** Milk production intensification has led in many countries, including Poland, to increased milk yields per cow. A higher milk yield resulted in changes in cow productivity, including extended lactations. There is a paucity of information on the quality of milk harvested during the last months of lactations exceeding 10 months. Production capacity cheese ("cheese expenditure") is an important parameter of providing a recovery as much as the possible components of the milk processed are dry substances, which in turn affects the economics of production. The aim of the study was to determine the influence of the lactation period (from standard lactation; extended lactation phase) on the performance of the acid curd cheese. the relationship between total protein content and acidity of fresh milk collected in two separate periods of lactation on the yield of acid cheese was also evaluated.

**Material and methods.** The study included 1384 samples of milk collected from Polish Holstein-Friesian cows, the Black-White variety. The basic chemical composition of fresh milk and acid-curd cheese produced in the laboratory were analyzed. The cheese milk yield was evaluated on the basis of the quantity of the resulting curd mass.

**Results.** According to our estimates, under laboratory conditions an average of 100 kg of milk per cow in population produced an estimated 20.1 kg of curd cheese. The basic chemical composition of raw milk, which was diverse in terms of the period of lactation, showed a higher dry matter, fat and protein content in milk acquired during the extension phase of lactation compared to the milk of standard lactation. It has been found that the lower titratable acidity of fresh milk appeared with a higher yield of cheese curd. This difference was between 1.76 kg (with milk from cows milked during the extended lactation phase) to 2.72 kg from 100 kg of cheese milk (milk with the standard lactation). Thus, the optimum level of titratable acidity of milk for cheese yield is 6.0–7.5°SH.

**Conclusions.** Most samples with the highest yields of acid curd cheese (>20%) were obtained from the milk from collected in the period from day 306 till the end of lactation (60.54%).

**Keywords:** cow's milk, acid curd cheese, lactation period, milk acidity

## INTRODUCTION

The production of milk and its processing are two very important elements of food production. The domestic dairy sector is developing rapidly, and all actions are aimed at providing consumers with products of the highest quality at a parallel processing profitability. Dairy products are practical necessities valued as carriers of protein and calcium. The raw material for their production is mainly cow's milk. The composition of

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milk is approx. 35–40% determined by the genotype of the animal (Nienartowicz-Zdrojewska et al., 2004; Sawa et al., 2004). According to Król et al. (2011), the breed of cow has a significant influence on the level of basic chemical components of milk, for example, Jersey cows produce milk significantly distinguishable in terms of dry matter, crude protein, casein and fat. This also means that we can affect its composition to a degree of 60–65% by proper feeding, maintenance, care and use, which, as reported by Verdier-Metz et al. (2001), have the greatest impact on the curd cheese yield prepared from 100 kg of milk. Cheese yield is an important parameter indicating the highest possible recovery of the components in the dry substance of processing milk, which in turn affects the economics of production (Abd El-Gawad and Ahmed, 2011).

Casein is the main milk protein, the content of which is about 2.4–2.5%, i.e., approx. 75–78% of total protein in milk. The remaining protein is whey proteins (17%). A low casein content in milk reduces the cheese yield, and this fact increases production costs in the dairy industry. Amenu and Deeth (2007) and Amenu (2004) found that reducing the level of casein to 0.1% in milk decreased the yield of cheddar-type cheese by 0.5/100 kg.

The acidity of milk is one of the basic criteria for it being accepted in the purchase center and determines its technological usefulness. Titratable acidity of milk depends on some of the components contained therein, mainly acidic phosphates, casein and carbon dioxide, but it is also affected by other factors such as nutrition, stage of lactation, age of cows or season of the year (Górska and Mróz, 2004; Strzałkowska et al., 2001).

