Nutritional and dietetic quality of milk and traditional cheese made from the milk of native breeds of sheep and goats

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ABSTRACT
Sheep and goats of native breeds provide milk rich in nutrients as a raw material for traditional products, especially cheeses available only in specific regions. The aim of this study was to evaluate the quality of the raw material for production of traditional fresh cheese (bundz) and the product itself made of milk from the Podhale Zackel sheep and Carpathian goat – both Polish breeds. The milk from the Podhale Zackels contained more than twice as much fat (7.30%, \( P \leq 0.01 \)) as milk from the Carpathian goats (2.82%) and it was richer in protein and lactose. The goat milk had twice as high a content (1.10%, \( P \leq 0.01 \)) of immunoglobulins compared to the sheep milk (0.58%). Higher levels of serum albumin (3.69%, \( P \leq 0.05 \)) and \( \beta \)-casein (58.89%, \( P \leq 0.01 \)) were determined in the Zackel milk. Podhale Zackel bundz was characterized by higher fat (24.92%, \( P \leq 0.01 \)) and protein (18.06%, \( P \leq 0.01 \)) content than the goat bundz (21.33%-fat; 16.74%-protein). In the sheep bundz, the content of CLA acid was significantly higher (2.23%, \( P \leq 0.01 \)), than in the goat bundz (0.28%). In sensory evaluation both cheeses received high marks (≥4.50) but the panellists preferred the aroma of the sheep bundz.

Introduction
Many livestock production sectors are prepared for an intensive system that is intended to produce the best possible results and highest profits. Some breeds have been bred for intensive use. Holstein Friesian cattle have been leading the way in milk yield for years, but under slightly more difficult conditions and without balanced feeding, they might not achieve such impressive results. Not all breeds perform well in an intensive farming system, therefore it is important to protect biodiversity, the preservation of which is possible thanks to the breeding of animals of native breeds, perfectly adapted to local, often difficult conditions (Kawęcka and Krupiński 2014; Krupiński et al. 2017) (Figures 1 and 2).

In Poland, 15 native breeds of sheep are covered by the genetic resource protection programme, the systematic implementation of which has contributed to an increase in their population. In 2008, ewes included in the genetic resource conservation programme accounted for about one-third of the number of ewes entered in the books, and after 10 years they accounted for about 80% of the active population (PUSF 2020). In the case of goats, the native breed of greatest importance is the Carpathian breed which, after a successful restitution process, returned to Polish breeding in 2010, constituting 7% of the population included in the performance evaluation at that time, and currently nearly 50% (PUSF 2010, 2020). Sheep and goats of native breeds provide milk rich in nutrients as a raw material for traditional products, which are often available in limited quantities and only in a specific region (Kawęcka and Sikora 2019). Regional food is becoming increasingly popular among consumers because products made according to traditional home-made recipes are perceived as tasty, original and healthy (Knyisz et al. 2018). On the List of Traditional Products maintained by the Polish Ministry of Agriculture and Rural Development, there are over 1,900 items, including 120 dairy products, among which the most numerous are cheeses made from goat milk and traditional products of mountain sheep farming (MARD data 2020). The most recognizable regional cheese is oscypek, a smoked sheep’s milk cheese which enjoys EU protection as a Protected Designation of Origin (PDO) (Commission Regulation (EC) No 127/2008), similar to byndza podhalańska and redykolka, registered under the designation of origin scheme. The production methods for these cheeses – unchanged for centuries – have been passed down from generation to generation, using traditional tools, nomenclature and customs (Kawęcka et al. 2020a). Fresh rennet cheese, bundz, produced in shepherd’s huts immediately after milking, is a very popular tasty cheese made from sheep’s milk. The taste of bundz is not constant, nor is its composition, which may vary depending on where the milk from which it was produced was taken; the tastiest bundz is that coming from sheep grazing in spring, known as May bundz (Kawęcka and Pasternak 2019). The production of goat’s bundz, like that of sheep’s bundz, dates back to Wallachian traditions of five hundred years ago. Goat bundz is mild, slightly sour with a delicate aroma of goat’s milk. Its characteristic taste comes from the diet of Carpathian goats,
which graze on meadows and pastures extensively used. In summer, they have access to areas rich in herbs and various grasses, while in winter the goats are fed on hay from mown meadows. To date, local producers make goat’s cheese according to their own procedures, using cheese-making additives to improve technological parameters and pasteurizing the milk for product safety (Reinfuss 1990)(Figures 3 and 4).

