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PROCESSABILITY OF MILK IN THE PRODUCTION OF CURD CHEESES ON FAMILY FARMS IN THE SUMMER AND WINTER SEASONS

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Abstract. The aim of the study was to compare quality of curd cheeses produced from raw and pasteurized milk in a family farm in the summer and winter seasons. Conducted analyses showed that the season of the year, in which milk was produced, influenced its chemical composition and selected quality attributes. In terms of milk processability a more advantageous composition and better quality attributes were found in winter compared to summer. Quality of produced curd cheeses was affected by the season of milk production as well as milk type (raw vs. pasteurized). In the winter season the yield of curd cheese was over 1.5-fold greater from pasteurized milk in comparison to the summer season. Curd cheeses produced from raw milk were firmer, more elastic and sliceable, while those produced from pasteurized milk were less cohesive and more suitable was spreads. The organoleptic analysis of curd cheeses showed that more advantageous consumer value was found for cheeses produced in the winter season.

Key words: small family farms, season, pasteurization, cow milk, curd cheeses.

INTRODUCTION

Growing food consumer awareness has been observed recently, particularly in terms of the effect of food on consumer health, the environmental impact of food production and livestock welfare. Among other things, this promotes increased interest in organic food and traditional products manufactured following old recipes and formulations, free from any preservatives, artificial colouring agents and flavour enhancers. Research results reported by many authors indicate that consumers perceive food produced applying traditional methods as healthier, tastier and more original. It is also assumed that consumers are willing to pay more for organic products containing no additives (Żakowska-Bienas and Kuc 2009). Cow's milk is a source of quality protein (containing exogenous amino acids), minerals, vitamins (primarily fat-soluble such as A, D, E, and K) and enzymes. Research results have confirmed that components of milk and dairy products, particularly probiotic bacteria, show immunostimulatory properties,

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and as such they are of great important in the prevention of cancer, cardiovascular disease, osteoporosis and type 2 diabetes. Additionally, milk proteins exhibit antioxidant, anti-thrombotic, antibacterial and hypotensive properties (Huth et al. 2006). According to Kuczaj et al. (2016), the impact of genetic factors on milking performance of cows and milk composition amounts to approx. 25–30%, while environmental conditions (feeding, management conditions, milking system) account for approx. 65–70%. Physiological factors also need to be considered (such as the cow's age, health status, body condition, stage of lactation, hormonal stimulation), as they are responsible for approx. 5–10% of the impact.

Among environmental factors modifying milk yield and composition a significant role is played by feeding of cows. On traditional farms the feed ration is determined by the season of the year. Within a calendar year the summer feed ration is based primarily on the pasture or fresh forage and concentrate, while the winter feed ration comprises mainly preserved forage (silage, haylage), roughage (hay, straw), as well as root and tuber crops, and cereal grain.

Curd cheese is the main dairy product and its quality is determined primarily by milk composition and thorough execution of successive procedures during its production process. The milking season of cows in traditional farms may change properties of the resulting cheese. Moreover, curd cheeses may be produced both from raw and pasteurised milk. Pasteurisation is thermal milk processing executed at a temperature over 100°C, which aims at the elimination of vegetative cells of pathogenic and saprophytic microorganisms.

Increased demand for traditional products, particularly dairy products, provides an opportunity to generate extra income for smallholder farmers keeping dairy cows. Many such farmers decide to sell not only milk, but also dairy products (cream, butter or cheeses). Increasing numbers of on-farm dairies are being established, where family members produce traditional cheeses and other organic dairy products.

In view of the above it was decided to conduct this study, which aim was to compare the quality of curd cheeses produced from raw and pasteurised milk on a family farm in the summer and winter season.

