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The effect of daily production in selected lactation phases on the composition and cheese- making characteristics of Holstein-Friesian cow's milk

Wpływ produkcji dobowej w wybranych fazach laktacji na skład i cechy serowarskie mleka krów rasy holsztyńsko-fryzyjskiej

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ABSTRACT

It was decided to analyze the daily milk production in selected lactation periods of Holstein-Friesian cows and to determine its impact on the basic milk components as well as parameters determining its cheese-making usefulness. The lactation was divided into six phases considering subsequent days of lactation after calving: 1st phase up to 30 days, II- 31-60, III- 61-100, IV- 101- 200, V- 201-300, VI >300. In each phase, considering daily milk production, two production groups were selected. The study results suggest that the intensity of daily milk secretion has a significant impact on the share of ingredients commonly assessed for cheese-making utility. Increased daily production of milk may favor a higher protein and casein level, however, there is not such a strong correlation with κ-casein concentration. As a result, it may affect the quality and efficiency of cottage cheese production. At the same time, it should be noted that changes in the content of the analyzed milk components were related to the changes in the chloride level, and their share was dependent on the daily milk production ($P<0.05$). The consequence of this was degradation of important cheese-making features: the reduction of curd amount and the prolongation of coagulation time.

Keywords: cheese manufacturing parameters, correlation, lactation period, milk yield, milk composition

ABSTRAKT

Analizowano wielkość produkcji dobowej mleka u krów rasy holsztyńsko- fryzyjskiej. Określono jej wpływ na zmiany poziomu podstawowych składników mleka a także parametrów jego przydatności serowarskiej. Laktację podzielono na 6 faz: I faza do 30 dnia laktacji, II- 31-60, III- 61-100, IV– 101-200, V– 201- 300, VI>300. W każdej z badanych faz, uwzględniając dobową produkcję mleka (DMP) wyodrębniono dwie grupy produkcyjne. Podział ten oparto na wartościach granicznych DMP wyliczonych w obrębie każdej fazy. Otrzymane wyniki badań sugerują, że intensywność wydzielania mleka w ciągu doby ma istotny wpływ na udział składników, które powszechnie określają przydatność serowarską mleka. Zwiększona produkcja dobowa mleka może sprzyjać większej zawartości białka ogólnego oraz kazeiny, jednak nie ma już tak silnego związku z koncentracją κ-kazeiny. Należy jednocześnie zauważyć, że zmiany zawartości analizowanych składników mleka, powiązane były z kształtowaniem się poziomu chlorków, a ich udział był uzależniony od dobowej produkcji mleka ($P<0.05$). Konsekwencją tego było pogorszenie ważnych cech serowarskich mleka, zmniejszenie ilości twarogu oraz wydłużenie czasu koagulacji.

Słowa kluczowe: parametry przydatności serowarskiej, korelacja, faza laktacji, wydajność mleka, skład mleka

INTRODUCTION

High milk production in cows often destabilizes the body's homeostasis and may be the cause of many mammary gland disorders. These are manifested, among other things, by reduced casein, calcium and lactose level in milk (Batavani et al., 2007; Raji et al., 2012). The reason for this is usually poor utilization of amino acids and other components supplied by blood to the mammary gland (Hanigan et al., 2004; Lapierre et al., 2013). Therefore, it is believed that an increase in milk secretion may, to a certain extent, affect its processing quality (Gerlich et al., 2014). In addition to the main components of milk, its cheese-making utility is also influenced by the chlorine compounds present in it (Raimondo et al., 2009). An increase in their concentration is usually observed in the milk of cows with symptoms of mastitis (Ogola et al., 2007; Tsioulpas et al., 2007). The negative effect of increased concentration of these compounds on the content of casein and the stability of its micellar structure was also confirmed (Michalcova and Krupova, 2007; Lucey and Horne, 2009; Dalgleish and Corredig, 2012).

In industrial production, improvement of efficiency is focused primarily on the amount of milk obtained. On the other hand, relatively little attention is paid to the features defining cheese-making utility, which largely result from the physiological efficiency of the mammary gland (McManaman and Neville, 2003; Ogola et al., 2007; Kuchtik et al., 2008). Therefore, it was decided to analyze the volume of daily milk production in selected lactation periods of Holstein- Friesian cows and to determine its impact on the basic milk components level as well as parameters determining its cheese-making usefulness. The hypothesis was based on the assumption that increased daily production may favor undesirable changes in the levels of milk compounds that determine its utility for cheese-making.