The aim of this study was to evaluate the quality of the milk from sheep and goat of native breeds from the Carpathian Mountains as a raw material for production of the traditional Polish fresh cheese bundz, and the quality of the cheese itself.

**Materials and methods**

**Milk samples**

The material for the study consisted of pooled milk samples from Podhale Zackel sheep and Carpathian goats kept in two herds (each species) in the Polish Carpathians. The animals were kept in traditional systems, with constant access to pasture from May to September. Pooled milk samples for analysis were collected in June, during the grazing season, with manual milking in the morning and evening, from two herds of Polish Zackel (about 30) and two herds of Carpathian goat (about 30). Samples of milk from the morning and evening milking were collected once a week from 4 herds, for 3 consecutive weeks of June – 12 pooled samples from each species (2 samples from 2 herds, once a week, for 3 weeks). The milk was transported in 5 liter bottles under refrigeration to the laboratory, where the milk evaluation, as well as the lab-scale cheese processing and its evaluation were performed.

**Physical and chemical analyses of the milk samples**

The following parameters were evaluated in the milk samples: density, pH, titratable acidity (°SH), rennet solidification time, chemical composition, and protein fraction composition. Density was determined using a lactodensimeter (DanLab Poland, measurement range: 1.015–1.045 g/cm³), titratable acidity using the titration method (AOAC 2006). Evaluation of pH was performed using a CP-411 Elmetron digital pH metre, equipped with ERH-111 electrode from Hydromet (Poland). The dry matter, lactose and ash were analysed according to AOAC (2006); protein – PN-EN ISO 8968-1:2014-03 (2014) and fat – PN-ISO 11870:2016-07 (2016) The separation of protein fractions was performed with SDS-PAGE gel electrophoresis. A Mini Protein 3Cell device from BIORAD was used for separation and quantitative analysis was performed using Gelscan v. 2.0 software for electrophoretic gel analysis from Kucharczyk.

**Cheese production method**

Fresh rennet cheese (bundz) was produced under laboratory conditions (laboratory of the University of Agriculture in Krakow, Poland) from pooled milk in two separate vats, according to the recipes used in the production of these cheese. The goat’s milk was pasteurized at 75°C for 15 s and then immediately cooled to the preparation temperature of 32°C. Pasteurization of goat’s milk is currently used by many producers/breeders to ensure the health safety of the obtained cheeses. In order to make up for calcium losses caused by pasteurization, the supplementation of calcium chloride (CaCl₂) was used (Pawlos et al. 2021). CaCl₂ at 0.02% and LAB (lactic acid bacteria) in lyophilized form as starter cultures, type FL-
DAN, made by CHr Hansen, were added to the goat’s milk. The sheep’s bundz was made using traditional methods, without pasteurizing the milk or using calcium chloride. LAB starters were added to the goat milk (32°C). After 30 min of incubation, Fromase 2200 TL rennet in 1:1000 solution (DSM France) was added to both the kind of milk at 32°C. Then, after 45 min at 32°C the curds were obtained from both kinds of milk. The curds were cut into grains of 3-6 mm and the mixture was stirred for 10 min. The whey was subsequently drained and the grains were dried for 5 min. After that, the dried grains were placed into perforated stainless steel moulds and allowed to drain for 24 h in the laboratory conditions (18°C). The cheese samples were analysed the day after (24 h).

Chemical analysis of the cheese

The total protein content was determined by the Kjeldahl method, total lipid content by the Soxhlet method, water content by drying the sample at 102°C for 4 h, and the total ash content using the method of incineration of the sample at 550°C. The content of vitamin A and E was determined using the reversed-phase HPLC method (SOP M.001 method – Standard Operation Procedure, M – the number of the procedure at the Central Laboratory of the NRIAP). The method of flame atomic absorption (SOP M.008c) was adopted to determine the levels of calcium, magnesium, sodium and potassium in the milk and dairy products. The separation and determination of fatty acids were performed in a VARIAN 3400 gas chromatograph using a Flame Ionization Detector (FID), and a RTX 2330 capillary column (105 m x 0.32 mm x 0.2 μm). The analysis conditions were: the column programming temperature within the range of 140–210°C, injector port temperature: 250°C, carrier gas: helium (flow: 3 mL/min), the injection 0.7 mL. For CLA determination, the acids standards of Sigma-Aldrich (C24 #18,919-1AMP; Sigma-Aldrich). Other fatty acids were determined by comparing with Sigma-Aldrich standards (Supelco FAME mixC4–C24 #18,919-1AMP; Sigma-Aldrich).

