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# Basic chemical composition, casein content and energy value of the milk of cows of the Polish Red, White-Backed and Simmental breeds, taking into account their daily yield

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**Basic chemical composition (protein, fat, lactose and dry matter), casein content and energy value were assessed in 972 milk samples from 172 cows of three breeds: Polish Red (324), White-Backed (334) and Simmental (314). The results were analysed with respect to daily milk yield, distinguishing three groups in each breed: <10.0, 10.0-20.0 and >20.0 kg. The milk obtained from cows with yield of <10.0 kg had significantly higher protein content (3.78%) than the other two groups, i.e. 10.0-20.0 kg milk yield (3.48%) and >20.0 kg (3.22%). Higher (P≤0.01) casein content and fat content (2.48% and 4.51%) were also noted in the milk of the cows with daily yield <10.0 kg than in the other two groups, in which the content of these components was very similar (casein 2.59% and 2.54%, and fat 4.27% and 4.14%). The reverse tendency was noted for lactose content, which increased with daily milk yield. The energy value of 1 kg of milk in the case of yield <10.0 kg was about 7% higher than in the milk from group III cows (with yield >20.0 kg), with the smallest differences noted for the milk of the Simmental cows (3.9%), compared to the Polish Red and White-Backed breeds (7.7% and 8.3%).**

**KEY WORDS: local breeds cows / milk / chemical composition / energy value**

Milk and dairy products have an important role in the human diet, and their share in the daily menu is an important criterion in assessment of nutrition in various population groups. The nutritional value of milk is mainly determined by the content of basic chemical components, particularly high-value proteins and easily assimilated fat, as well as important vitamins and mineral salts [4, 5]. The quantitatively dominant protein in cow's milk, playing a significant role in the dairy processing industry, is casein. Its content in

cow milk usually ranges from 2.4% to 2.8% and accounts for 75-80% of the total pool of proteins [2].

Significant achievements in biotechnology in the 20th century, particularly progress in reproductive technology (such as artificial insemination and embryo transfer), have eliminated natural limitations in the rapid transfer of high-yield breeds across distances. This has directly contributed to displacement of local breeds, which are usually characterized by markedly lower performance [12].

As native breeds of animals are characteristic for a given region or country, they are exceptionally well adapted to local environmental conditions. They also constitute an important element of local traditions, playing a significant role in the preservation of cultural heritage [12]. Milk obtained from local breeds of cows usually has higher nutritional value (higher content of health-promoting components, such as whey proteins or CLA), and is also more suitable for processing, and particularly for production of brand-name ripened cheeses [8, 9, 12, 13].

Native breeds of cattle are usually raised on low-input farms (also referred to as conventional or extensive), which are generally characterized by lower stocking density, a high proportion of permanent grassland, a low level of mineral fertilization, and low consumption of concentrate feeds [7]. Cows on these farms produce milk mainly from bulky feed (not always of the best quality), and therefore their daily yield falls below 10 kg of milk [6, 14], and dairy farmers are faced with the question of whether to continue milking these cows (with yield of 5-9 kg) or to dry them out.

The objective of the study was to analyse the chemical composition (including casein content) of milk obtained from three breeds of cow, including two native breeds (Polish Red and White-Backed) and the Simmental breed, taking into account their daily yield.

## Material and methods

The material for the study consisted of 972 milk samples collected from 172 cows of three breeds: Polish Red (57 cows, 324 samples), White-Backed (56 cows, 334 samples) and Simmental (59 cows, 314 samples). The Polish Red cows were kept on five farms in the Lower Beskid region, the White-Backed on four farms in eastern Poland, and the Simmentals on four farms in the Bieszczady region. All herds were subject to use value assessment for dairy cattle and met the requirements for milk production defined in European Commission regulations.

All of the farms included in the study were low-input farms dominated by permanent grassland. The cows were housed in tie-stall barns and their diet was based on on-farm fodder. In the spring/summer season (May-August) the diet was based on pasture forage with hay, and in the autumn/winter season (September-March) on haylage and hay. In addition, on seven of the farms the cows received maize silage. The feed ration was supplemented with concentrate feed. Direct-to-can milking was used on three farms with Polish Red cows and two with White-Backed cows, and pipeline milking on the others.

The milk samples were collected individually from each cow, from a complete milking procedure during control milking (AT4 method), twice a year (in the spring/summer and autumn/winter seasons. Samples from cows with diseased udders were eliminated. Proximate chemical composition was determined in each milk sample, i.e. content of fat, protein, lactose and dry matter, using a Bentley Infrared Milk Analyzer, and casein content according to AOAC [1]. The energy value of 1 kg of milk was calculated as well, using physiological gross energy factors according to Rubner [15].