MATERIAL AND METHODS

The study was conducted in a small traditional farm located in the Wielkopolska region (Poland). The material for analyses comprised bulk samples of raw and pasteurised milk, as well as samples of curd cheese produced from this milk. Milk was collected from four Polish Holstein-Friesian Black-and-white cows. The cows were in a similar phase of lactation after the following calvings: 1, 4, and 6 (2 cows). The animals were kept in a stanchion barn. The feed rations in the summer and winter seasons were standardised depending on milk yields according to the INRA (2007) system. In the period from May to October cows grazed in the pasture between the morning and evening milkings. In the grazing pasture the grass mixture accounted for approx. 90% with legumes constituting the rest. After evening milking in the barn each cow was given maize silage, hay and concentrate. In turn, from October to May cows were kept indoors. The daily feed ration comprised the following feeds: maize silage, rye silage, grass haylage, hay and concentrate. No commercial feeds, additives or concentrates were used in feeding of cows apart from mineral licks, which served as dietary supplements. Milkings were performed twice a day using a direct to can milking machine (DeLaval). Equal time intervals were kept between milkings. Milk for analyses and for curd cheese production was collected twice a month within one week's interval and it always came from the morning milking. In the summer season milk was collected in July, August and September, while in the winter it was in December, January and February. Each milk batch was divided into two equal parts (raw milk and milk to be pasteurised). Next from the raw milk batch 100 ml of milk were collected to a sterile container, which was sealed tightly and left to cool in a fridge at a temperature of 4°C. Milk for pasteurisation was heated on a gas cooker to a temperature of 75°C while mixing continuously to ensure uniform heating. After the pre-set temperature was reached and maintained for approx. 20 seconds the pot with milk was transferred to a water bath (cold water with ice cubes) to rapidly reduce the temperature to 31°C. The cooled milk was supplemented with MYE heterofermentative lyophilised lactic acid starter cultures (*Lactococcus lactis subsp. lactis*, *Lactococcus lactis subsp. cremoris*, *Lactococcus lactis subsp. lactis biovar diacetylactis*, *Streptococcus salivarius subsp. thermophilus*, *Leuconostoc mesenteroides subsp. cremoris*). In the case of raw milk the natural lactic acid microflora was used. Fermentation of both milk types was run for approx. 60 h in a room at a temperature of approx. 20°C. After a soft curd was formed it was cut into pieces with a knife, mixed and flooded with boiling water (1.25 l boiling water per 2 l milk). After mixing milk was left for approx. 30 minutes to ensure formation of a desirable curd. Afterwards the curd mass was formed in the containers, which was subsequently screened on a sieve. The curd on the sieve was left for approx. 12 h until all whey was drained. On the following day curd cheeses were weighed, wrapped in cling film and cooled for 3 h in a fridge. After that time curd cheeses were placed in a freezer at −18°C. In the summer and winter seasons 12 cheeses each were produced (6 from raw milk and 6 from pasteurised milk). All the cheeses were produced following local guidelines concerning good manufacturing practice and good hygienic practice. In order to conduct analyses milk and curd cheese samples were transported to the laboratory in a coolbox.

All the analyses were performed twice on milk and curd cheese samples, except for cheese texture, with 8 measurements taken on each cheese. Arithmetic means were calculated for the recorded results. Frozen milk and curd cheeses were gradually thawed in a fridge. Next milk was heated in a water bath at a temperature of 38°C. In the tested milk samples the following parameters were determined: basic composition and casein, somatic cell count, pH, titratable acidity, colour and clotting point. In curd cheeses the following parameters were recorded: pH, titratable acidity, colour and cheese yield. Produced curd cheeses were also evaluated organoleptically.