Statistical analysis

The results were statistically analysed with the use of STATISTICA package, v. 13.1, 1984–2016 Dell Indust. (StatSoft Poland, https://www.statsoft.pl/statistica_13/) and One-Way ANOVA (‘analysis of variance’), distinguishing the animal species as the source of variation. The significance of the differences was estimated using the Duncan test. Testing was carried out at the significance level p ≤ 0.05 and p ≤ 0.01.

Sensory evaluation

Bundz was evaluated for various sensory attributes: appearance, texture, aroma and flavour – specific for sheep/goat cheese – according to the method of PN-ISO 4121:1998. A 5-point grading scale (1 = lowest to 5 = highest) was used: 1 – very undesirable, 5 – very desirable, typical for cheese. The sensory panel consisted of six members trained in sensory profiling – to distinguish and evaluate analysed cheese features: researchers consuming cheeses twice a week. The cheese temperature was adjusted to 10°C and the room temperature was 22°C. The number of samples analysed: 12 samples of cheese from each species.

Results

Table 1 presents the chemical composition and physical characteristics of the milk from the Podhale Zackels and Carpathian goats. The Sheep milk was characterized by 18.8% dry matter, 7.30% fat, 5.74% protein and 4.86% lactose. The value of the all the aforementioned parameters differed significantly from the values obtained for the Carpathian goats, whose milk showed almost half lower dry matter content – 10.99%, over 2.5 lower fat content – 2.82%, twice lower protein content – 2.88%, and lower lactose content – 4.43% (Table 1). The physical characteristics of milk from the Podhale Zackels and Carpathian goats also differed significantly. The sheep milk had higher density and pH. The biggest difference was found in the case of acidity, which was 8.6°SH for the Podhale Zackel milk and 4.98°SH for the Carpathian goat milk. There was no significant difference in ash content (Table 1).

Table 2 shows the composition of the protein fractions of the studied milk. Significant differences were found between the goat and sheep milk in all protein fractions, except lactoferrin. The goat milk was characterized by twice higher immunoglobulin content (1.10%) than the sheep milk (0.58%). The level of serum albumin was higher in the milk of Podhale Zackels (3.69%) than in the milk of Carpathian goats (2.62%), similarly to the level of β-casein, which was 58.89% in the sheep and 42.37% in the goats (Table 2). The content of other fractions was higher in the Carpathian goats, whose milk was characterized by twice higher α-casein content (12.71%) than that of the Zackels (6.54%), as well as more than twice higher α-lactoglobulin and three times higher peptide levels. The content of κ-

| Parameters          | Sheep   | Goat    |
|---------------------|---------|---------|
| Dry matter, %       | 18.80A ± 0.09 | 10.99B ± 0.11 |
| Fat, %              | 7.30A ± 0.19   | 2.82A ± 0.12   |
| Protein, %          | 5.74A ± 0.19   | 2.88B ± 0.05   |
| Ash, %              | 0.90 ± 0.01    | 0.86 ± 0.11    |
| Lactose, %          | 4.86A ± 0.14   | 4.43 ± 0.20    |
| Density, g/cm3      | 1.04A ± 0.00   | 1.03A ± 0.00   |
| pH                  | 6.79A ± 0.05   | 6.70 ± 0.02   |
| Acidity, °SH        | 8.60A ± 0.31   | 4.98B ± 0.16   |
| A, B – P ≤ 0.01; a, b – P ≤ 0.05 – means in rows and denoted using different letters differ significantly. |

| Fraction              | Sheep   | Goat    |
|-----------------------|---------|---------|
| Immunoglobulin        | 0.58A ± 0.31 | 1.10A ± 0.36  |
| Lactoferrin           | 2.45 ± 0.96  | 2.46 ± 0.40   |
| Serum albumina        | 3.69A ± 1.21 | 2.62B ± 0.52  |
| o-lactalbumin         | 3.42A ± 1.25 | 8.108 ± 1.19  |
| β-lactoglobulin       | 11.98A ± 1.34 | 14.17B ± 1.31|
| o-casein (Alpha S1)   | 6.54A ± 1.86 | 12.71B ± 1.99 |
| β- casein             | 58.89A ± 1.34 | 42.37 ± 3.38  |
| κ- casein             | 11.67A ± 0.40 | 13.96B ± 1.19 |
| Peptides              | 0.78A ± 0.24  | 2.52B ± 0.68   |
| A, B – P ≤ 0.01; a, b – P ≤ 0.05 – means in rows and denoted using different letters differ significantly. |
casein and β-lactoglobulin was also found to be significantly higher in the goat milk than in the sheep milk (Table 2).

