

ANTIOXIDANT CAPACITY OF MILK, CHEESE AND WHEY FROM COWS RAISED IN MOUNTAINOUS AREAS

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Abstract

The aim of the study was to determine the level of antioxidants in milk, cottage cheese and whey from cows kept on a family farm in Orava. The fatty acid (FA) profile in raw milk, cheese and whey was also assessed, as it is of major importance in shaping the antioxidant capacity of products obtained from them. Antioxidant capacity was determined using the TEAC (Trolox Equivalent Antioxidant Capacity) method based on spectrophotometric measurement of the quenching of ABTS radicals by antioxidants contained in the sample at a wavelength of 734 nm. The fatty acid profile was analysed using a Trace GC Ultra gas chromatograph. The analysis included the contents of fatty acids with hypocholesterolemic (DFA) and hypercholesterolemic (OFA) effects, and the atherogenic index (AI) was calculated. The antioxidant capacity of raw milk was markedly higher than the antioxidant activity of cottage cheese and whey. Milk obtained from cows raised in the mountainous Orava region had higher TEAC values than those reported in the literature for milk from cows from other regions of Poland. During the pasture season, milk, cheese and whey had significantly higher ($P < 0.05$) proportions of health-promoting monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), as well as higher contents of conjugated linoleic acid (CLA) and α -linolenic acid (C18:3 n-3). Significantly higher ($P < 0.05$) levels of desirable hypocholesterolemic fatty acids (DFA) were found in milk and its products in summer. Milk, cottage cheese and whey obtained in summer also had the lowest atherogenic index (AI), with significant differences compared with the winter period.

Keywords: cow's milk, cottage cheese, whey, antioxidants, fatty acids

Introduction

Milk and dairy products, especially those obtained from animals of local breeds, are a valuable source of functional food because they are produced naturally, under specific conditions and from animals fed particular feeds (Bochenek and Kuczyńska, 2017; Barłowska et al., 2016; Krzęcio-Nieczyporuk and Antosik, 2015; Dopieralska et al., 2020). Consumer interest in dairy

products from mountainous areas has recently increased; such products are regarded as being of the highest quality due to both their specific sensory properties and their excellent nutritional and health-promoting value (Magan et al., 2021). Pasture grazing is the main and least expensive feeding strategy for improving animal health and the milk fatty acid profile and for reducing methane production (Kholif and Olafadehan, 2022; Rodríguez-Bermúdez et al., 2023). Feeding cattle with grass contributes to a marked increase in the relative amounts of beneficial fatty acids in animal products (Lopez et al., 2022). In addition to environmental and physiological factors, the fatty acid profile of milk is also affected by cow genotype (Przybylska and Kuczaj, 2024).

Antioxidants present in milk play an important role in maintaining normal body functions. Even at low concentrations, they inhibit or delay peroxidation reactions of oxidizable components. A unique property of antioxidants is their ability to donate a missing electron to a free radical before the radical removes it from another molecule that is physiologically important (Bialek and Czauderna, 2016). Free radicals can initiate peroxidation of unsaturated fatty acids and form cholesterol oxidation products. These processes damage important tissues and may contribute to many diseases of modern civilization, including cancer, atherosclerosis, diabetes, Parkinson's disease and Alzheimer's disease (Kulbacka et al., 2009; Cichosz and Cieczot, 2012). Vetter and Wendlinger (2013) demonstrated that not only major fatty acids but also various classes of bioactive fatty acids, which are valuable antioxidants, contribute to the beneficial properties of fats. They occur in the lipids of various foods, including fat-rich dairy products, particularly butter. A more favourable fatty acid profile is found in milk and dairy products from cows whose basic roughage is pasture herbage (Barłowska and Litwińczuk, 2009; Barłowska et al., 2012; Gabryszuk et al., 2013).