MATERIALS AND METHODS

Animals, housing and feeding

Holstein-Friesian (HF) cows participated in the study. The animals were kept in two production groups, in a free-stall barn with separate lying areas. T4C 3.7 (Lely, Maassluis, NL) management software and transponders were used for cow identification. The barn was equipped with fans to ensure air circulation and the milking was carried out in workplaces operated by robots (A3, Lely, Maassluis, NL).

The cows were fed using the total mixed ration (TMR) system. The roughage was prepared in a feed wagon and administered in the feed corridor using automatic shaving (Juno robot, Lely, Maassluis, NL). The diet was supplemented with automatic concentrated feed, depending on the daily milk production. The demand for nutrients and diet balancing were determined according to INRA Feeding Methods in INRAtion Software for Ruminant Diet Calculation, version 2.03 (DJ Group, Cracow, Poland; 2001). The roughage consisted of silage (maize, alfalfa, grass-silage), straw and concentrate (soy and rapeseed grist). Mineral-vitamin and buffering supplements were added along with the feed. In order to cover the energy deficit, for the first 100 days after calving, until lactation peak was reached, all cows additionally received concentrated feed in the form of granules and glycerin. The amount of that feed was adapted to the current milk yield.

The cows' lactation was divided into six phases (PL) considering subsequent days of lactation after calving. In each lactation phase, the least square means value ± standard error (LSM ± SE) was calculated: 1st phase - up to 30 days of lactation (20 ± 6.2), II - 31-60 (47 ± 12.9), III - 61-100 (82 ± 9.3), IV - 101-200 (155 ± 10.2), V - 201-300 (251 ± 12.4), VI> 300 (344 ± 15.7).

Differences were estimated at P<0.05. In each study phase, considering daily milk production (DMP), two production groups (GP) were selected: A and B. Selection was based on the DMP limit values calculated within PL. The following values were obtained: (LSM ± SE): PLI - 28.0 ± 0.9, II - 34.0 ± 1.2, III - 34.0 ± 0.8, IV - 30.0 ± 1.1, V - 28.0 ± 0.8 and PLVI - 18.01 ± 0.9. Differences were estimated at P<0.05.

The experiment was carried out in cows whose production age ranged from 2nd to 4th lactation. In GPA, 13.1% of cows were in the 2nd lactation, 24.0% in the 3rd and 9.8% in the 4th lactation. In GPB, respectively: 11.5, 36.6 and 4.9%. The homogeneity analysis of production age was based on the results of standard error (SE). SE values were as follows: for PL from 5.24 to 4.66 (P<0.05), for GPA 1.64 and for GPB 3.39 (P<0.05). The mean value (SEM) was 1.87 (P<0.05).

Sampling and milk analysis

The study material consisted of milk obtained individually from cows once in each PL. The milk sample was cumulative from all milkings during the day (the principle of proportionality was applied). Samples were collected in sterile bottles using an autosampler. The studies included samples with a potential acidity ranging from 6.0 to 7.5 °SH (titrimetric method, AOAC, 2000) and with a microbial content of up to 1 ml ≤ 400,000 (WE, 2004). The number of microorganisms was determined in the milk using a Bactoscan 8000s (Bentley Instruments Inc., Chaska, USA). Protein, lactose and dry matter levels were measured using a Bentley Combi 150 (Bentley Instruments Inc., Chaska, USA). Analysis was performed by laboratories accredited by the Polish Accreditation Centre (Quality Certificate ICAR; PN-EN ISO/IEC 17025). Total casein level was measured after precipitation and purification of casein in acetate buffer (pH 4.6, 20 °C). In the resulting sediment (casein), total nitrogen level was measured using the Kjeldahl method (AOAC, 2000), and converted to the total protein level using the equivalent of 6.25. Measurement of κ-casein was performed using HPLC liquid chromatograph (Varian Inc., Palo Alto, CA, USA). The resulting clot (casein) was dissolved in TRIS-HCl buffer (pH 8.0). Protein separation was performed on an Aeris XB-C-18 column, 3.6 u, 250 × 4.6 mm (Phenomenex Inc., Torrance, CA, USA) at a temperature of +40.0 °C (flow: 1.5 mL/min. by 30 min). Eluent A: 0.1% trifluoroacetic acid aqueous solution (TFA), eluent B: 0.1% TFA solution in acetonitrile. The concentration of κ-casein was measured on the basis of a calibration curve drawn using the bovine κ-casein standard (Sigma-Aldrich, St. Louis, MO, USA). The chloride level was measured according to the ISO 5943 (ISO, 1988) standard method. The calcium level was measured by atomic absorption spectrophotometry (NMKL, 1996). The chlorine-sugar number (LClc) was calculated using the formula: chlorides / lactose ×10. Raw milk was inoculated with pasteurisation (68 °C/30 min), and then cooled (32 °C). The curd yield (%) was calculated based on the weight of the curd obtained after adding the enzyme to milk (520 mg chymosin L^1; Chr. Hansen's Laboratory, Arpajon, FR). To obtain curd and whey, 25 mL of enzyme was added per 100 mL of milk, and stirred. The rennet clotting time (RCT) in milk was determined as the time until the creation of first curd flakes (was measured from the time of the addition of the enzyme to the milk). Milk coagulation was monitored while maintaining the rennet-treated milk samples at a constant temperature (+30 °C). Separation of curd and whey was performed by centrifugation (4500 × g for 15 min.). In the obtained curd and whey, the protein level was measured using the Kjeldahl method (AOAC, 2000).