Curd cheeses are dehydrated milk casein, obtained by acid, acid-rennet or thermal-calcium methods. According to Szulc (2012), from 100 kg of skim milk, approx. 20 kg of curd cheese can be obtained. The classic methods of producing cottage cheese with separated whey lose up to 60% of dry milk components (Bednarski, 2001), including nutritionally valuable whey proteins, which are also attributed to health benefits (Marshall, 2004; Smithers, 2008).

The aim of the study was to evaluate the influence of the cow's lactation period, during which the milk was collected, on acid curd cheese yield relative to the protein content and acidity of fresh milk.

## MATERIAL AND METHODS

The study included milk collected from Polish Holstein-Friesian cows, the Black and White variety. The percentage of yield of acid-curd cheese (curd) was estimated, which was produced in laboratory conditions using fresh milk. Milk samples were collected on the day when performance assessment was carried out in the herd by an employee of the Polish Federation of Cattle Breeders and Dairy Farmers. In total, 1384 milk samples were collected for analysis, 1,161 between day 1 and 305 of lactation (i.e., standard lactation) and 223 samples between day 306 and the end of complete lactation (i.e., so-called extended lactation period).

Information on daily performance, somatic cell count, dry matter, protein and fat content in the milk from the day of sampling was obtained from breeding documentation on the animals' performance (RW-2). The evaluation employs method A and is carried out by authorized Polish Federation of Cattle Breeders and Dairy Farmers employees. Physical and chemical milk evaluation includes the following parameters: percentage of fat content, percentage of protein content, percentage of lactose content, percentage of dry matter content and somatic cell count. This analysis is performed by laboratories accredited by the Polish Accreditation Centre, who apply the quality system in accordance with the Standard PN-EN ISO/IEC 17025 and operate following ICAR guidelines.

Somatic cell count (SCC) was log-transformed to a somatic cell score (SCS) as follows (Wiggans and Shook, 1987): $SCS = \log_2(SCC/100{,}000) + 3$.

The acidity of fresh milk was determined by titration in °SH according to the Polish Standard (PN-A-86122:1968. Milk. Research methods), within 2 hours of milk sampling.

The cheese yield of the milk was evaluated on the basis of the quantity of curd mass produced. Coagulation of milk proteins was performed in milk heated to 30°C. The procedure consisted of determining the weight of 30 ml of milk placed in Falcon tubes and adding to this 0.1 ml of a 50% solution of $CaCl_2$. This was then mixed, 0.03 ml of coagulant (lactic acid bacteria CesKa®-stAr C 07; 1:30,000) was added, and left for 3 minutes. The tubes were put into a water bath at 50°C, heated for 30 minutes and then transferred to a water bath at room temperature. Once cooled, the

curd was centrifuged for 30 minutes at 2500 rpm and at a chamber temperature of 20°C. The resulting whey was decanted and the tubes containing the cheese mass were turned upside down and placed on filter paper to drain the whey residue. The drying time was 30 min. Then the weight of the resultant curd was determined and its yield was calculated in relation to the weight of the milk (Jurczak, 2005).

All calculations were performed in *Statistica* ver. 12.5. The significance of differences between the means was estimated using Duncan's test at a significance level of $P \leq 0.05$.

## RESULTS AND DISCUSSION

Analyzing the basic chemical composition of fresh milk, differentiaed in terms of the lactation period (Table 1), a higher content of dry matter, fat and protein was found in the milk collected in the extended period of lactation compared to the milk from standard lactation. Studies by Auldist et al. (2010), Salamończyk (2013) and Sorensen et al. (2008) also found higher contents of dry matter, fat and protein in the milk of cows in late lactation. According to Auldist et al. (2010), who evaluated the composition and quality of milk from cows in extended lactations, milk from this period contained more fat and protein than milk collected during the first 10 months after calving. The study by Siemianowski et al. (2013b) indicated that the higher the dry matter content in the milk, the higher the dynamics of acidification and increase in the values defining condensation, consistency, cohesiveness and curd viscosity index. Increasing the dry matter content in milk also affected the basic chemical composition of the acid curd cheese (Siemianowski et al., 2013a).