The results were divided according to daily milk yield (three groups: under 10.0; 10.0-20.0 and over 20.0 kg) and breed (Polish Red, White-Backed and Simmental). StatSoft Inc. STATISTICA was used for the statistical computations. Two-way analysis of variance was used to determine the effect of breed and daily yield. Significance of differences between means was determined by an LSD (least significant differences) test at $P \leq 0.05$ and $P \leq 0.01$.

## Results and discussion

The results presented in Table 1 indicate significant ($P \leq 0.01$) differences in the percentage content of protein, casein, fat, lactose, and dry matter in the milk for different ranges of daily milk yield (under 10.0 kg, 10.0-20.0 kg and over 20.0 kg). The content of these components (except for lactose) increased as daily milk yield decreased. The milk obtained from the native breeds of cow with yield under 10.0 kg had significantly higher protein content (3.76%) than the other two groups, with yield of 10.0-20.0 kg (3.48%) and under 20.0 kg (3.22%). In group I (cows with yield of under 10.0 kg) significantly higher ($P \leq 0.01$) content of casein and fat was noted as well (2.84% and 4.51%, respectively) than

**Table 1**
The chemical composition of the milk of the cows of analyzed breed with respect to their daily milk yield

| Daily milk yield | n | | Protein (%) | Casein (%) | Fat (%) | Lactose (%) | Dry matter (%) |
|---|---|---|---|---|---|---|---|
| <10.0 kg | 273 | $\bar{x}$ | $3.76^{C}$ | $2.84^{B}$ | $4.51^{B}$ | $4.64^{A}$ | $13.57^{C}$ |
| | | SD | 0.63 | 0.54 | 0.76 | 0.33 | 1.00 |
| 10.0-20.0 kg | 488 | $\bar{x}$ | $3.48^{B}$ | $2.59^{A}$ | $4.27^{A}$ | $4.70^{A}$ | $13.30^{B}$ |
| | | SD | 0.55 | 0.44 | 0.71 | 0.35 | 1.04 |
| >20.0 kg | 211 | $\bar{x}$ | $3.22^{A}$ | $2.54^{A}$ | $4.14^{A}$ | $4.78^{B}$ | $13.07^{A}$ |
| | | SD | 0.46 | 0.42 | 0.64 | 0.32 | 1.02 |
| Average | 972 | $\bar{x}$ | 3.50 | 2.65 | 4.31 | 4.70 | 13.33 |
| | | SD | 0.59 | 0.48 | 0.72 | 0.34 | 1.04 |

A, B, C – differences between ranges of daily milk yield significant at $P \leq 0.01$

**Table 2**
The chemical composition of the milk of cows of each breed with respect to their daily milk yield

| Breed cows | Daily milk yield (kg) | n | Protein (%) | | Casein (%) | | Fat (%) | | Lactose (%) | | Dry matter (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| White-Backed | <10.0 | 135 | $3.61^{B}$ | 0.64 | 2.62 | 0.46 | $4.33^{B}$ | 0.79 | 4.57 | 0.28 | 13.38 | 1.10 |
| | 10.0-20.0 | 145 | $3.25^{A}$ | 0.56 | 2.52 | 0.45 | $4.14^{AB}$ | 0.67 | 4.61 | 0.30 | 13.07 | 0.94 |
| | >20.0 | 54 | $3.05^{A}$ | 0.55 | 2.57 | 0.35 | $3.91^{A}$ | 0.60 | 4.71 | 0.30 | 12.83 | 0.88 |
| Polish Red | <10.0 | 104 | $3.97^{B}$ | 0.62 | $3.00^{B}$ | 0.52 | $4.80^{B}$ | 0.64 | 4.71 | 0.39 | 12.87 | 0.77 |
| | 10.0-20.0 | 172 | $3.52^{A}$ | 0.56 | $2.58^{A}$ | 0.45 | $4.47^{A}$ | 0.65 | 4.76 | 0.35 | 13.59 | 1.03 |
| | >20.0 | 48 | $3.28^{A}$ | 0.41 | $2.50^{A}$ | 0.51 | $4.44^{A}$ | 0.46 | 4.84 | 0.44 | 13.46 | 1.02 |
| Simmental | <10.0 | 34 | $3.70^{B}$ | 0.47 | $3.17^{B}$ | 0.55 | 4.28 | 0.67 | 4.67 | 0.25 | 13.42 | 0.98 |
| | 10.0-20.0 | 171 | $3.62^{B}$ | 0.48 | $2.67^{A}$ | 0.41 | 4.18 | 0.74 | 4.72 | 0.37 | 13.21 | 1.07 |
| | >20.0 | 109 | $3.28^{A}$ | 0.42 | $2.54^{A}$ | 0.41 | 4.12 | 0.67 | 4.78 | 0.27 | 13.02 | 1.05 |