Statistical analysis

The results were compiled statistically in Statistica 13.0 software (2016). A two-way analysis of variance was used. Results were presented using the least-squares method (LSM) and standard error (SEM). The difference significance in obtained averages was estimated using the Duncan test at P<0.05. Between the selected production features and milk quality parameters, correlations were estimated using the Pearson linear correlation model. The level of significance value was P<0.05.

RESULTS

The greatest effect of production group (GP) and lactation phase (PL) was observed in milk dry matter (DM). The larger amount, on average, 0.50 percentage point (P<0.05) was found in the milk of all GPA cows from I to PLIV (Table 1). The smallest amount of DM occurred in cows in phases II and III of lactation, while higher DM values for both GPA and GPB were observed in the last three PL. Values of the correlation coefficient were negative with GP (-0.476) and positive with PL (0.408) are confirmation of the observed trends. Weaker dependences with GP and PL were recorded in the casein: protein ratio (Table 1). In all phases of lactation in cow's milk from GPA, higher value parameters were found (on average by 1.58 percentage point) with the greatest differences from PLI to IV (on average by 2.25 percentage point), while these were significantly lower in PLV and VI (average 0.25 percentage point). It should be noted that the greatest difference (3.4 percentage point) was noted at lactation peak (PLIII). In the case of this indicator, correlation coefficient values were 0.284 with GP and 0.254 with PL (Table 1). Table 3 also showed a strong positive correlation between casein: protein ratio and casein concentration (0.615, P<0.05). This Table also shows that DM was slightly, but still positively correlated with protein level (0.227, P<0.05), casein level (0.316, P<0.05) and the casein: protein ratio (0.329, P<0.05).

The correlation coefficient values found in Table 1 shows that GP and PL had little influence on protein and casein level. However, it should be noted that despite this, the obtained dependences with GP and PL were confirmed by positive correlations (0.226 and 0.193 respectively). In turn, the κ-casein level was dependent by the daily milk production, and the lowest level was found in PLIII (Table 1). The milk of cows with higher DMP (GPB) was characterized on average by a 0.024 mg/ml lower concentration of κ-casein, which was confirmed by the negative correlation with GP. In Table 3, noteworthy are the negative correlations of κ-casein level to chloride (P<0.05) and LClc (P<0.05) levels, whose value in turn was strongly correlated with GP (Table 2).

Table 2 data on the parameters characterizing cheese-making usefulness shows the strong influence of GP and PL. This referred, first of all, to the features that could affect the amount and rate of clot formation, i.e. chlorides, LClc and calcium level. It was shown that in all phases of lactation, milk of GPB cows had higher chloride levels (on average 32.67 g/dL) and higher LClc (by 0.14 percentage point). In both cases, a positive correlation with GP was found. Observing the decreasing tendency of both parameters from PLIV, a negative correlation with PL (Table 2) was found. The analysis of calcium concentration showed that the milk obtained from cows from GPA in all phases of lactation had a higher level of this parameter, on average by 0.045 g/L (P<0.05, Table 2). This tendency was confirmed by a negative value of the correlation coefficient. The calcium concentration in milk usually decreased until lactation peak (PLIII), after which it was increasing. In general, however, a positive correlation with the number of milking days - PL (Table 2) was found. It is worth noting that the calcium level in milk was negatively correlated with chloride level (P<0.05) and LClc (P<0.05) (Table 3).