The basic composition of milk (milk solids, fat, protein, lactose, minerals) and clotting point were determined using the Lactostar apparatus (Funke-Gerber). Somatic cell count in milk was established with the use of a BactoCount IBC instrument (Bentley). Casein content in milk samples was determined applying the method developed by Walker (PN 68/A-86122). Active acidity (pH) of both raw milk and cheeses was measured with a Handylab 2 pH-meter using a glass calomel electrode. In the case of curd cheeses they had been homogenised prior to analyses (5 g cheese with an addition of 50 ml distilled water). Titratable acidity (total acidity) of milk and of homogenised curd cheese was determined by titration using NaOH solution in the presence of phenolphthalein as a chemical indicator changing colour at pH = 8.3. Colour of milk and curd cheeses was measured using a CR-5 spectrophotometer (Konica Minolta) in the CIE (L^*, a^*, b^*) system. Symbol L^* denotes colour lightness ranging from 0 % (black) to 100% (white); a^* denotes the share of the red or green colour (positive values indicating the share of the red colour, while negative values – the share of the green colour, respectively); b^* denotes the position of colour between blue ($-b^*$) and yellow ($+b^*$). Texture (hardness and springiness) of curd cheeses was measured using a TA.XT.plusTextureAnalyser (Stable Micro Systems). Contact force was analysed using a 1.2” spherical probe with the diameter of 0.5 mm, which penetrated curd cheese samples with the velocity of 2.0 mm/s to a depth of

10 mm. Results were analysed using the FarPoint Technologies programme. Cheese yield was determined based on the quantity of milk used in its production and the mass of the resulting curd cheese, and next from the mathematical ratio the amount of milk required to produce 1 kg curd cheese was established depending on milk density. The obtained curd cheese was subjected to organoleptic analysis by a 5-person trained panel (women, aged 25–50 years). Colour, texture, aroma, taste and overall appearance were assessed. Scores for individual parameters were given in a 5-point scale (1 – least advantageous; 5 – most advantageous).

Statistical analysis of recorded results was conducted using the StatSoft Inc. Statistica 13.1 programme (2018) applying the one-way analysis of variance. Specific comparisons of object means were performed using Tukey's test. The actual somatic cell count in milk was subjected to log transformation according to Ali and Shook (1980), applying the formula y = ln (x + 10), where x denotes the actual somatic cell count in 1 ml milk.

RESULTS

Table 1 compares selected quality parameters of raw milk collected from cows in the summer and winter seasons. The analysis showed no significant statistical difference only between the means for lactose content in milk produced by cows in the summer and winter seasons. In contrast, significantly higher contents of milk solids non-fat ($p \le 0.01$), fat ($p \le 0.05$), crude protein ($p \le 0.05$) and casein ($p \le 0.05$) were recorded for milk produced in the winter season compared to that from the summer season. Moreover, identical dependencies at $p \le 0.01$ were found for titratable acidity and freezing point. In turn, milk from the summer season compared to the winter season showed significantly higher values of the following parameters: concentrations of minerals ($p \le 0.01$), pH ($p \le 0.01$), LnSCC ($p \le 0.05$) and colour (b* at $p \le 0.01$, L* at $p \le 0.05$ and a* at $p \le 0.05$).

Table 1. Comparison of selected quality attributes of raw milk obtained from cows in the summer and winter seasons

Attribute		Season			
		summer		winter	
		$\bar{x}$	SD	$\bar{x}$	SD
Non-fat dry mass [%]		8.60^{A}	0.20	8.87^{B}	0.43
Fat [%]		3.80^{a}	0.23	4.02^{b}	0.57
Crude protein [%]		3.17^{a}	0.18	3.62^{b}	0.37
Casein [%]		2.59^{a}	0.14	2.96^{b}	0.30
Lactose [%]		4.55	0.20	4.44	0.13
Minerals [%]		0.88^{A}	0.01	0.81^{B}	0.03
LnSCC		2.98^{a}	0.23	2.56^{b}	0.44
pH		6.74^{A}	0.04	6.63^{B}	0.07
Titratable acidity [°SH]		6.60^{A}	0.60	7.77^{B}	0.31
Curd setting point [°C]		-0.547^{A}	0.012	-0.527^{B}	0.060
Colour	L*	88.53^{a}	0.30	87.93^{b}	0.66
	a*	-3.05^{a}	0.24	-3.83^{b}	0.70
	b	13.57^{A}	0.50	12.14^{B}	0.82

Means denoted with different letters differ statistically: A, B – highly significantly ($P \le 0.01$); a, b – significantly ($P \le 0.05$).