A, B – differences between ranges of daily milk yield within a breed significant at $P \leq 0.01$

in the other two groups, in which the content of these components was very similar (casein – 2.59% and 2.54%, fat – 4.27% and 4.14 %). As daily yield increased, a successive decrease in dry matter in the milk was observed in the groups: 13.57% in group I, 13.30% in group II and 13.07% in group III. The reverse tendency was noted for lactose content: as daily milk yield increased, lactose content increased as well (from 4.64% to 4.78%), but statistically significant differences (P≤0.01) were noted only between group III and the other two groups. Wójcik et al. [16] report that a decrease in mean daily yield in Polish Holstein-Friesian cows raised on an organic farm, from 28.9 kg of milk in the first three months of lactation to 13.9 kg in its final stage (months 10-12), was linked to a 0.41 p.p. increase in protein content (from 3.24% to 3.65%), a 0.24 p.p. increase in fat (from 4.20% to 4.44%) and a 0.30 p.p. increase in dry matter (from 13.0% to 13.3%). Similar relationships were reported by Januś et al. [11] in Polish Black-and-White Holstein-Friesians. A decrease in daily yield from 35.3 to 25.1 kg of milk was also associated with a significant increase in the concentration of fat (by 0.43 p.p., P≤0.05), protein (by 0.58 p.p., P≤0.01) and dry matter (by 0.98 p.p., P≤0.01) in the milk.

Analysis of the results for individual breeds (Tab. 2) revealed fewer statistically significant differences for the milk components analysed in each range of daily milk yield. For each of the three breeds the significantly (P≤0.01) highest protein content was noted when yield was less than 10.0 kg (White-Backed – 3.61%, Simmental – 3.70%, Polish Red – 3.97%). In the case of casein, significant (P≤0.01) differences for milk yield of under 10.0 kg were noted in the Simmental (3.17%) and Polish Red (3.00%) cows, and in the case of

**Table 3**
The energy value of the milk of cows of each breed with respect to their daily milk yield

| Breed cows | Daily milk yield (kg) | n | Energy value | | | |
|---|---|---|---|---|---|---|
| | | | kJ/kg | | kcal/kg | |
| | | | $\bar{x}$ | SD | $\bar{x}$ | SD |
| White-Backed | <10.0 | 135 | 3169.96$^{B}$ | 390.37 | 759.86$^{B}$ | 93.76 |
| | 10.0-20.0 | 145 | 3039.11$^{A}$ | 345.08 | 728.43$^{A}$ | 82.87 |
| | >20.0 | 54 | 2927.25$^{A}$ | 316.02 | 701.54$^{A}$ | 75.90 |
| Polish Red | <10.0 | 104 | 3446.92$^{B}$ | 311.45 | 826.33$^{B}$ | 74.78 |
| | 10.0-20.0 | 172 | 3244.17$^{A}$ | 337.00 | 777.64$^{A}$ | 80.91 |
| | >20.0 | 48 | 3202.24$^{A}$ | 248.51 | 767.55$^{A}$ | 59.63 |
| Simmental | <10.0 | 34 | 3184.74 | 314.27 | 763.37 | 75.50 |
| | 10.0-20.0 | 171 | 3139.47 | 350.07 | 752.48 | 84.08 |
| | >20.0 | 109 | 3065.03 | 298.81 | 734.60 | 71.78 |

A, B – differences between ranges of daily milk yield within a breed significant at P≤0.01

fat content, for White-Backed (4.33%) and Polish Red (4.80%). No significant differences within individual breeds were noted for content of dry matter or lactose.

The energy content of 1 kg of milk in the case of yield under 10.0 kg was on average about 7% higher than in the group III cows (with yield of over 20.0 kg) – Table 3. The smallest differences in this regard were noted for the milk of the Simmental cows (3.9%), and the greatest for Polish Red and White-Backed (7.7% and 8.3%). Barłowska et al. [3] report that an increase in daily milk yield from about 20 to 30 kg in Polish Black-and-Red Holstein-Friesian and Simmental cows was linked to a significant reduction in the content of non-fat dry matter, including protein and casein, while in Montbéliarde cows no such correlation was observed. Januś and Borkowska [10] report that, as in the present study, the breed of cow significantly influenced the calorific value of milk at various daily yields. This difference for Polish Holstein-Friesians with milk yield up to 20 kg and over 30 kg was 8.5%, but only 2.7% for the Montbéliarde breed.

To sum up, the milk produced by cows of native breeds with daily yield of under 10 kg is an excellent material for processing, e.g. for cheese production, due to its high concentration of protein (3.80%), including casein (2.84%). The most valuable milk in this regard was that of the Polish Red cows.

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