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The influence of the addition of herbs to the winter diet of sheep on the yield of bundz rennet cheese and its nutritional value

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The study was carried out on samples of raw sheep milk and bundz rennet cheese produced from it. The milk was obtained from ewes of the coloured variety of Polish Merino, from February to April, housed indoors and fed with preserved bulky feed and a mixture of concentrate feeds. Three groups were formed for the experiment: group I – control, fed without the addition of herbs to the concentrate feed, and groups II and III, in which an herb mixture was added to the concentrate feed in the amount of 10 and 20 g/sheep/day, respectively. Six experimental batches of bundz rennet cheese were made from the sheep milk, and the effect of the addition of herbs to the sheep diet on the chemical composition of the raw milk used to make cheese, the cheese yield and its nutritional value was analysed. The results showed that the use of herbal supplements in the feed of the coloured variety of Polish Merino sheep in winter had no effect on the chemical composition of the raw milk, and thus its value for processing, expressed as the yield of bundz rennet cheese. The addition of herbs in the amount of 20 g/sheep/day to the diet of sheep significantly increased the content of minerals in cheese made from the milk obtained from the group III sheep, by 6.1% and 6.6% as compared to groups I and II, respectively ($P \leq 0.05$). The experimental factor had no influence on the other parameters of the nutritional value of the cheese, i.e. on the content of protein and fat or their mutual proportions, or on its energy value.

KEYWORDS: sheep feeding / herbs / sheep milk / rennet cheese

At a time of increased incidence of diet-related diseases, functional food, i.e. food with health-promoting constituents with proven beneficial effects on one or more functions of the body in addition to nourishment, takes on particular importance [10, 20]. Contemporary, informed consumers therefore search for products that are not only tasty and safe, but also natural and beneficial to their health [16, 24, 31]. According to con-

sumer surveys, improved food quality means a return to traditional methods of animal husbandry, natural feeding of livestock, and traditional methods of food production, without interference in the form of additives such as vitamins or minerals [1, 30]. On the other hand, survey results indicate acceptance for measures taken to reduce the content of constituents with a negative effect on health, e.g. cholesterol and fat [30, 34]. New trends in consumer behaviour are reflected in the growing interest in traditional, regional food with guaranteed quality [1]. In a study by Żakowska-Biemans and Kuc [35], as many as 78% of survey respondents declared interest in purchasing such food, with the vast majority considering it to be 'healthy', 'less processed' and 'tasty'. They also emphasized the authenticity of this category of products, owing to original formulas and the natural origin of the ingredients. The best-known and most commonly purchased sheep products included cheeses (72% of respondents), e.g. oscypek, feta, bryndza and bundz. Sheep milk, besides its unquestionable health-promoting properties, also has high nutritional value [2]. Research on the content of individual milk constituents has shown that sheep's milk has much higher content of dry matter, and thus protein and fat, than cow or goat milk [8]. Hence it is an excellent raw material for cheese production and is distinguished by greater cheese yield (the amount of cheese in kg obtained from 100 kg of milk) than cow or goat milk.

The research cited indicates that traditional and regional food can become an important segment of the market, meeting the expectations of consumers interested in high quality food and unique taste qualities. To meet the expectations of consumers, research was undertaken in which herbs were added to the diet of sheep as a natural factor stimulating their production and health and thereby improving the quality of their milk and the cheese produced from it. For this purpose, varied levels of an herbal mixture were added to the diet of sheep housed indoors and fed preserved bulky feed derived from monoculture crops.

Material and methods

The research was carried out at the National Research Institute of Animal Production, Experimental Station in Kołuda Wielka. The experimental material consisted of 75 Polish Merino ewes of the Coloured variety (aged 2 to 8 years), milked commercially from February to April, after the lambs had been weaned at the age of 8-9 weeks. The ewes were housed indoors and fed preserved bulky feed (grass haylage, sugar beet pulp silage and hay) and compound concentrate feed. Nutrition levels were established according to INRA-88 standards for milking sheep, based on the requirements of a ewe with a body weight of 70 kg producing on average 0.5 kg of milk.