Results of comparisons for selected parameters of curd cheeses produced from raw and pasteurised milk are given in Table 2. It was found that curd cheese produced from raw milk in comparison to that obtained from pasteurised milk showed significantly higher ($p \le 0.01$) titratable acidity, hardness and springiness as well as significantly lower ($p \le 0.05$) mass of produced curd cheese and colour parameter a*.

Table 2. Comparison of selected attributes of curd produced from milk raw and pasteurized

Attribute		Curd cheese			
		raw milk		pasteurized milk	
		$\bar{x}$	SD	$\bar{x}$	SD
pH		4.21	0.15	4.23	0.12
Titratable acidity [°SH]		72.00^{A}	2.40	54.00^{B}	4.50
Colour	L*	96.35	0.78	95.83	0.55
	a*	−2.59^{a}	0.32	−2.11^{b}	0.20
	b*	11.62	0.42	12.06	1.15
Texture	firmness [g]	197.83^{A}	61.54	66.66^{B}	32.89
	elasticity [g]	−11.84^{A}	3.58	−19.42^{B}	6.56
Curd cheese yield	mass [g]	366.00^{a}	49.00	434.00^{b}	59.00
	yield [kg]	5.55	0.73	5.27	2.11

Means denoted with different letters differ statistically: A, B – highly significantly ($P \le 0.01$); a, b – significantly ($P \le 0.05$).

Table 3 presents results of comparisons for selected parameters of curd cheese produced from raw milk in the summer and winter seasons. Statistical analysis showed that curd cheese obtained from milk produced in the winter season compared to curd cheese from milk obtained in the summer season showed significantly higher values for the following parameters: pH ($p \le 0.01$), hardness ($p \le 0.01$), mass of produced curd cheese ($p \le 0.05$), as well as a significantly lower ($p \le 0.05$) value for colour a*.

Table 3. Comparison of selected attributes of curd cheese produced from raw milk during the summer and winter seasons

Atribute		Season			
		summer		winter	
		$\bar{x}$	SD	$\bar{x}$	SD
pH		4.07^{A}	0.06	4.35^{B}	0.05
Titratable acidity [°SH]		72.00	2.24	71.00	2.64
Colour	L*	96.65	0.65	96.04	0.81
	a*	−2.40^{a}	0.27	−2.78^{b}	0.24
	b*	11.53	0.24	11.71	0.54
Texture	firmness [g]	134.10^{A}	18.07	243.72^{B}	34.01
	elasticity [g]	−12.56	3.89	−11.33	3.32
Curd cheese yield	mass [g]	341.00^{a}	35.00	395.00^{b}	49.00
	yield [kg]	5.91	0.65	5.82	0.61

Means denoted with different letters differ statistically: A, B – highly significantly ($P \le 0.01$); a, b – significantly ($P \le 0.05$).

Similar comparisons for selected attributes of curd cheeses, this time produced from pasteurised milk from the summer and winter seasons, are given in Table 4. Here statistical analyses showed no significant differences between curd cheeses from the summer and winter seasons for colour b* and springiness. In turn, curd cheese produced in the winter season compared to that from the summer season showed significantly higher values ($p \leq 0.01$) for the following parameters: hardness and mass of curd cheese, as well as lower titratable acidity, with the means for this attribute differing at the significance level $p \leq 0.05$. Significantly higher values (at $p \leq 0.01$) for the following attributes: colour a* and b* as well as cheese yield, were recorded for curd cheeses produced in the summer.