Results of the cheese yield analysis showed a stronger impact of PL, which was confirmed by the positive value of the correlation coefficient (0.193, Table 2). The cheese yield increased over time of milking days, ranging on average from 19.75% (PLI) to 21.3% (PLVI). Slightly less dependence strength and negative correlation value were observed in case of GP. The average lower cheese yield was noticed in GPB. The differences found were 0.45 percentage point on average, and trend was confirmed by a negative correlation value. The correlation of GP with proteins drained with whey is also important. In whey from GPB cows, the content if this was usually higher. This effect was observed in all lactation phases and the average difference was 0.08 percentage point GPB milk was characterized by a longer coagulation time, by 23.33 seconds (P<0.05) on average. Both indices showed positive correlation values with GP (Table 2).

It is worth noting that the formation of these indicators was also influenced by the chloride concentration in milk obtained from GP (Table 3). In the case of cheese yield, a negative correlation with chloride was shown (P<0.05), whereas with time of coagulation and the level of proteins in whey, this relationship was positive (P<0.05).

The results regarding the dependence between the total protein, casein and κ-casein contained in milk also seem to be important (Table 3). They show a stronger dependence of the total protein with casein (P<0.05) than with κ-casein. It is also important that κ-casein content was dependent on the level of casein in milk (P<0.05), the concentration of which was significantly affected by daily milk production.

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Table 1. Daily milk production and milk composition of cows in different phases of lactation

Parameter	I		II		III		IV		V		VI			Correlation P<0.05	
	A	B	A	B	A	B	A	B	A	B	A	B	SEM	GP X	PL X
n	22	39	22	39	29	32	31	30	32	29	36	25			
DMP (L)	22.1^{a}	32.4^{d}	30.3^{c}	36.9^{e}	29.8^{c}	37.1^{e}	26.9^{ba}	33.9^{d}	24.9^{a}	31.0^{d}	15.7^{f}	21.9^{a}	0.35	-	-0.644
Total protein (%)	3.25^{a}	3.49^{b}	3.20^{a}	3.49^{b}	3.43^{b}	3.47^{b}	3.36^{c}	3.31^{c}	3.37^{c}	3.35^{c}	3.32^{c}	3.35^{c}	0.03	0.226	ns
Lactose (%)	5.36^{a}	5.32^{b}	5.37^{a}	5.36^{a}	5.27^{c}	5.25^{c}	5.16^{de}	5.21^{d}	5.19^{d}	5.16^{de}	5.13^{e}	5.11^{e}	0.04	0.129	-0.365
DM (%)	13.4^{a}	12.9^{b}	13.1^{a}	12.5^{b}	12.9^{b}	12.4^{b}	13.4^{a}	13.0^{b}	13.7^{c}	13.8^{c}	14.3^{a}	14.2^{a}	0.06	-0.476	0.408
Casein (mg/mL)	2.46^{b}	2.54^{a}	2.39^{b}	2.54^{a}	2.56^{a}	2.45^{b}	2.48^{b}	2.39^{b}	2.45^{b}	2.52^{a}	2.56^{a}	2.59^{a}	0.01	0.193	0.129
Casein:protein (%)	75.6^{a}	73.4^{b}	74.7^{a}	73.2^{b}	74.7^{a}	71.3^{c}	74.2^{a}	72.3^{c}	75.3^{a}	75.5^{a}	76.8^{c}	77.1^{c}	0.31	-0.284	0.254
κ-casein (mg/mL)	0.384^{a}	0.354^{b}	0.382^{a}	0.350^{b}	0.372^{d}	0.349^{c}	0.372^{d}	0.354^{c}	0.373^{d}	0.355^{c}	0.380^{a}	0.359^{c}	0.02	-0.135	ns

Phase of lactation (PL: I - VI) / Production group (GP: A, B) Correlation, SEM- standard error of the mean; DMP- daily milk production; DM- dry matter; ^{a,b,c,d,e} - means in the row with different letters differ significantly (P<0.05); ns- not significant

Table 2. Daily milk production and milk quality parameters of cows in different phases of lactation