The results of the analysis of the chemical composition of bundz produced from the sheep and goat milk are presented in Table 3. The composition of the sheep cheese differed significantly from the goat cheese with respect to all studied parameters except for ash, vitamin A and vitamin E content (Table 3). Dry matter content was, as in the case of milk, higher in the sheep bundz (47.85%) than in the goat bundz (40.26%). Cheese made from the sheep milk was also characterized by a higher level of fat – 24.92%, and protein – 18.06% than cheese made from the goat milk, which contained 21.33% and 16.74% of these components, respectively. The level of carbohydrates was four times lower in cheese made from the milk of the Carpathian goats (0.72%) than in the cheese made from the milk of the Podhale Zackels (2.99%). As regards the content of macronutrients, the sheep bundz was characterized by a significantly lower content of calcium, magnesium, and potassium than the goat bundz (Table 3).

Table 3 shows the fatty acid profile of the studied cheeses, which differed significantly species. Only for arachidic acid (C20:0) the difference was not statistically significant. Significantly higher content of saturated fatty acids (C8:0, C10:0, C12:0, C14:0, C16:0, C18:0) was found in the goat cheese as compared to the sheep cheese. The greatest difference in the content of these fatty acids was found in the case of caprylic acid (C8:0), whose level was more than 2.5 times higher in the goat cheese than in the sheep cheese. The level of monounsaturated oleic acid (C18:1) was also higher, being 20.63% in the sheep bundz and 23.60% in the goat bundz. The sheep cheese was characterized by a significantly higher content of di-unsaturated acid (C16:1) and tri-unsaturated α- and linolenic acids (C18:3-n3 and C18:3-n6 respectively). A relatively large difference was also observed in the level of conjugated linoleic acid CLA, which in the goat cheese was 0.28%, while it was almost 8 times higher in the sheep cheese – 2.28% (Table 4).

Table 4 shows the sensory evaluation of the Polish Zackel and Carpathian goat cheese. Almost all parameters were highly rated (≥4.50) – only the aroma of the goat bundz was scored lower (4.0), which was the lowest score in the entire panel. The score of the sheep cheese aroma was 4.70 and it differed significantly from the goat cheese (Table 5). The evaluation of the sheep cheese was generally higher, although the other parameters (except for aroma) did not differ significantly.

### Discussion
Sheep and goat milk and products made from them are considered healthy and very valuable in terms of important nutrients. The milk of these species is suitable for the production of a whole range of dairy products (Pandya and Ghodke 2007), especially cheeses, both fresh and matured. Goat milk may be an alternative for people suffering from food allergies as it contains less casein than cow milk, which is responsible for about 60% of allergic reactions associated with milk consumption (Ballabio et al. 2011; Hochwallner et al. 2014; Kawęcka and Sikora 2019). Milk from the Podhale Zackels and Carpathian goats differed significantly in terms of composition. The high concentration of dry matter is characteristic of sheep milk and varies, among other things, depending on the month of lactation, as does the content of other nutrients (Kawęcka et al. 2020a). In our study, the content of dry matter in the milk of the Podhale Zackels was 18.8% and coincided with the results of other authors (Paciorek and Bonczar 2001). The Podhale Zackel milk also had a high fat content (7.3%), similar to the milk studied by Merlin Junior et al. (2015), which contained 7.28% fat. This level was significantly higher than in the Carpathian goats (8.28%) whose milk contained slightly less fat than the milk of goats described by other authors (3.1–4.2%) (Ferro et al. 2017; Paszczyk et al. 2019). Adequate levels of fat in human consumption are important, as it is a carrier of numerous nutrients such as vitamins A, D, E and K (Albahran and Greaves 2016; Molik and Kordeczka 2020). Protein content was twice as high in the sheep milk, at 5.74%, than in the goat milk, at 2.88%, similar to Jandal