Three feeding groups were created in the experiment: group I (control) was fed bulky feed and compound concentrate feed without herbs, while groups II and III received the same feed as group I, but with a herb supplement added to the concentrate feed in the amount of 10 and 20 g/head/day, respectively. The herb mixture used in the experiment was composed of 9 herbs (common nettle *Urtica dioica*, fennel *Foeniculum capillaceum*, ca-

raway *Carum carvi*, coriander *Coriandrum sativum*, fenugreek *Trigonella foenumgracum*, peppermint *Mentha piperita*, English marigold *Calendula officinalis*, chamomile *Matricaria chamomilla*, and milk thistle *Silybum marianum*). It was intended to benefit the animals mainly by improving their digestion and metabolism, by acting as galactogogues, and by exerting bacteriostatic and anti-inflammatory effects, thereby improving the quality of the milk used to produce cheese.

Six experimental batches of bundz rennet cheese were made from sheep milk (at two--week intervals). The cheeses were made from 10 kg of milk from each group, using the vat method, at the Kołuda Wielka Experimental Station processing plant associated with the farm. Before processing the milk was collected and stored for 2 days at 4°C. The milk was pasteurized at 75°C for half an hour, after which it was cooled to 34°C and treated with calf rennet in the amount of 0.15 ml/kg of milk. The curd was sliced and then placed in cheese moulds lined with cheesecloth. The cheese mass was subjected to 10 kg of pressure per mould (i.e. 2.5 kg/kg of cheese) for 12 hours. The cheese blocks were weighed 12 hours after being removed from the cheese mould. The cheese yield was calculated as the ratio of the weight of the cheese to the weight of the milk it was made from, expressed as a percentage.

The proximate chemical composition of samples of bulk milk and bundz was determined. For milk, the content of dry matter, non-fat dry matter, protein, fat and lactose were determined with a MilcoScan apparatus in the laboratory of the regional dairy cooperative (OSM) in Inowrocław. For the cheese, dry matter (oven-dry method), protein (Kjeldahl method), fat (Soxhlet method), and ash (combustion method) were analysed in the laboratory of the Kołuda Wielka Experimental Station. Based on the chemical composition, the basic nutritional parameters of the cheese were calculated, i.e. the protein-to-fat ratio and gross calorific value, using physiological gross energy factors according to Rubner [29].

The results of the experiment were analysed statistically by one-way analysis of variance (ANOVA) using the STATISTICA 6 PL package, where the experimental factor was the addition of herbs in the three groups. Statistical differences between groups were verified by Duncan's test.

Results and discussion

There were no statistically confirmed differences between groups in the content of dry matter, non-fat dry matter, protein, fat or lactose, or in the protein-to-fat ratio in the raw milk used to make bundz (Table 1). The dry matter of the sheep milk had similar content of protein, fat and lactose, which did not differ statistically between feeding groups. The concentrations of basic chemical constituents of the milk during the experiment did not vary more characteristically depending on either the diet of the sheep or the period of research (Fig. 1). It should be noted that the content of dry matter in the milk from successive stages of the study was more uniform in the experimental groups, while showing more pronounced fluctuations in the milk from the control group, mainly in protein and fat content. Fluctuations in the concentrations of these constituents in the milk from successive batches did not exceed 2%.

Table 1
Chemical composition of raw milk used to make cheese

Item		Group			SEM
		I	II	III	
Number of experimental batches	n	6	6	6	
Content of chemical constituents in milk (g/100 g):					
dry matter	$\bar{x}$	20.60	20.45	20.46	0.125
	V%	3.3	1.9	2.8	
non-fat solids	$\bar{x}$	12.39	12.36	12.39	0.861
	V%	4.0	2.8	1.9	
protein	$\bar{x}$	7.04	6.96	7.02	0.094
	V%	7.4	5.2	5.2	
fat	$\bar{x}$	8.21	8.09	8.07	0.064
	V%	4.1	3.7	2.3	
lactose	$\bar{x}$	4.66	4.71	4.67	0.031
	V%	2.8	1.8	3.9	
Protein-to-fat ratio	$\bar{x}$	0.857	0.860	0.870	0.014
	V%	8.6	7.5	5.4	
Content of chemical constituents in milk dry matter (%):					
protein	$\bar{x}$	34.14	34.01	34.30	0.323
	V%	5.0	4.2	3.4	
fat	$\bar{x}$	39.85	39.55	39.45	0.278
	V%	3.8	3.3	2.1	
lactose	$\bar{x}$	22.62	23.02	22.82	0.129
	V%	2.6	2.5	2.2	