Table 4. Comparison of selected attributes of curd cheese produced from pasteurized milk in the summer and winter seasons

Atribute		Season			
		summer		winter	
		$\bar{x}$	SD	$\bar{x}$	SD
pH		4.14^{A}	0.03	4.43^{B}	0.08
Titratable acidity [°SH]		62.00^{a}	4.79	56.00^{b}	2.83
Colour	L*	96.02	0.49	95.63	0.56
	a*	-1.98^{A}	0.12	-2.25^{B}	0.17
	b	12.84^{A}	1.12	11.28^{B}	0.43
Texture	firmness [g]	42.60^{A}	8.77	93.12^{B}	19.89
	elasticity [g]	−18.41	3.89	−20.54	2.34
Curd cheese yield	mass [g]	320.00^{A}	82.00	567.00^{B}	115.00
	yield [kg]	6.66^{A}	3.65	3.65^{B}	0.70

Means denoted with different letters differ statistically: A, B – highly significantly ($P \leq 0.01$); a, b – significantly ($P \leq 0.05$).

Table 5. Organoleptic analysis of curd cheese produced during the summer and winter seasons on a five – point scale

Season	Colour	Texture (curd)	Aroma	Taste	Overall score	Overall score for the season
Summer	4.75	3.50	3.75	3.25	3.81	4.08
	5.00	3.75	4.25	3.00	4.00	
	5.00	4.25	4.25	3.25	4.19	
	5,00	4.00	4.75	4.00	4.44	
	4.75	1.25	4.50	3.50	3.50	
	4.75	3.75	5.00	4.75	4.56	
Winter	5.00	4.75	4.75	4.25	4.69	4.64
	5.00	4.50	4.75	4.75	4.75	
	4.75	4.50	3.75	3.75	4.19	
	5.00	4.50	4.50	4.75	4.69	
	5.00	4.50	5.00	4.50	4.75	
	5.00	4.25	4.75	5.00	4.75	

Table 5 presents results of organoleptic analysis (in a 5-point scale) for curd cheeses produced in the summer and winter seasons. Curd cheeses from the winter season received the total mean by 0.56 points higher compared to curd cheeses produced in the summer. In terms of individual elements of the analysis in a vast majority of evaluated samples parameters of curd cheese produced in the winter were more advantageous. In the case of texture, taste and overall evaluation, curd cheese made from milk produced in the winter in relation to curd cheese from milk obtained in the summer received higher scores among all the analysed samples.

DISSCUSION

Cow's milk is a multicomponent and polydisperse particle mixture, composed of three basic phases: colloid (protein), emulsion (fat) and molecular (aqueous solution of lactose and minerals). Fat, protein, lactose and ash are found in milk in respective ratios. Kuczaj et al. (2016) reported that 100% lactose, 90% protein and from 50% to 60% fatty acids present in milk are produced in the mammary gland from precursors absorbed from blood. In turn, the other milk constituents penetrate to milk by filtration from blood. It is assumed that when 1 l milk is produced by a cow approx. 450–500 l blood pass through its udder. The chemical composition of milk is the result of action of numerous factors such as breed, age, individual traits, keeping conditions, management and health status of cows. The resulting differences in milk composition may be as high as 50%, although some constituents (e.g. lactose) show limited variability (Szulc et al. 2010). In herds of dairy cows fed in a traditional system a significant role is played by the season of the year. This is determined by the abundance of specific feed types on farms as well as potential use of pasture in cow feeding. On traditional farms as a rule cows are kept indoors in the winter fed primarily preserved feeds (silages, haylages), root crops as well as roughages and concentrates, whereas in the spring and summer season animals are kept on the pasture grazing on pasture sward, with roughage and concentrate reported as supplementation of the feed ration on the farm. Our study showed that the season of the year have a significant effect on the basic chemical composition of milk, its physico-chemical parameters as well as somatic cell count (Table 1). More advantageous values of analysed parameters were found for milk produced in the winter compared to that from the summer season. Similar results concerning the chemical composition of milk were reported by Czyżak-Runowska et al. (2020). Typically in traditional farms greater concentrations of fat and protein are recorded in milk produced in the winter season compared to that from the summer season, which results, among other things, from the composition of feeds used in the feed ration for cows. A study by Coppa et al. (2019) also showed that the composition of cow's milk depends on the season of the year (diversified diet) and feeding system (grass, maize silage). Moreover, those authors indicated a marked role of the location of pastures (lowland vs. upland) in terms of contents of bioactive components in milk produced by cows. It was found that grazing of cows in upland regions is more advantageous, since it promotes e.g. a higher share of fatty acids in milk: C 18:3n-3, CLA*cis*-9, *trans*-11, MUFA (mono unsaturated fatty acids) and PUFA (poly unsaturated fatty acids). This fact results from a greater share of herbs in the pasture sward. When conducting studies on a group of cows kept under identical conditions and using the same feed Bernabucci et al. (2015) showed that air temperature and humidity were factors determining the chemical composition of milk throughout the year. Lower contents of fat and protein were observed in milk in the summer compared to the winter. Those authors reported that high temperature and humidity cause heat stress in cows, which influences milk yield and its parameters, as well as processability for cheese production. Similar results were reported by Aharoni et al. (2002) and Bertocchi et al. (2014). The photoperiod is another factor affecting milking performance of cows. In the opinion of Dahl et al. (2000), in dairy cattle the photoperiod determines several hormonal changes, which may influence milk production, feeding behaviour and growth of animals. Most commonly it is observed that milk yield increases with the elongation of daylight hours and in turn it may result in a reduced concentration of milk constituents. In the opinion of Bernabucci et al. (2015), a change in cheese processability parameters of milk during heat waves is connected with decreased α_S-casein and β-casein contents. Those authors suggested that a reduction in the contents of these casein fractions in milk during the summer period is partly caused by decreased availability of energy and protein, which typically occurs during heat stress. Milk from the summer period is also characterised by inferior coagulation properties. Contents of basic milk constituents are also influenced by the age of cows, as with age the concentration of fat and protein in milk decreases. Similar dependencies have been observed in the case of early lactation and the occurring mastitis.