### Table 3. Chemical composition of goat's and sheep's cheese (mean ± standard deviation).

| Chemical composition | Sheep     | Goat     |
|----------------------|-----------|----------|
| Dry matter, %        | 47.85 ± 0.19 | 40.26 ± 0.23 |
| Fat, %               | 24.92 ± 0.21 | 21.33 ± 0.12 |
| Protein, %           | 18.06 ± 0.11 | 16.74 ± 0.11 |
| Ash, %               | 1.89 ± 0.04 | 1.83 ± 0.16 |
| Carbohydrates, g/100 g | 2.99 ± 0.11 | 0.72 ± 0.02 |
| Ca, g/kg             | 5.48 ± 0.15 | 7.17 ± 0.42 |
| Mg, g/kg             | 0.26 ± 0.01 | 0.34 ± 0.01 |
| K, g/kg              | 0.90 ± 0.03 | 2.12 ± 0.034 |
| Vit A, µg/g          | 2.28 ± 0.21 | 2.54 ± 0.24 |
| Vit E, µg/g          | 6.47 ± 0.97 | 5.16 ± 0.54 |

A, B – P ≤ 0.01; a, b – P ≤ 0.05 – means in rows and denoted using different letters differ significantly.

### Table 4. Fatty acid profile of sheep's and goat's cheese (%) (mean ± standard deviation).

| Fatty acids      | Sheep     | Goat     |
|------------------|-----------|----------|
| C8:o Caprylic acid | 1.73 ± 0.08 | 4.59 ± 0.04 |
| C10:o Capric acid  | 5.13 ± 0.13 | 9.35 ± 0.05 |
| C12:o Lauric acid  | 2.92 ± 0.09 | 3.95 ± 0.02 |
| C14:o Myristic acid | 10.38 ± 0.31 | 11.82 ± 0.05 |
| C16:o Palmitic acid | 26.36 ± 0.41 | 29.80 ± 0.03 |
| C16:1 Palmitoleic acid | 0.70 ± 0.01 | 0.60 ± 0.01 |
| C18:o Stearic acid  | 11.36 ± 0.03 | 12.22 ± 0.04 |
| C18:1 Oleic acid    | 20.63 ± 0.50 | 23.60 ± 0.04 |
| C18:2 Linoleic acid  | 2.05 ± 0.03 | 1.99 ± 0.01 |
| C18:3 α-Linolenic acid | 0.04 ± 0.01 | 0.03 ± 0.00 |
| CLA Conjugated linoleic acids | 2.23 ± 0.02 | 0.28 ± 0.01 |

A, B – P ≤ 0.01; a, b – P ≤ 0.05 – means in rows and denoted using different letters differ significantly.

### Table 5. Sensory evaluation of sheep's and goat's cheese*.

| Characteristics | Sheep     | Goat     |
|-----------------|-----------|----------|
| Appearance      | 4.70 ± 0.48 | 4.50 ± 0.53 |
| Texture         | 4.70 ± 0.48 | 4.50 ± 0.53 |
| Aroma           | 4.70 ± 0.48a | 4.00 ± 0.67a |
| Flavour         | 4.70 ± 0.48 | 4.70 ± 0.48 |

a, b – P ≤ 0.05 – means in rows and denoted using different letters differ significantly.

* 5-point grading scale (1 = lowest to 5 = highest) was used: 1 – very undesirable, 5 – very desirable, typical for cheese.
(1996) summary with 6.21% and 2.9%, respectively. The level of lactose in the studied milk of the Carpathian goats (4.43%) was comparable to that determined by Barłowska et al. (2013) in the breedless goats (4.39%), whereas the lactose content in the studied milk of Zackels, amounting to 4.86%, was slightly higher than the average content of this component determined by Ptasińska (2011) in Polish mountain sheep – 4.52%. On the other hand, the acidity of sheep milk was slightly lower in our study (8.60°SH) than in the study of the aforementioned author (9.15°SH). The density and pH of the Zackel milk of 1.04 g/cm³ and 6.79 were very similar to the results of 1.034 g/cm³ and 6.76 achieved by Lacaune dairy sheep (Merlin Junior et al. 2015).