Pakulski [25], in a study on the milk of Coloured Merino sheep during winter feeding, found an increase in the content of dry matter, protein and fat, and a decrease in lactose content in successive stages of milking. Similarly, as in the present study, Lacerda et al. [22] found no influence of the experimental factor (the addition of oregano to the feed of Holstein cows and zebu) on the chemical composition of milk. Kraszewski et al. [21], on the other hand, reported an increase in fat, protein and lactose content in the milk of cows fed a 2% herbal supplement. The lack of influence of the experimental factor on the chemi-

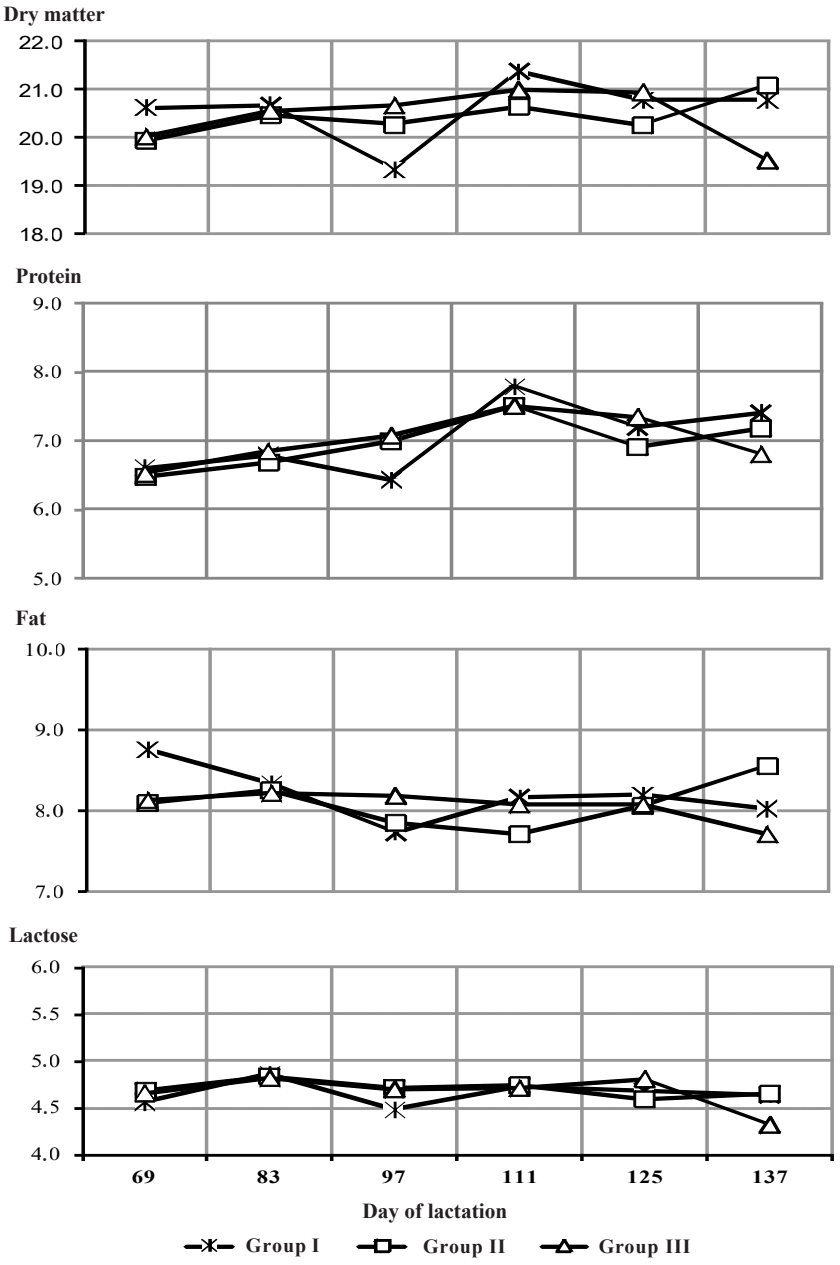

Fig. 1. Chemical composition of raw milk for cheese-making in the period from 69 to 137 days of lactation