	Phase of lactation (PL: I - VI) / Production group (GP: A, B)													Correlation P<0.05	
Parameter	I		II		III		IV		V		VI				
	A	B	A	B	A	B	A	B	A	B	A	B	SEM	GP X	PL X
n	22	39	22	39	29	32	31	30	32	29	36	25			
Chloride (g/dL)	84^{a}	91^{b}	89^{b}	98^{c}	92^{b}	96^{c}	92^{b}	95^{c}	82^{a}	90^{b}	80^{a}	90^{b}	0.04	0.554	-0.362
LClc (%)	1.57^{a}	1.71^{a}	1.66^{a}	1.83^{c}	1.74^{b}	1.83^{d}	1.78^{a}	1.82^{c}	1.58^{a}	1.74^{b}	1.56^{a}	1.79^{b}	0.24	0.670	-0.304
Acidity (°SH)	7.17	6.96	7.11	7.07	7.17	6.90	7.07	6.95	6.93	6.97	6.98	6.94	0.52	-0.155	ns
Calcium (g/L)	1.58^{a}	1.53^{b}	1.57^{a}	1.53^{b}	1.57^{a}	1.50^{b}	1.65^{c}	1.61^{a}	1.64^{c}	1.61^{a}	1.64^{c}	1.60^{a}	0.07	-0.463	0.354
Cheese yield (%)	20.1^{a}	19.4^{b}	19.3^{b}	19.1^{b}	19.3^{b}	19.2^{b}	20.4^{ad}	19.8^{b}	21.5^{c}	20.8^{d}	21.5^{c}	21.1^{c}	0.10	-0.163	0.193
Cheese protein (%)	12.1	12.1	11.9	11.4	12.4	11.8	12.5	12.8	12.7	12.6	12.7	12.4	0.13	-0.220	ns
Whey protein (%)	0.77^{a}	0.87^{b}	0.77^{a}	0.88^{b}	0.81^{a}	0.88^{b}	0.82^{a}	0.88^{b}	0.81^{a}	0.86^{b}	0.79^{a}	0.86^{b}	0.08	0.311	ns
RCT (s)	123^{a}	137^{c}	119^{a}	145^{c}	119^{a}	142^{c}	126^{a}	139^{c}	113^{b}	146^{c}	117^{ab}	148^{c}	1.23	0.346	ns

Phase of lactation (PL: I - VI) / Production group (GP: A, B) Correlation, SEM- standard error of the mean; DMP- daily milk production; DM- dry matter; ^{a,b,c,d,e}- means in the row with different letters differ significantly ($P<0.05$); ns- not significant

Table 3. Pearson's correlation for milk and whey composition with cheese manufacturing parameters

Parameter	Total protein (%)	DM (%)	Casein:protein (%)	κ-casein (mg/ml)	Calcium (g/L)	Chloride (g/dL)	Whey Protein (%)
Casein (mg/mL)	0.655*	0.316*	0.615*	0.286*			0.365*
κ-casein (mg/mL)	0.205	0.194*	0.126*		0.123	-0.444*	0.724*
DM (%)	0.227*					-0.235*	
Casein : protein (%)	-0.188*	0.329*			0.115	-0.105	
Chloride (g/dL)					-0.254*		0.464*
LClc (%)	0.145*	-0.192*	-0.202*	-0.285*	-0.457*	0.657*	0.382*
Cheese yield (%)		0.129		0.255*	0.164*	-0.353*	-0.248*
RCT (s)		-0.153*		-0.572*	-0.266*	0.559*	-0.401*

DM- dry matter; LClc- chloride-lactose ratio; RCT- rennet clotting time; *- P<0.05)

DISCUSSION

Apart from colloidal calcium phosphate compounds and sodium and potassium salts, acidity is an important factor conditioning the stability of milk casein micelles. The study by Rollema (1992) showed that higher calcium concentration and lower acidity entails higher milk micelle stabilization. This is confirmed by the results of the presented study, in which higher curd yield produced from milk with higher calcium concentration has been demonstrated (Table 2). The relationship between milk acidity, casein stability and milk technological utility was shown in studies by Batavani et al. (2007) and Michalcova and Krupova (2007). Although in the presented study no direct correlation between milk acidity and cheese-making characteristics has been demonstrated, it can be indirectly demonstrated in the cited studies. No statistically significant differences in acidity were obtained (Table 2), however, a slightly lower value of SH was noted in cows with a higher daily production, confirmed by weak but still negative correlation (-0.155; P<0.05). This fact can be partly explained by the higher content of casein which is acidic. Statistically significant differences were found in lower curd yield, longer RCT and higher whey protein concentration in milk of cows with a higher daily production. The correlation of chloride content (0.554; P<0.05) and calcium level (-0.463; P<0.05) with daily milk production was also observed (Table 2). These results correspond with Raji et al. (2012).