Protein fractional composition is an important parameter of milk, especially in terms of whey protein content, which accounts for about 20-25% of all milk proteins. About 3/4 of cow whey proteins are albumins: α-lactalbumin (α-LA), β-lactoglobulin (β-LG) and bovine serum albumin (Król et al. 2008). Caseins constituted 77.1% in the studied milk of the Podhale Zackels, and 69.04% in the milk of the Carpathian goats; in both cases the highest level of β-casein was determined. Fatihov and Haertdinov (2017) determined a slightly higher level of caseins – 76.7% in Saanen goats, which is a typical dairy breed. Lower content of α-casein (Alpha S1), a frequent cause of food allergy, was determined in the milk of the Carpathian goats, compared to goats studied by the foregoing authors, which indicates that it is an individual feature, probably dependent on breed. The content of Alpha S1 (12.71%) corresponded to the range declared by Strzalkowska et al. (2013) for goat milk, which was 0-20%. An even lower level of α-casein was determined in the milk of Podhale Zackels (6.54%), constituting a large difference compared to the concentration of this component in cow milk (25.5%) (Fatihov and Haertdinov 2017). Our own results are very similar to Balthazar et al.’s (2017), who defined the proximate Alpha S1 content in sheep milk as 6.7%. Albumins in sheep milk totalled 19.9%, whereas in the Carpathian goats the level was higher at 24.89%, which corresponds to the level described by Król and Brodzia (2015). Higher levels of α-lactalbumin and β-lactoglobulin were noted in Carpathian goat milk than in Podhale Zackel milk. α-lactalbumin is a carrier of calcium in the body and also shows anti-carcinogenic and supportive properties in stressful situations (Layman et al. 2018). Similar properties are demonstrated by β-lactoglobulin which, although being a potential allergenic component, is a carrier of retinol and long-chain fatty acids and expresses antiviral and antioxidant activity (Kontopidis et al. 2004). In recent years, human organisms have been observed to be more susceptible to the allergenic effects of casein than whey proteins (Natale et al. 2004; Pastuszka et al. 2016). It is also noteworthy that twice higher levels of immunoglobulins were determined in the milk of the Carpathian goats than in the milk of the Zackels. This proves its valuable health-promoting properties, as immunoglobulins participate, among others, in the destruction of pathogenic microorganisms, such as fungi and bacteria (El-loly 2007).

Sheep and goat cheeses are much valued products, both because of the tradition of their production and palatability, as well as their valuable nutritional properties (Kawęcka and Pasternak 2019; Kawęcka et al. 2020b). In addition to oscypek, fresh bundz is an equally well-known and popular sheep cheese, although sheep milk is also excellent for processing into hard maturating cheeses (Danków and Pikul 2011). On the other hand, goat milk is most often used for the production of fresh acid and rennet cheeses, cottage cheese, brine cheese, and hard and semi-hard cheeses, including maturating cheeses (Kawęcka and Sikora 2019). The chemical composition of milk and its suitability for further processing depends on the species of animal, but there are more influencing factors such as breed, month of milking, stage of lactation and nutrition (Kawęcka et al. 2020a; Molik and Kordeczka 2020). Apart from factors affecting milk composition, the properties of cheese can also be influenced by the production technology (Kawęcka et al. 2020b).

The analysis of fresh cheeses made from the milk of Podhale Zackel and Carpathian goats showed that the content of basic components such as dry matter, protein and fat was higher in the sheep cheese than in the goat cheese, according to the results obtained in the analysis of the studied milk. The dry matter content of fresh sheep bundz was 47.85%, similar to 45.11% and 46.26% (Kawęcka and Pasternak 2019). The dry matter content of the goat bundz, 40.26%, was lower than the level determined in the Podkarpacki goat cheese by Kawęcka et al. (2020b) – 44.01%, and higher than in the fresh cheese from Carpathian goat milk – 37.39%, studied in another experiment (Kawęcka and Sikora 2019). Herrera et al. (2010) reported a relatively high range of 44.9-47.2% dry matter content in cheeses made from the milk of goats of different breeds. Janśtová et al. (2010) also determined a high level of dry matter in the studied goat cheeses at 46.83%. The fat level in the studied bundz originating from the Podhale Zackels was higher – at 24.92%, than in the bundz studied by Bonczar et al. (2009), produced from pooled milk samples of Polish mountain sheep – 20.66%, and slightly lower than in own earlier studies of bundz from the milk of mountain sheep originating from two different shepherd’s huts – 29% and 26.33% (Kawęcka and Pasternak 2019). The fat was within the range reported for sheep bundz by Kudelka (2014) at 23–27%. The study Jarzynowska and Peter (2018a) showed a lower fat content in bundz from the milk of Koludzka sheep – 15.21% and Coloured Polish Merino Sheep – 16.9% (Jarzynowska and Peter 2018b). The fat content of the studied cheese from the milk of Carpathian goats was higher (21.33%) than in other mentioned (18.68% and 19.4%) (Kawęcka and Sikora 2019; Kawęcka et al. 2020b). On the other hand, cheese from milk of hybrid Saanen and Alpine goats in a study by Medeiros et al. (2014), was characterized by a higher fat content, at 23.35%. Barłowska et al. (2018) showed that cheeses from goats grazing in mountain regions have more dry matter and protein in their composition. The protein content of 18.06% in bundz from Zackel milk was higher than in previous own studies, where it was 15.70% and 16.45% (Kawęcka and Pasternak 2019), respectively, and was higher than that shown by Ochrem et al. (2017), who studied the composition of cheeses from the Podhale region and determined the protein content in bundz to be 15.72%. A higher protein content in bundz from Polish mountain sheep milk – 20.79% – was determined by Bonczar et al. (2009).
Analysing the foregoing data, it is possible to notice a variation in the content of basic components in cheese from the same breed, but on different pastures.