The average content of somatic cells in milk in the evaluated population exceeded, although not by much, the requirements for fresh milk intended for purchase (Commission Regulation EC No. 1662/2006 of 6 November 2006 amending EC Regulation No 853/2004). Under these provisions, milk delivered to the purchase center can not contain more than 400,000 somatic cells per 1 ml.

The study by Kwaśnicki (2007) found that the most beneficial types of dairy curds can be obtained from extra class milk, which had a low level of somatic cells and more valuable chemical composition (4.15% fat, 3.37% protein, 4.72% lactose, 12.84% dm) compared to the milk in which the remaining usefulness

**Table 1.** The chemical composition of raw milk collected from cows from different periods of lactation (first 305 days of lactation and from day 306 to the end of the lactation), from which curd cheese was produced under laboratory conditions

| Parameter | Standard lactation (from day 1 to 305 of lactation) | Extended lactation period (from 306 to the end of the lactation) | Average |
|---|---|---|---|
| | $\bar{x}$ ±SD | $\bar{x}$ ±SD | $\bar{x}$ ±SD |
| Daily milk yield, kg | 31.0[a] ±6.33 | 25.9[b] ±4.47 | 30.2 ±6.34 |
| Milk composition | | | |
| Dry matter, % | 13.29[b] ±1.13 | 14.34[a] ±1.11 | 13.46 ±1.19 |
| Fat, % | 4.34[b] ±0.91 | 5.02[a] ±0.92 | 4.45 ±0.95 |
| Protein, % | 3.44[b] ±0.38 | 3.91[a] ±0.40 | 3.52 ±0.42 |
| Somatic cell score (SCS) | 3.35 ±2.00 | 3.80 ±1.65 | 3.42 ±1.96 |
| Titratable acidity of fresh milk, °SH | 7.46 ±0.81 | 7.52 ±0.74 | 7.47 ±0.80 |

[a, b] Statistically significant differences, at $p \leq 0.05$, between means in rows.

subclasses for the production of cheese were determined. Numerous studies (Barbano et al., 1991; Klei et al., 1998; Sapru et al., 1997) showed that milk with a high somatic cell count caused increased protein loss (reduction in the level of casein) in the milk, and hence the reduction in cheese yield. According to Barbano et al. (1991), the upper limit of somatic cells in 1 ml of milk for cheese making is 100,000 per 1 ml.

Comparing the data in Table 2 for the percentage of milk samples from different periods of lactation from which the corresponding percentage of curd cheese yield was obtained, it may be noted that the highest number of samples with the highest yield of acid curd cheese (>20%) were of the milk collected in the period from day 306 until the end of lactation (60.54%). In the case of standard lactation, only half (51.34%) of such samples from 1 kg of milk provided more than 0.20 kg of acid curd. The study by Auldist et al. (2010) also demonstrated a higher cheese yield from milk derived from extended lactations. The authors did not find any deterioration in the quality (appearance, taste, texture) of the cheese produced. According to Sapru et al. (1997), fat and protein losses during cheddar cheese production were higher for cow's milk produced at the end of lactation compared to milk produced at the beginning of lactation. However, because milk from later lactation had a higher fat and casein content, the losses did not have a significant effect and the yield of cheese from milk obtained from the end of the lactation was higher than that of cheese produced from milk from the beginning of lactation. The effect of the lactation period on the quality of cheese produced was limited to the differences in salt content and higher moisture of cheese prepared from milk obtained from the late lactation period (Sapru et al., 1997).