A unique feature of conjugated linoleic acid (CLA) in milk is its high antioxidant activity, which is approximately 100 times greater than that of α -tocopherol and is reflected in a broad spectrum of health-promoting biological effects (Molik et al., 2021). Enriching milk with beneficial fatty acids may make it a valuable source of compounds with anticancer potential (CLA and polyphenols) for human health (Kholif and Olafadehan, 2022; Lopez et al., 2022). It has been shown that feeding cattle with access to pasture significantly increases the amount of this acid in milk, from 1.5–2% in winter to 6.5–7% in the summer months (Ciołkowska et al., 2012; Gabryszuk et al., 2013; Kuczyńska et al., 2013; Żbikowski, 2015). Cifuni et al. (2022) reported that milk from mountain and upland pastures contains high levels of beneficial fatty acids, such as C18:3 n-3 and CLA, as well as terpenoids, compared with milk from lowland grasslands.

Given the important role of antioxidants in maintaining normal body functions, this study was undertaken to determine antioxidant levels in milk from cows kept on a farm in Orava and in cheeses produced from that milk. The fatty acid profile of raw milk and cottage cheese was also evaluated, because their lipid fraction is important in shaping the antioxidant capacity of the resulting products.

Materials and methods

The study material consisted of bulk milk and cottage cheese obtained from six cows of the Polish Red (RP), Polish Red-and-White (RW), HF $\times$ Montbéliarde (MO) and Montbéliarde (MM) genetic groups kept on a family farm. The barn was located in the Orava–Podhale Beskids, in the southern part of the Małopolska Province. The average milk yield of cows in this herd was approximately 6,500 L per lactation.

The cows were housed in tie-stall barns on litter. Their feeding was based on forage from permanent grasslands. During the summer season (May to October), the animals grazed on pasture, and the ration was supplemented with a barley–maize meal (approximately 0.4

kg/head) and hay ad libitum. During the winter season (November to April), the cows received meadow hay ad libitum, supplemented during milking with barley–maize meal (approximately 0.4 kg/head), and from December with wet beet pulp at approximately 5 kg/head. The cows were milked in their stalls twice daily.

A representative sample of bulk milk from all cows, 2 L from each complete evening and morning milking, was collected once a month from May to April. Milk samples were stored in a refrigerator at 4°C and, after mixing, transported in a thermobox to the laboratory of the Department of Genetics, Animal Breeding and Ethology at the University of Agriculture in Krakow. In total, 12 samples each of fresh milk, cheese and whey were analysed; antioxidant capacity and fatty acid profile were determined in duplicate. After milk samples had been taken for analysis, the remaining milk was left in a vessel to sour under laboratory conditions for 2–3 days at 20–22°C without the addition of bacterial cultures. After acidification, the milk was heated to approximately 38–40°C until a curd formed and whey separated. The contents were poured onto a sieve lined with sterile gauze over a beaker and pressed with a 1-kg weight for one hour. Immediately after the cheese and whey were obtained, samples were collected for the above analyses, which were carried out on the same day.

Antioxidant capacity was determined by the TEAC (Trolox Equivalent Antioxidant Capacity) method, based on spectrophotometric measurement of ABTS radical quenching by antioxidants present in the sample at a wavelength of 734 nm. Antioxidant capacity was measured in the aqueous fraction (Re et al., 1999). Antioxidants were extracted from milk, cheese and whey with distilled water at 8,600 rpm for 2.5 min using an X120 homogenizer (Danlab). The homogenate was then centrifuged (MPW 223E) at 4,000 rpm for 20 min. The supernatant was carefully transferred to dark-glass vials and stored tightly closed in a refrigerator until analysis (maximum 2 h). The stock ABTS reagent was prepared by adding 0.0384 g of 2,2'-azinobis-(3-ethylbenzothiazoline) acid to 10 mL of distilled water to obtain a final concentration of 7 mM. Next, 0.0066 g of potassium persulfate was added to obtain a concentration of 2.45 mM. The prepared reagent was incubated for 16 h in the dark to generate free radicals. The working reagent was prepared by diluting the stock reagent to an absorbance of 0.700 ± 0.02 measured at 734 nm against distilled water. Antioxidant capacity was determined by mixing 3 mL of the working solution with 30 µL of an aqueous antioxidant extract obtained from milk, cheese and whey samples and measuring absorbance after 30 min at 734 nm using a Genesys 20 UV–VIS spectrophotometer. A solvent blank was prepared by mixing 30 µL of distilled water with 3 mL of the ABTS working solution. Results were expressed as µM TE (Trolox Equivalent)/g fresh matter of product.