Macroelements and vitamins – including calcium, magnesium, potassium and vitamin A and E – which play an important role in the proper growth and functioning of the body, are important components of cheese. Although hard cheeses are characterized by a higher content of some elements (Kawęcka et al. 2020b), it can be concluded that in the studied cheeses from the milk of the Podhale Zackels and Carpathian goats, their content was also of interest. The content of Ca, Mg and K in sheep bundz was 5.48, 0.26 and 0.90 g/kg, respectively, whereas the level of calcium in oszypek made from the milk of Polish mountain sheep was higher and amounted to 9.4 g/kg. A higher calcium content of 7.17 g/kg and more than twice the potassium content than in bundz from the Zackel milk were determined in the Carpathian goat bundz. The content of Mg and K in the oszypek was slightly lower than in the bundz – at 0.39 and 0.64 g/kg, respectively (Kawęcka et al. 2020b). Vitamin A and E levels were similar in both types of cheese, similar to Kawęcka et al. (2020b), with goat cheese having a slightly higher vitamin A content and a slightly lower vitamin E content than sheep cheese. The opposite results were presented by Milewski et al. (2016), where vitamin A levels in goat cheese were almost twice as low as in sheep cheese. There were noticeable differences in vitamin E content when comparing own results – where the level was 6.47 μg/g in sheep cheese, and 5.16 μg/g in goat cheese – with the results of Milewski et al. (2016) – at 2.41 and 2.27 μg/g, respectively. The mineral and vitamin content of goat milk, into their cheese, depends on the season, stage of lactation and somatic cell count (Strzalkowska et al. 2008; Mestawet et al. 2012).

Sheep and goat milk were characterized by different fatty acid profiles. C14:0, C16:0 and C18:0 acids were predominant in the cheeses from both species, similarly to sheep and goat cheeses studied by Paszczyk et al. (2020). The conducted studies showed higher levels of C8:0, C10:0, C12:0, C14:0, C16:0, and C18:0 saturated fatty acids in goat bundz than sheep bundz, similar to the aforementioned authors (Paszczyk et al. 2020). High levels of C12:0, C14:0 and C16:0 acids are not desirable because of their adverse effects on the human cardiovascular system (Zwierzchowski et al. 2011; Givens 2012). However, it should be added that a higher content of monounsaturated oleic acid (C18:1), showing hypolipidemic effects – lowering the level of LDL fraction and the amount of total cholesterol, has been observed in goat bundz. Analyses of cheese made from the milk of Kołudzka sheep (Jarzynowska and Peter 2018a) showed a very similar content of C8:0, C10:0 and C14:0 acids to their content in bundz from the Zackel milk. The level of C12:0 (2.92%) and C16:0 (26.36%) acid was lower (3.54%) and (28.98%), while the content of C16:0 (11.36%) acid was much higher than the level shown by the aforementioned authors (7.44%). In their studies, Bonczar et al. (2009) showed twice the content of C8:0, C10:0 and C12:0 acids, and C16:0 acid content similar to the level in bundz from Zackel milk. However, C18:1 acid levels were significantly higher than in the study of these authors, as were the C18:2, C18:3 and CLA contents. In the goat bundz, C8:0 acid levels were twice as high as in the cheese studied by Medeiros et al. (2014). In contrast, the results of these authors reported a higher C18:2 content. The content of acids such as C10:0, C14:0, C16:0 and C18:0 was slightly higher, while the content of C12:0 and C18:1 was lower in the goat bundz tested in this study. Zackel milk bundz contained almost 8 times more CLA acid than goat milk bundz. CLA linoleic acid dienes exhibit exceptional antioxidant, anti-atherosclerotic and antineoplastic properties, in addition to stimulating the immune system. The CLA trans-10, cis-12 isomer counteracts obesity and reduces the risk of type 2 diabetes (Kowalska and Cichosz 2013).