cal composition of milk in our research, with a simultaneous increase in milk yield [12] (by 10.9% in group II and as much as 20.4% in group III, as compared to the control), which was negatively correlated with the content of protein and fat in the milk, indicates that the technological parameters of the milk (cheese yield) were not negatively affected. The raw material in our research contained more protein and less fat than in a study by Pakulski and Pakulska [27] on bulk milk from Coloured Merino ewes during an analogous winter period (protein – 6.3%, fat – 9.1%). On the other hand, Pakulski et al. [28] showed that the milk of this breed of sheep fed a summer diet had a lower content of dry matter (19.20%), protein (5.89%) and fat (7.66%), and higher content of lactose (5.13%) than in the present study. The lower concentrations of these constituents in that study [28] was due to the use of green forage rather than preserved bulky feed in the diet. The effect of the feeding season on the chemical composition of milk is also confirmed by other studies [3, 7, 26, 33]. Pakulski and Dulewicz [26] showed lower content of chemical constituents in raw milk from East Friesian ewes in the summer/autumn season than in Polish Merino ewes in the winter. It should be noted that the protein concentration in the milk in the present study was much higher than in the milk of Polish Merino and East Friesian sheep in the study cited (4.5% and 3.7% respectively). On the other hand, the dry matter of the milk in that study contained less protein (Polish Merino – 23.5%, East Frisian – 23.2%), and in the case of Polish Merino more fat (45.0%) than in our research.

The available literature contains few studies on the production of sheep milk in the winter. The vast majority of research in this field has been conducted in the summer, with pasture feeding. The raw milk obtained from the ewes in our study contained more protein and fat and thus was more valuable for cheese production than milk obtained from sheep grazed on mountain pastures [6, 9, 17, 18, 19, 23]. Konieczny [19], in a study on the milk of Polish Mountain sheep, kept in a pasture in organic farming conditions, reported higher content of fat (9.0%) and lactose (6.2%) and lower content of protein (4.1%) than in our research. As a result, this milk had a much lower protein-to-fat ratio, amounting to just 0.46. The raw milk in the present study had higher concentrations of chemical constituents than those reported by Molik et al. [23] in the milk of pasture-grazed Polish Mountain and Olkuska sheep (average dry matter 18.6%, protein 5.9% and fat 7.3%) and the milk of local Balkan breeds of sheep grazed in mountain areas in a study by Gerchev and Mihaylov [9]. These differences in milk composition were probably due to the different genotypes of the sheep and the use of different feeding systems. However, a review of the literature indicates that the milk obtained from the sheep in the present study had high content of protein and fat, and thus good potential for cheese production.

There were no statistically confirmed differences between feeding groups in the yield of cheese mass from the milk (Fig. 2). The yield of bundz rennet cheese shown in our research was much higher than that reported by Pakulski and Dulewicz [26]: 26.3% from the milk of Merino sheep and only 23.2% from the milk of East Friesian sheep. Similarly, lower bundz cheese yield was demonstrated by Pakulski et al. [28] in the summer from

the milk of Coloured Merino and East Friesian sheep and their crossbreds (29.2%, 25.8% and 24.7%, respectively), as well as by Kawęcka and Paraponiak [18] from the milk of Mountain sheep and the Bergschaft and Weisses Alpenschaf breeds (22.0%, 23.2% and 23.5%, respectively).

The differences in cheese yield may have resulted from the specificity of micro-production, in which it is difficult to maintain standard cheese production parameters. However, differences in the concentrations of the constituents of milk obtained from sheep of different breeds and in different feeding conditions may have been more significant. A high positive correlation between protein and fat content in milk and cheese yield has been demonstrated by Sevi et al. [32] and Bojanić-Rašović et al. [5]. The influence of the concentrations of chemical constituents in raw milk (sheep and sheep + cow) on cheese yield in the production of semi-hard cheeses and soft cheeses is also confirmed by other studies [4, 5, 11, 13, 14, 15]. On the other hand, research conducted by Pakulski and Dulewicz [26] and by Jarzynowska [11] has shown that apart from the influence of the chemical composition of the milk, the production technology also affects the yield of cheese mass. Jarzynowska [11] found that more cheese was produced by the acid-rennet method (curd cheese) than by the rennet method (bundz), and more cheese was produced from sheep milk than from sheep + cow milk. Pakulski and Dulewicz [26] reported greater yield in the production of bundz as compared to oscypek and semi-hard ripened cheese, and in the processing of Polish Merino milk as compared to the milk of East Friesian sheep. A comparison of our results with these literature data suggests that milk obtained from Coloured Merino in the winter was of high technological value for the production of bundz.