**Table 2.** The percentage of milk samples, from which the proper acid curd cheese yield was obtained

| The yield of acid curd cheeses % | Standard lactation (from day 1 to 305 of lactation) | | Extended lactation period (from 306 to the end of the lactation) | |
|---|---|---|---|---|
| | *n* | % | *n* | % |
| ≤15.0 | 43 | 3.70 | 7 | 3.14 |
| 15.1–20.0 | 522 | 44.96 | 81 | 36.32 |
| >20.0 | 596 | 51.34 | 135 | 60.54 |
| Total | 1 161 | 100.00 | 223 | 100.00 |

Table 3 shows the relationship between total protein content in milk and lactation period on curd cheese yield [%]. On average, from 100 kg of milk from the cows' population evaluated, 20.1 kg of acid curd cheese was obtained under laboratory conditions for selected breed. It should be noted that the highest cheese yield was obtained from samples containing more than 3.60% total protein. From 100 kg of milk

**Table 3.** The yield of the curd cheese based on the protein content of milk fresh harvested at different periods of lactation, %

| Protein content % | Standard lactation (from day 1 to 305 of lactation) | | Extended lactation period (from 306 to the end of the lactation) | | Total/Average | |
|---|---|---|---|---|---|---|
| | *n* | $\bar{x}$ ±SD | *n* | $\bar{x}$ ±SD | *n* | $\bar{x}$ ±SD |
| ≤3.20 | 331 | $20.07^{A}$ ±2.49 | 4 | $17.09^{B}$ ±1.82 | 335 | $20.04^{b}$ ±2.50 |
| 3.21–3.60 | 455 | $20.03^{B}$ ±2.56 | 44 | $20.18^{A}$ ±2.34 | 499 | $20.05^{b}$ ±2.54 |
| >3.60 | 375 | $19.97^{B}$ ±2.64 | 174 | $20.62^{A}$ ±2.41 | 549 | $20.17^{a}$ ±2.59 |
| Total/Average | 1 161 | $20.03^{b}$ ±2.56 | 223 | $20.47^{a}$ ±2.43 | 1 384 | 20.10 ±2.55 |

[a, b] Statistically significant differences, at $p \leq 0.05$, between means in row.
[a, b] Statistically significant differences, at $p \leq 0.05$, between means in column.
[A, B] Statistically significant differences, at $p \leq 0.05$, between means in rows.

collected from the last lactation period (after day 306), 0.65 kg more cheese could be obtained than from milk from the first 10 months of lactation. This is confirmed by the study by Wedholm (2008), who reported that a higher percentage of total protein promoted cheese productivity even up to 2.40% with respect to fresh weight. This indicated a significantly higher cheese yield from milk derived from the period spanning day 306 to the end of lactation. As reported by Litwińczuk et al. (1980/1981), correlation coefficients between the content of casein and total protein were 0.53–0.78 ($P < 0.01$). Research by Januś and Borkowska (2011a; 2011b) and Salamończyk (2013) showed that the higher protein content in milk in the last months of lactation resulted from lower daily milk productivity. Producing 1 kg of cheese by reducing milk usage by only 0.1 liter allows an extra 10 kg of cheese to be obtained from 100,000 milk liters (Chojnowski and Nowak, 2013).

The significant influence on cheese yield of protein and fat content in milk was confirmed by a study by Verdier-Metz et al. (2001). The authors pointed out that there was a linear relationship between the content of these basic milk components on cheese yield. Auldist et al. (2010), by evaluating the composition of milk from extended lactations as compared to milk from 10-month lactations, found a higher content of dry matter (in particular protein, but also fat) in milk from longer lactations. They also pointed to the better coagulation properties of milk obtained from extended lactations, which increased the profitability of cheese produced from 100 kg of milk.

The acidity of milk is a basic criterion for assessing its freshness, and determines its technological applicability. According to the Polish Standard (PN-A--86002:1999), the titratable acidity of raw milk to be purchased should be 6.0–7.5°SH. Milk with an acidity lower than 6°SH may be derived from cows suffering from *mastitis*. The next stage of the study was to evaluate the effect of the acidity of fresh milk on the yield of acid curd cheese [%] prepared in laboratory conditions (Table 4). Fresh milk acidity had a statistically significant effect on the amount of cheese produced from this milk. Most curd cheese was obtained from milk samples in which the acidity was lower than 7.5ºSH (21.12 kg from 100 kg of milk). In addition, comparison of milk acidity in two separate lactation periods confirmed significantly higher cheese yields from milk with a lower acidity. The difference in the amount of cheese obtained, depending on the acidity of fresh milk, ranged from: 1.76% (during the period of lactation extension) to 2.72% (in standard lactation).