The results of sensory evaluation of Polish Zackel and Carpathian bundz showed that the products were tasty and highly appreciated (≥4.50). There are many factors affecting sensory features of cheeses, such as the type of feed (composition of pasture, hay) or stage of lactation (Park et al. 2017) but also the breed, which has a significant influence on the physicochemical and sensory properties of sheep and goat cheese (Fresno et al. 2020; Fernández et al. 2021). The score of the Podhale Zackel's cheese aroma was significantly higher than the Carpathian goat’s, which was characterized by the respondents as a specific odour, originating from goats (‘goaty’). The difference between the sheep and goat cheese aroma was probably due to the significantly higher content of caprylic and capric acid in goat than in sheep bundz, which agree with the results described by other authors (Queiroga et al. 2013; Kawęcka et al. 2020b). Queiroga et al. (2013) related sensory evaluation with the fatty acids profile analysis and found that the goat cheeses showed higher contents of short-chain fatty acids (caproic, caprylic and capric) than the cheese made of mixed or cow’s milk. Traditional cheeses, due to their local origin, the raw material from which they are made and the unchanged recipe, often have characteristic sensory qualities. Boudalia et al. (2020), who studied the chemical composition and sensory features of the Algerian cheese ‘Bouhezza’ prepared with raw cow, goat and sheep milk showed that the sensory acceptance of sheep and goat cheese were lower and the cheese made of cow milk achieved the highest score. According to Filipczak-Fiutak et al. (2021), traditionally smoked cheeses made from goat, sheep and cow milk produced at different conditions did not differ in the organoleptic evaluation which – according to the authors – was the result of the smoking process, which positively influences the organoleptic quality of goat and sheep cheeses, the taste and smell of which are often unacceptable to some consumers.

Conclusions

Dairy products from native breeds are valued on the food market and usually only available locally because they are not mass produced. The tested milk and traditional fresh rennet cheese differed in most of the compared parameters. In terms of composition, milk from the Podhale Zackel sheep contained more than twice as much fat as milk from the Carpathian goats and was richer in both protein and lactose. Both the sheep and goat milk had a favourable composition of protein fractions, while the Carpathian goat milk had twice as high a content of immunoglobulins important for human health.
(destroying pathogenic microorganisms) compared to the sheep milk. Higher levels of serum albumin and β-casein were determined in the Podhale Zakiel milk. The sheep and goat bundz, similarly to milk, differed significantly with regard to the studied parameters. Cheese made from the milk of the Podhale Zakiel was characterized by higher fat and protein content than cheese made from the milk of the Carpathian goats. The differences between the species concerned all fatty acids. High content of CLA, which is valuable for the body, was found in bundz from the Zakiel milk, at several times higher than in cheese from the Carpathian goat milk. The results of the sensory evaluation indicated the high quality of Polish traditional fresh cheeses. Sheep and goat bundz scored high marks (≥4.5) for all the analysed features, but for some panellists, the aroma of the goat bundz was too ‘goaty’, which is specific for products made goat milk.

Traditional products are unique because of their origin and the quality of the raw material (milk) from which they are made. In the past, cheeses were made from the milk of the easiest species to keep in harsh environmental conditions, and in mountainous regions, usually small ruminants such as sheep and goats, on natural pastures. For this reason, traditional cheeses are characterized by a specific smell and taste, reflecting the sensory qualities of milk obtained from a given species. The taste and aroma of goat’s and sheep’s traditional cheeses do not necessarily suit all consumers but, among other things, thanks to its unique features, the product can be recognizable and appreciated by the cheese connoisseur.

Disclosure statement
No potential conflict of interest was reported by the author(s).

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