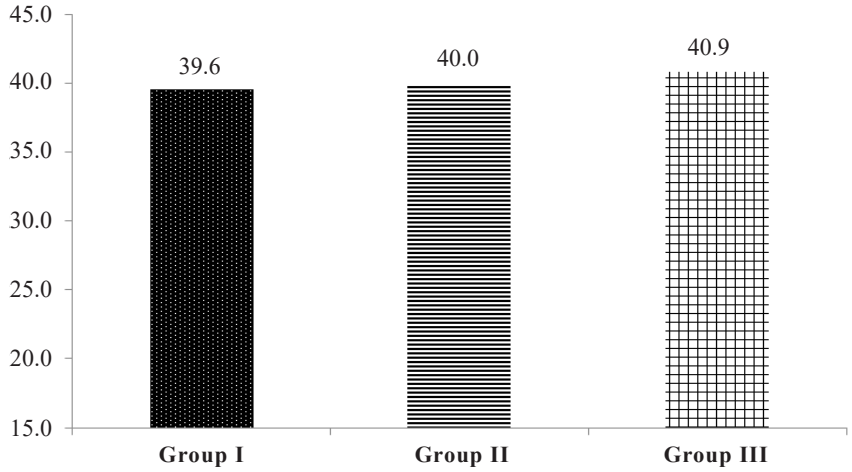

Fig. 2. Yield of bundz rennet cheese (kg/100 kg milk)

There were no large or statistically confirmed differences in the content of dry matter, non-fat dry matter, protein or fat, in the protein/fat ratio, or in the energy value of bundz obtained from the milk of different groups (Table 2). However, the experimental factor did influence the mineral content in the form of ash, which was higher in the Group III cheese than in groups I and II, by 6.1% and 6.6%, respectively (P≤0.05). The content of chemical constituents in the bundz during the course of the study is shown in Figure 3. The curves for dry matter, protein, fat and ash are similar in all feeding groups, with more pronounced fluctuations in successive batches of cheese occurring only for fat content in the first three batches. These may have due to the fact that the cheese was produced in laboratory conditions, with no standardization of production processes, and may have resulted in part from the treatment of the curd.

Table 2
Chemical composition and nutritional value of bundz cheese

Item		Group			SEM
		I	II	III	
Number of cheese batches	n	6	6	6	
Content of chemical constituents (g/100 g):					
dry matter	$\bar{x}$	36.65	36.88	37.83	0.310
	V%	3.4	4.6	1.7	
non-fat solids	$\bar{x}$	21.44	21.17	21.99	0.210
	V%	6.4	5.2	2.1	
protein	$\bar{x}$	14.85	14.66	15.24	0.158
	V%	3.5	6.5	2.5	
fat	$\bar{x}$	15.21	15.71	15.84	0.262
	V%	9.5	6.7	5.4	
ash	$\bar{x}$	2.29[b]	2.28[c]	2.43[a]	0.029
	V%	5.2	3.6	4.4	
Protein-to-fat ratio	$\bar{x}$	0.976	0.933	0.962	0.020
	V%	11.0	7.8	8.0	
Caloric value (kcal/100 g)	$\bar{x}$	213	217	221	2.413
	V%	5.8	5.2	3.0	