Fatty acid content was determined after prior extraction of fat from milk, cheese and whey using a chloroform–methanol (2:1) solvent mixture. Five milligrams of fat were dissolved in 50 µL of toluene and, after adding 100 µL of 2 N sodium hydroxide in methanol, esterified for 20 min at room temperature. Then 0.5 mL of 14% BF₃ in methanol was added and the reaction was continued for another 20 min at room temperature. The resulting esters were dissolved in hexane, and 1 µL was injected into the chromatograph (Ledoux et al., 2005).

Fatty acids (FA) were identified by comparison with methyl ester standards: “Linoleic acid, conjugated methyl esters” (Sigma) for CLA and “Supelco 37 Component FAME Mix” (Sigma-Aldrich Co., St. Louis, MO) for the remaining fatty acids. Fatty acids were analysed using a Trace GC Ultra gas chromatograph (Thermo Electron Corporation, Milan, Italy) with a flame ionization detector (FID) and a Stabilwax column (30 m × 0.25 mm × 0.25 µm).

The analysis included saturated fatty acids (SFA) and unsaturated fatty acids (UFA), including monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), the content of fatty acids with hypocholesterolemic effects (DFA) and hypercholesterolemic effects (OFA), and the atherogenic index (AI).

$$AI = C12:0 + (4 \times C14:0) + C16:0 / (PUFAn-6 + PUFAn-3 + MUFA)$$

$$DFA = UFA + C18:0$$

$$OFA = C14:0 + C16:0$$

The results were subjected to statistical analysis using Statistica 10.1. The significance of differences between group means was estimated using Tukey's HSD test at $P \leq 0.05$.

Results

Table 1 presents the results of antioxidant-capacity analyses for milk, cheese and whey over the annual period. The results clearly show that milk had the highest antioxidant capacity (2.96–4.14 $\mu\text{M TE/g}$ fresh matter), followed by cottage cheese (0.87–1.21 $\mu\text{M TE/g}$ fresh matter), whereas whey had the lowest values (0.35–0.56 $\mu\text{M TE/g}$ fresh matter). The lowest milk value was recorded in December and the highest in February; these differences were significant ($P < 0.05$). For cheese, the lowest value was likewise observed in December and the highest in April, which was statistically confirmed ($P < 0.05$). Whey, however, had a significantly ($P < 0.05$) lowest antioxidant capacity in March and the highest in April. Although significant differences in TEAC values occurred between some months of the year, no statistically significant differences in antioxidant capacity of milk, cheese or whey were found between the winter and summer seasons.

The fatty acid profiles of milk, cheese and whey according to production season are presented in Tables 2 and 3. Significantly higher ($P < 0.05$) contents of CLA and α -linolenic acid (C18:3 n-3), a precursor of health-promoting eicosanoids, were found in cow milk, cottage cheese and whey during the summer period. Milk, cheese and whey also contained significantly ($P < 0.05$) more vaccenic acid (C18:1 n-7) in the summer months. This acid is a precursor for the formation of CLA isomers. The level of short- and medium-chain SFA (C4:0–C12:0) in milk, cheese and whey was significantly ($P < 0.05$) higher in summer. Only the C4:0 butyric acid content in cottage cheese and whey did not differ significantly between seasons. Milk and the products obtained from it during the summer season were characterized by a significantly ($P < 0.05$) higher content of PUFA, especially n-3 fatty acids. Milk, cheese and whey had a favourable content of hypocholesterolemic fatty acids (DFA), and their levels were significantly ($P < 0.05$) higher in summer. Milk, cottage cheese and whey obtained in summer also had the lowest atherogenic index (AI), with significant differences compared with the winter period.