In this study milk produced in the summer season was characterised by a significantly lower titratable acidity and higher pH compared to milk from the winter season (Table 1). Nevertheless, milk from both seasons showed advantageous freshness and good processability. Similar results were reported by Czyżak-Runowska et al. (2020). In their study Brodziak et al. (2012) found no significant effect of the season on pH of milk obtained from four genotypes of cows.

Milk colour influenced consumer preferences and quality of dairy products. In this study (Table 1) milk coming from the summer and winter seasons differed significantly in terms of three colour parameters (L*, a*, b*). In the summer season of milk production the raw material was characterised by a less intensive white (L*) and green colour (−a*,), as well as a more saturated yellow colour (b*) compared to milk from the winter season. The yellow colouring of milk indicates the presence of β-carotene, which share in the pasture sward is high. Faulkner et al. (2018) showed a much higher share of β-carotene in milk of cows fed grass or grass and clover. Scarso et al. (2017) stated that parameters of milk colour (L*, a*, b*) are influenced by the breed, milking time, stage of lactation and the share of Jersey genes in the animal's genotype.

According to the regulations binding in Poland (Dz. U. Nr 117 poz.1011 z 25 lipca 2002 r.), in the conducted analyses of quality of raw cow's milk the freezing point of cow's milk should be max. −0.520°C. This parameter in milk is constant and closely correlated with osmotic pressure. This value is controlled by the quantity of substances dissolved in milk. The addition of water has a considerable effect on freezing point. In this study the freezing point of milk produced in both investigated seasons (summer vs. winter) met the requirements of binding standards (Table 1).