a, b, c – P≤0.05

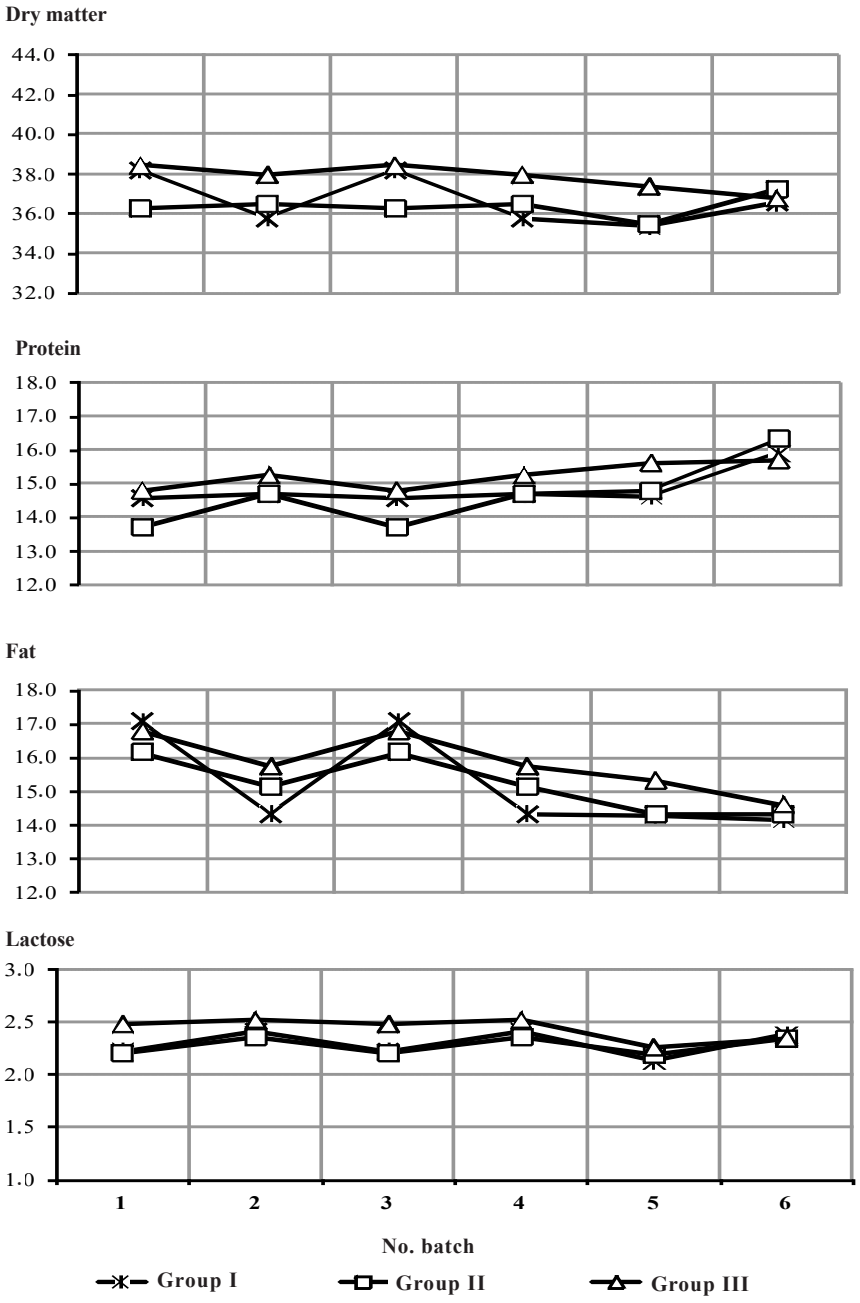

Fig. 3. Chemical composition of cheese produced in each experimental batch

The bundz produced in the present study contained a similar amount of protein and much less fat, and thus had a better protein-to-fat ratio, than bundz in the study by Pakulski and Dulewicz [26]: 15.0%, 21.2% and 0.707, respectively. Similarly, Pakulski et al. [28] found that bundz obtained in the summer from the milk of Polish Coloured Merinos and East Friesian sheep contained more fat (18.5% and 20.8% respectively) and a similar amount of protein (15.2% and 16.0% respectively), and thus had a less favourable protein--to-fat ratio (0.822 and 0.770) than in our research. Bonczar et al. [6], on the other hand, in research on the composition of bundz obtained from the milk of pasture-grazed mountain sheep, showed a higher content of protein and fat (about 21%), with a similar protein-to-fat ratio (1.009). The differences in the composition of bundz produced in our research and in the studies cited are due to differences in production technology rather than the chemical composition of the raw milk. This is confirmed by studies showing a similar composition of the same type of cheese obtained from sheep and sheep + cow milk, differing considerably in the concentrations of chemical constituents (bundz [6], ripened semi-hard cheese [13, 14]). Pakulski et al. [27] demonstrated the effect of the production technology on cheese composition, making various kinds of cheese from the milk of Polish Merinos in winter. They found that cheese that was scalded and then smoked contained the least fat (10.3%), while ripened cheese contained the most (23.3%). The lowest protein content was found in brined cheese (12.6%) and the highest in cheese that was scalded and then smoked (22.6%).

To conclude, the use of herbal additives in the diet of Coloured Polish Merino sheep in the winter did not affect the chemical composition of the raw milk and thus its technological value expressed as the yield of bundz rennet cheese. The addition of herbs in the amount of 20 g/head/day to the diet of sheep (group III) significantly increased the content of minerals in the cheese produced from their milk, by 6.1% and 6.6%, respectively ($P \leq 0.05$) in comparison to groups I and II. The experimental factor (the addition of herbs) did not affect the other parameters of the nutritional value of the cheese, i.e. the content of protein and fat, their ratio, or the energy value.

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