Table 1. TEAC of milk, cheese and whey over the year in $\mu\text{M TE/g}$ fresh matter

Months	Milk	Cheese	Whey
V	3,03 ± 0,26 ^d	1,02 ± 0,25 ^a	0,48 ± 0,02 ^a
VI	3,14 ± 0,33 ^{ad}	0,99 ± 0,10 ^a	0,52 ± 0,13 ^a
VII	3,19 ± 0,11 ^{ad}	1,01 ± 0,02 ^a	0,52 ± 0,21 ^a
VIII	3,26 ± 0,74 ^a	0,98 ± 0,41 ^a	0,49 ± 0,13 ^a
IX	3,39 ± 0,42 ^a	1,01 ± 0,03 ^a	0,51 ± 0,11 ^a
X	3,90 ± 0,82 ^b	1,02 ± 0,21 ^a	0,52 ± 0,09 ^a
Summer season	3,61 ± 0,21 ^a	1,01 ± 0,10 ^a	0,51 ± 0,09 ^a
XI	3,05 ± 0,22 ^d	0,99 ± 0,21 ^a	0,49 ± 0,05 ^a
XII	2,96 ± 0,08 ^d	0,87 ± 0,08 ^a	0,49 ± 0,04 ^a
I	3,43 ± 0,54 ^{ac}	1,10 ± 0,08 ^{ab}	0,43 ± 0,10 ^{ab}
II	4,14 ± 0,21 ^b	0,94 ± 0,11 ^a	0,47 ± 0,08 ^a
III	3,80 ± 0,36 ^{bc}	0,95 ± 0,13 ^a	0,35 ± 0,06 ^b
IV	3,65 ± 0,88 ^{bc}	1,21 ± 0,04 ^b	0,56 ± 0,10 ^a
Winter season	3,78 ± 0,49 ^a	0,98 ± 0,14 ^a	0,46 ± 0,08 ^a

Means ± SD in the monthly columns marked with different letters (a, b, c, d) differ significantly at $P < 0.05$.

Means ± SD in the season columns marked with different letters (a, b, c, d) differ significantly at $P < 0.05$.

Table 2. FA profile in milk, cheese and whey according to season (% of total FA)