The main indicator showing the health status of the mammary gland is connected with the somatic cell count (SCC) in milk. In turn, the shares of individual cell elements being somatic cells vary and depend on the stage of mastitis and on the environment, in which cows are being kept. Mammary gland disorders cause reduction of milk yields and adverse changes in the chemical composition of milk, which as a consequence leads to a deterioration of its nutritive value and processability. In affected cows a reduction is observed in the synthesis of lactose, fat and casein (Barłowska et al. 2009; Król et. al. 2010), while levels of constituents passing to milk from blood, i.e. albumins, globulins and minerals, increase. Moreover, milk contents of K, Ca, P and Mg as well as vitamins A, B_1, B_2, C and D are reduced. The microbiological quality of milk deteriorates, which in combination with the decreased production, medical treatment costs, as well as inferior efficiency of technological processes and quality of obtained products generates considerable financial losses. Milk coming from a healthy udder in 1 ml contains less than 100 thousand somatic cells, while the level of 100 up to 200 thousand/ml indicates slight, non-specific disorders within the mammary gland. The level above 200 thousand/ml means that the udder is infected with pathogenic microorganisms and is affected by an inflammatory process. The investigations presented in this study (Table 1) showed that the season of the year influences the number of somatic cells in milk. Greater SCC levels in milk were recorded in the summer season (Table 1). Results recorded in this study confirmed findings presented by other authors: Pytlewski and Dorynek (2000), Antkowiak et al. (2002), Saravanan et al. (2015) and Alhussien and Dang (2018). It is thought that high air temperature and grazing on pastures promote the incidence of the so-called summer mastitis in cows. This is most probably determined by the reduced immunity of animals in that period, as well as the udders rubbing against hind limbs when going to the pasture and advantageous conditions for the development of insects, which may transfer microorganisms between cows.

Raw milk coming from a cow in terms of its microbiological quality is not a clean product, it may contain microorganisms harmful for humans (e.g. pathogens). As a result, their potential presence in milk warrants thermal treatment of milk. Pasteurisation of raw milk aims at reducing the number of microorganisms to a level guaranteeing safety of this food product. According to Wang et al. (2016), thermal processing of milk may cause disadvantageous consequences, including changes in milk acidity and lactose degradation. Thermal processes may also affect mineral balance of milk, particularly calcium and phosphates, causing transfer of calcium and phosphates to the colloid phase. In this study pasteurisation of milk samples was performed by heating them to 75°C (while mixing continuously) and maintaining this temperature for 20 s, followed by cooling milk batches for approx. 20–30 minutes to a temperature of 31°C. It is generally known that the chemical composition of processed milk, i.e. fat content as well as the level and composition of caseins, have the most significant effect in the production of curd cheeses. Szpendowski et al. (2004) reported that depending on the chemical composition of the raw material, the course of protein coagulation or the applied technology of cheese mass separation the resulting curd cheeses exhibit different physico-chemical, nutritional and sensory characteristics, as well as varied yields. In the opinion of Pawlos et al. (2022), stability of milk proteins is affected by changes in milk pH, heating temperature and the addition of calcium compounds or chelating agents, which may alter calcium distribution. In this study curd cheese produced from raw milk compared to that obtained from pasteurised milk was characterised by higher titratable acidity, as well as hardness and springiness. Moreover, the mass of produced curd cheese was lower and its colour defined by the parameter a* showed lesser saturation towards the green colour (Table 2). In the opinion of Dmytrów et al. (2010), the differences in acidity of dairy products result from the activity and growth rate of starter bacteria, as well as the type of used milk and its chemical composition. The high share of proteins and minerals promotes the activity of lactic acid bacteria. In this study pasteurisation of raw milk may have eliminated some of the natural lactic acid bacteria responsible for the intensity of milk coagulation. For this reason curd cheese produced from pasteurised milk showed lesser titratable acidity. Probably pasteurisation also contributed to lesser degradation of milk constituents, particularly fat and protein, thus the yield of curd cheese produced from such milk in this study was higher.

Experimental curd cheeses were also subjected to rheological analysis, consisting in the evaluation of their hardness and springiness. Hardness is a force required to obtained desirable deformation of a sample. The result of cheese hardness measurement is influenced by such factors as cheese cohesiveness, distribution of water in the curd, homogeneity of samples and technological processes applied in its production (Mulawka et al. 2019). Mazur et al. (2015) showed that an increase in contents of protein and water in acid-set (sour milk) cheeses enhance their hardness. In the opinion of Pawlos et al. (2022), increasing the amount of calcium bound with casein by adding it to milk prior to thermal processing may elevate cheese hardness. In turn, springiness is defined as the capacity of a sample to return to the previous shape after the contact force ceases to act on it. According to Rogers et al. (2009), cheese with a lower fat content is characterised by a denser protein lattice and firmer consistency.