The acidity of milk is affected by such factors as the season (including feeding) and the age of the cattle. Sitkowska and Mroczkowska (2005) reported that during pasture feeding (summer), the acidity of the milk averaged 6.9°SH and was significantly ($P < 0.01$) lower than in winter feeding (7.8°SH). Górska and Mróz

**Table 4.** The yield of curd cheese [%] depending on the titratable acidity [°SH] of fresh milk, obtained in different periods of lactation

| Titratable acidity of fresh milk °SH | Standard lactation (from day 1 to 305 of lactation) | | Extended lactation period (from 306 to the end of the lactation) | | Total/Average | |
|---|---|---|---|---|---|---|
| | *n* | $\bar{x}$ ±SD | *n* | $\bar{x}$ ±SD | *n* | $\bar{x}$ ±SD |
| <7.5 | 567 | $21.11^{A}$ ±2.05 | 105 | $21.17^{A}$ ±1.99 | 672 | $21.12^{a}$ ±2.04 |
| 7.5−8.0 | 379 | $19.33^{B}$ ±2.53 | 81 | $20.06^{A}$ ±2.55 | 460 | $19.46^{b}$ ±2.55 |
| >8.0 | 215 | $18.39^{B}$ ±2.55 | 37 | $19,41^{A}$ ±2.72 | 252 | $18.54^{c}$ ±2.60 |
| Total/Average | 1 161 | $20.03^{b}$ ±2.56 | 223 | $20.47^{a}$ ±2.43 | 1 384 | 20.10 ±2.55 |

$^{a, b}$ Statistically significant differences, at $p \leq 0.05$, between means in row.
$^{a, b}$ Statistically significant differences, at $p \leq 0.05$, between means in column.
$^{A, B}$ Statistically significant differences, at $p \leq 0.05$, between means in rows.

(2004) found significant ($P < 0.05$) differences in the acidity of milk, depending on the age of the cows. Milk from the youngest cows (less than 3.5 years old) was characterized by the highest acidity (7.7°SH), while milk from the oldest cows (above 7.5 years old) had the lowest acidity (7.0°SH). Similarly, Strzałkowska et al. (2001) found a relationship between the cow's age and titratable milk acidity. Milk from primiparous cows had a higher acidity (6.77°SH) than that milk from cows in the third lactation and older (6.34°SH).

As reported by Strzałkowska et al. (1999), active milk acidity is negatively correlated with the protein content. Górska (2005) showed a reduction in the level of titratable acidity [°SH] in milk harvested above day 305 of lactation. O'Connel and Fox (2000) and Polák et al. (2001) found a relationship between low thermostability and higher whey protein content, and therefore, lower casein protein content. The highest value of thermal stability, with a protein content of 3.69%, was in the 14th month of lactation, suggesting a high level of casein proteins and better technological parameters of milk from later months of lactation.

## CONCLUSIONS

1. Most of the samples with the highest yields of acid curd cheese (>20%) were obtained from milk from collected in the period from day 306 till the end of lactation (60.54%).

2. The protein content in milk and its acidity affected the yield of acid curd cheese produced from fresh milk in laboratory conditions.

3. From 100 kg of milk collected from the last lactation period (above day 306), 0.65 kg more cheese could be obtained than from milk from the first 10 months of lactation, with a protein content >3.6%.

4. A comparison of milk acidity in two separate periods of lactation confirmed significantly higher cheese yields from milk with a lower titratable acidity (<7.5°SH).

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