FA	Summer (S) and winter (W) season					
	Milk		Cheese		Whey	
	S	W	S	W	S	W
C4:0	2,92 ± 0,03 ^a	3,1 ± 0,04 ^b	3,28 ± 0,03 ^a	3,32 ± 0,06 ^b	2,71 ± 0,09 ^a	2,62 ± 0,07 ^a
C6:0	1,85 ± 0,04 ^a	2,13 ± 0,05 ^b	2,07 ± 0,05 ^a	2,25 ± 0,04 ^b	1,68 ± 0,06 ^a	1,84 ± 0,05 ^a
C8:0	1,06 ± 0,03 ^a	1,34 ± 0,04 ^b	1,15 ± 0,04 ^a	1,38 ± 0,03 ^b	0,97 ± 0,03 ^a	1,17 ± 0,03 ^b
C10:0	2,25 ± 0,08 ^a	3,20 ± 0,10 ^b	2,44 ± 0,10 ^a	3,26 ± 0,09 ^b	2,05 ± 0,08 ^a	2,86 ± 0,09 ^b
C10:1	0,21 ± 0,01 ^a	0,34 ± 0,02 ^b	0,23 ± 0,01 ^a	0,34 ± 0,02 ^b	0,24 ± 0,02 ^a	0,30 ± 0,02 ^b
C12:0	2,49 ± 0,08 ^a	3,82 ± 0,12 ^b	2,66 ± 0,10 ^a	3,84 ± 0,11 ^b	2,27 ± 0,09 ^a	3,51 ± 0,12 ^b
C14:0	9,84 ± 0,15 ^a	13,61 ± 0,41 ^b	10,30 ± 0,18 ^a	13,39 ± 0,38 ^b	9,59 ± 0,21 ^a	13,03 ± 0,40 ^b
C14:1	0,63 ± 0,04 ^a	1,09 ± 0,07 ^b	0,66 ± 0,03 ^a	1,08 ± 0,07 ^b	0,63 ± 0,04	1,02 ± 0,07 ^b
C15:0	1,05 ± 0,03 ^a	1,32 ± 0,04 ^b	1,08 ± 0,02 ^a	1,29 ± 0,04 ^b	1,02 ± 0,04 ^a	1,27 ± 0,04 ^b
C16:0	29,29 ± 0,47 ^a	40,78 ± 0,98 ^b	29,25 ± 0,56 ^a	40,22 ± 0,94 ^b	29,63 ± 0,45 ^a	41,47 ± 1,08 ^b
C16:1n-9	0,55 ± 0,01 ^a	0,59 ± 0,01 ^b	0,54 ± 0,02 ^a	0,57 ± 0,02 ^b	0,58 ± 0,02 ^a	0,62 ± 0,02 ^a
C16:1n-7	1,72 ± 0,07 ^a	2,24 ± 0,06 ^b	1,72 ± 0,06 ^a	2,18 ± 0,07 ^b	1,74 ± 0,08 ^a	2,17 ± 0,07 ^b
C17:0	0,47 ± 0,03 ^a	0,53 ± 0,03 ^a	0,44 ± 0,02 ^a	0,53 ± 0,02 ^b	0,42 ± 0,01 ^a	0,54 ± 0,03 ^b
C17:1	0,33 ± 0,01 ^a	0,39 ± 0,01 ^b	0,31 ± 0,02 ^a	0,39 ± 0,01 ^b	0,35 ± 0,02 ^a	0,40 ± 0,01 ^b
C18:0	11,70 ± 0,13 ^a	5,98 ± 0,47 ^b	11,14 ± 0,10 ^a	6,12 ± 0,46 ^b	12,16 ± 0,12 ^a	6,61 ± 0,53 ^b
C18:1n-9	24,78 ± 0,65 ^a	15,43 ± 1,03 ^b	24,12 ± 0,68 ^a	15,62 ± 0,98 ^b	24,68 ± 0,83 ^a	16,16 ± 1,09 ^b
C18:1n-7	4,26 ± 0,18 ^a	1,50 ± 0,11 ^b	4,12 ± 0,16 ^a	1,56 ± 0,10 ^b	4,70 ± 0,15 ^a	1,67 ± 0,13 ^b
C18:2n-6	1,79 ± 0,03 ^a	1,21 ± 0,04 ^b	1,77 ± 0,02 ^a	1,23 ± 0,04 ^b	1,85 ± 0,02 ^a	1,30 ± 0,04 ^b
C18:3n-6	0,06 ± 0,00 ^a	0,07 ± 0,00 ^b	0,06 ± 0,01 ^a	0,07 ± 0,00 ^b	0,07 ± 0,01 ^a	0,07 ± 0,00 ^a
C18:3n-3	1,01 ± 0,04 ^a	0,69 ± 0,04 ^b	1,00 ± 0,04 ^a	0,69 ± 0,03 ^b	1,08 ± 0,04 ^a	0,71 ± 0,03 ^b
CLA	1,36 ± 0,07 ^a	0,38 ± 0,03 ^b	1,30 ± 0,05 ^a	0,39 ± 0,03 ^b	1,22 ± 0,06 ^a	0,40 ± 0,03 ^b
C20:0	0,17 ± 0,00 ^a	0,12 ± 0,01 ^b	0,16 ± 0,00 ^a	0,12 ± 0,00 ^b	0,17 ± 0,01 ^a	0,11 ± 0,01 ^b
C20:1	0,13 ± 0,00 ^a	0,08 ± 0,00	0,13 ± 0,00 ^a	0,09 ± 0,00 ^b	0,12 ± 0,01 ^a	0,09 ± 0,01 ^b

Means ± SD in columns for the same product marked with different letters (a, b, c, d) differ significantly at P<0.05.