This study showed the effect of the season of milk production on attributes of the resulting curd cheese (Tables 3 and 4). Curd cheese produced from raw milk from the summer season showed higher acidity, lower hardness and yield of cheese mass from a unit of milk (Table 3). Similar results were recorded for curd cheese produced from pasteurised milk in the summer season compared to that from the winter season (Table 4). Additionally, curd cheese from the winter season was characterised by a more advantageous yield and lesser saturation of the yellow colour. This study showed that curd cheeses produced from raw milk were harder, firmer, and more sliceable, while curd cheeses from pasteurised milk were less cohesive and showed ideal spreadability. In turn, Chen et al. (2015) found no significant effect of the season of the year on properties of soft cheeses, in contrast to other dairy products.

This study showed that cheeses from the winter season exhibited more advantageous organoleptic characteristics (based on colour, consistency, flavour attributes) compared to those from the summer season (Table 5). This most probably resulted from the fact that milk from the winter season had a significantly higher fat content. In the opinion of Mistry (2001), the rather indistinct or bland taste is a disadvantageous attribute in cheese. Bergamaschi and Bittante (2018) were of an opinion that the aroma of a dairy product is influenced by the feed consumed by cows, particularly pasture sward characteristic to a given region.

CONCLUSION

1. The season of cow's milk production influenced its chemical composition and selected quality attributes. Parameters considered more advantageous from the technological point of view were recorded in the winter rather than the summer.
2. In the summer season milk contained more somatic cells than it was in the winter season and the conducted pasteurisation had no effect on the reduction in SCC.
3. Quality of produced curd cheeses was influenced on the season of milk production and the type of milk (raw vs. pasteurised).
4. In the winter season the yield of curd cheese from pasteurised milk was over 1.5-fold greater compared to the summer season.
5. Curd cheeses produced from raw milk were harder and more springy, they were sliceable, while curd cheeses made from pasteurised milk were less cohesive and more spreadable.
6. The organoleptic analyses of curd cheeses showed more advantageous quality attributes of cheeses produced in the winter season compared to those in the summer season.

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PRZYDATNOŚĆ TECHNOLOGICZNA MLEKA DO PRODUKCJI TWAROGÓW W GOSPODARSTWACH RODZINNYCH W SEZONIE LETNIM I ZIMOWYM

Streszczenie. Celem pracy było porównanie jakości twarogów wyprodukowanych z mleka surowego i pasteryzowanego w gospodarstwie rodzinnym w sezonie letnim i zimowym. Przeprowadzone analizy wykazały, że pora roku pozyskania mleka miała wpływ na jego skład chemiczny oraz wybrane cechy jakościowe. Z technologicznego punktu widzenia korzystniejszy skład i cechy jakościowe mleka stwierdzono zimą niż latem. Na jakość wytworzonych twarogów wpływ miał zarówno sezon pozyskania mleka, jak i jego rodzaj (surowe, pasteryzowane). W sezonie zimowym otrzymano ponad półtora razy wyższy wydatek twarogu z mleka pasteryzowanego w porównaniu z okresem letnim. Twarogi wyprodukowane z mleka surowego były bardziej twarde i sprężyste, nadające się do krojenia, natomiast twarogi wytworzone z mleka pasteryzowanego były mniej zwięzłe, bardziej odpowiednie do smarowania. Ocena organoleptyczna twarogów wykazała, że korzystniejszymi walorami konsumenckimi charakteryzowały się sery wyprodukowane w sezonie zimowym.

Słowa kluczowe: małe gospodarstwa rodzinne, sezon, pasteryzacja, mleko krowie, twaróg.