Current knowledge indicates that milk calcium and chloride concentration is mainly entailed by mastitis (Gajdusek et al., 1996) and the physiological state of the organism (Neville et al., 1994). In general, in healthy cows, the milk calcium concentration does not change significantly, although in the cited studies various concentrations of this element were observed. In Kinal et al. (2007) and Sola-Larranaga and Navarro-Blasco (2009), calcium concentration ranged from 1.23 to 1.65 g / L. These values correspond with our research, however, are lower than those found by Kuchtik et al. (2008), where the calcium concentration ranged from 1.81 to 2.14 g / L and was the highest between 33 and 67 days and at the end of lactation. An important aspect of this element, confirmed in our study, is that calcium plays an important role in curd yield. Lucey and Fox (1993) and Metzger et. al. (2000) indicate that milk calcium is one of the factors affecting the casein coagulation process and the amount of curd obtained. Correlation coefficient values of the presented study associated with these parameters confirm these results. The study by van Hulzen et al. (2009) correspond with obtained results and show, that milk with lower calcium level is more often characterized by lower casein concentration.

From the point of view of cheese-making usefulness, casein should be the largest part of the total protein level. Its properties determine the quality and quantity of the curd. Studies carried out so far prove that the amount of casein is affected by many factors, including mammary gland inflammation which is associated with an increased SCC. Gellrich et al. (2014) showed that this effect may be stronger in cows that are secreting more milk throughout the day. The consequence is a change in the quality of milk associated with a smaller quantity and worse quality of the curd. The results of Gellrich et al. (2014) also showed that cows with a daily milk production of 37.8 kg (on average) had 0.46 percentage point less protein in comparison to cows with a milk productivity of 33.8 kg. According to Coulon et al. (1998), Hanigan et al. (2004) and Batavani et al. (2007) this effect, among others, is due to the physiological state of the mammary gland and is related to the secretion intensity in various stages of lactation. Therefore, it is reasonable to assume that intensive exploitation of the mammary gland supports the occurrence of undiagnosed subclinical inflammations. This causes changes in the proportion of ingredients responsible for cheese-making utility. This can be confirmed by, among others, the study by Batavani et al. (2007), which showed that chronic latent inflammation impairs the function of parenchyma in the mammary gland. The consequence is most often a change in lactose and chlorides levels (Hanus et al., 1992) and the intensity of casein synthesis (Urech et al., 1999). Usually chloride concentration in milk ranges between 0.8 and 1.4 g / mL (Gajdusek et al., 1996). However, their proportion in relation to lactose may range from 1.88 to 2.27 (Hanus et al., 1992). Changes in the ratio of lactose to chlorides (LClc) are directly related to the violation of homeostasis of the udder, usually caused by mammary gland inflammation. Changes in osmotic pressure stability in the mammary gland caused by decreased lactose level initiates the process of chloride transfer from blood into milk (Ogola et al., 2007). The presented study showed a positive correlation between chloride content (Table 2) and milk production (0.554; $P<0.05$). This may indicate, that greater milk production (GPB) is accompanied by a greater chloride transfer to the mammary gland (Ogola et al., 2007; Gajdusek et al., 1996; Hanus et al., 1992). This was confirmed by a strong correlation of LClc (Table 2) with GP (0.670; $P<0.05$), with similar lactose content at the same time (Table 1). This corresponds to the results of Tsioulpas et al. (2007) and Raimondo et al. (2009). They showed a clear correlation between the amount of milk secreted during a day and the concentration of certain fractions of chlorides. In this area, the results of our study also coincide with those presented by Ogola et al. (2007).

CONCLUSIONS

The study results suggest that the intensity of daily milk secretion has a significant impact on the share of ingredients commonly assessed for cheese- making usefulness. Increased daily production of milk may favor a higher protein and casein level, however, there is not such a strong correlation with κ- casein concentration. As a result, it may affect the quality and efficiency of cottage cheese production. At the same time, it should be noted that changes in the content of the analyzed milk components were related to the changes in the chloride level, and their share was dependent on the daily milk production. The consequence of this was degradation of important cheese-making features, the reduction of curd amount and the prolongation of coagulation time.

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