Table 3. Types and proportions of fatty acids in milk, cheese and whey according to season (% of total FA)

FA	Summer (S) and winter (W) season					
	Milk		Cheese		Whey	
	S	W	S	W	S	W
n-3	1,01 ± 0,04 ^a	0,69 ± 0,04 ^b	1,00 ± 0,04 ^a	0,69 ± 0,03 ^b	1,08 ± 0,40 ^a	0,71 ± 0,03 ^b
n-6	1,85 ± 0,03 ^a	1,28 ± 0,05 ^b	1,83 ± 0,02 ^a	1,30 ± 0,04 ^b	1,92 ± 0,20 ^a	1,37 ± 0,05 ^b
n3/n6	0,55 ± 0,03 ^a	0,54 ± 0,02 ^a	0,54 ± 0,02 ^a	0,53 ± 0,02 ^a	0,56 ± 0,02 ^a	0,52 ± 0,01 ^a
n6/n3	1,86 ± 0,10 ^a	1,88 ± 0,05 ^a	1,88 ± 0,08 ^a	1,90 ± 0,05 ^a	1,79 ± 0,60 ^a	1,37 ± 0,05 ^a
SFA	63,10 ± 0,56 ^a	75,92 ± 1,12 ^b	63,98 ± 0,65 ^a	75,72 ± 1,08 ^b	62,67 ± 0,80 ^a	75,04 ± 1,24 ^b
MUFA	32,62 ± 0,59 ^a	21,67 ± 1,03 ^b	31,82 ± 0,65 ^a	21,83 ± 1,00 ^b	33,04 ± 0,81 ^a	22,42 ± 1,15 ^b
PUFA	4,22 ± 0,06 ^a	2,34 ± 0,01 ^b	4,13 ± 0,06 ^a	2,38 ± 0,09 ^b	4,22 ± 0,09 ^a	2,48 ± 0,09 ^b
AI	2,01 ± 0,05 ^a	4,34 ± 0,30 ^b	2,13 ± 0,07 ^a	4,24 ± 0,29 ^b	1,97 ± 0,08 ^a	4,14 ± 0,32 ^b
OFA	39,13 ± 0,49 ^a	54,39 ± 1,29 ^b	39,54 ± 0,62 ^a	53,61 ± 1,26 ^b	39,22 ± 0,53 ^a	54,50 ± 1,44 ^b
DFA	48,54 ± 0,54 ^a	29,99 ± 1,59 ^b	47,10 ± 0,69 ^a	30,33 ± 1,53 ^b	49,41 ± 0,80 ^a	31,50 ± 1,76 ^b

Means ± SD in rows for the same product marked with different letters (a, b, c, d) differ significantly at P<0.05.

Discussion

Milk obtained from cows on the family farm showed higher antioxidant activity than values reported by Pokorska et al. (2017) for milk from Polish Holstein-Friesian cows of the same age (1.73–3.49 µM TE/g fresh matter). The higher TEAC values of milk from cows on the Orava farm may be associated with the contribution of Polish Red cow milk to the bulk milk, as well as with feeding based on herbage from permanent grasslands. Cottage cheese produced on the family farm in Orava had antioxidant capacity similar to that of cheese containing 4% fat from OSM Hajnówka (1.12 µM TE/g fresh matter) (Ochrem et al., 2015).

The results obtained in the present study are supported by Radkowska (2013), who demonstrated a positive effect of pasture feeding in mountain regions on the health-promoting

properties of milk, including higher contents of MUFA, PUFA and DFA. Likewise, Zapletal and Maj (2023) found higher levels of desirable DFA and DFA/OFA ratios, as well as markedly more CLA and C18:1 n-7, in commercial milk from mountain regions during the summer season. Milk, cottage cheese and whey also had a nutritionally desirable n-6/n-3 polyunsaturated fatty acid ratio because the n-6 to n-3 ratio in meadow and pasture plants is low.

Pasture feeding increased the proportions of PUFA and CLA. Pacheco-Pappenheim et al. (2021) demonstrated pronounced seasonal variation in the fatty acid and triacylglycerol composition of Dutch cow milk. The maximum proportion of C18:3 cis-9,12,15 in late spring and summer reflected increased consumption of fresh herbage during these periods. In winter, the high availability of short-chain FA and C16:0 increased the formation of low- and medium-molecular-weight triacylglycerols, whereas in summer high concentrations of long-chain unsaturated FA increased the formation of high-molecular-weight triacylglycerols. Niero et al. (2021) demonstrated a positive effect of mountain grazing on the FA profile of milk from Simmental and crossbred cows on an Alpine farm from a nutraceutical point of view. Concentrations of C14:0, C16:0 and short- and medium-chain FA were lower throughout the summer season. According to Allison et al. (2020), milk from cows grazing permanent grasslands has a more favourable FA profile. Such milk contains higher levels of unique bioactive FA than conventional milk and milk enriched with n-3 fatty acids, particularly in summer. The results obtained for milk, cheese and whey in the present study confirm the seasonal variation in FA profile reported in the cited studies.

Conclusions

The antioxidant capacity of raw milk markedly exceeded the antioxidant activity of cottage cheese and whey. Milk obtained from cows from mountainous areas in Orava had higher TEAC values than those reported in the literature for cow milk from other regions of Poland. During the pasture season, milk, cheese and whey had significantly higher ($P<0.05$) proportions of health-promoting MUFA and PUFA and higher contents of CLA and α -linolenic acid (C18:3 n-3). Significantly higher ($P<0.05$) levels of desirable hypocholesterolemic fatty acids (DFA) were found in milk and its products during the summer season. Milk, cottage cheese and whey obtained in summer also had the lowest atherogenic index (AI), and the differences compared with winter were significant.

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ANTIOXIDANT CAPACITY OF MILK, CHEESE AND WHEY FROM COWS RAISED IN MOUNTAINOUS AREAS

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SUMMARY

The aim of the study was to determine the level of antioxidants in milk, cottage cheese and whey from cows kept on a family farm in Orava. The fatty acid (FA) profile in raw milk, cheese and whey was also assessed, which is of significant importance in shaping the antioxidant capacity of products obtained from them. The antioxidant capacity was determined using the TEAC (Trolox Equivalent Antioxidant Capacity) method based on spectrophotometric measurement of the quenching of ABTS radicals by antioxidants contained in the sample, at a wavelength of 734 nm. The fatty acid profile was analyzed using a Trace GC Ultra gas chromatograph. The analysis included the content of fatty acids with hypocholesterolemic (DFA) and hypercholesterolemic (OFA) effects and calculated the atherosclerotic index (AI). The antioxidant capacity of raw milk significantly exceeded the antioxidant activity of cottage cheese and whey. Milk obtained from cows from mountain areas in Orava was characterized by higher TEAC values compared to the results of studies presented in the literature and conducted on milk from cows from other regions of Poland. Milk, cheese and whey were characterized by a significantly higher ($P<0.05$) share of health-promoting monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) and the content of conjugated linoleic acid (CLA) and α -linolenic acid C18:3n-3 in the pasture season. Significantly higher ($P<0.05$) levels of

desirable acids with hypocholesterolemic effect (DFA) were found in milk and its products in the summer season. Milk, cottage cheese and whey obtained in the summer season also had the lowest atherosclerosis index (AI), and the differences compared to the winter period were significant.

Keywords: cow's milk, cottage cheese, whey, antioxidants, fatty acids