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DIFFERENCES OF SOME INDICATORS OF RAW MILK PROPERTIES AND ESPECIALLY MINERAL COMPOSITION BETWEEN SMALL RUMINANTS AS COMPARED TO COWS IN THE CZECH REPUBLIC

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Abstract

HANUŠ, O., VYLETĚLOVÁ, M., GENČUROVÁ, V., HULOVÁ, I., LANDOVÁ, H.: *Differences of some indicators of raw milk properties and especially mineral composition between small ruminants as compared to cows in the Czech Republic.* Acta univ. agric. et silvic. Mendel. Brun., 2008, LVI, No. 5, pp. 51–56

Sheep and goat farming is returning back into the Czech Republic (CR) because of positive effects of alternative milk consumption on human health. Especially the elements Ca and Mg are important for nutrition. Paper presents the comparison of mineral milk composition of goats (White short–haired–W, n = 60), sheep (Tsigai–C, n = 60) and cows (Holstein–H, n = 36; Czech Fleckvieh–B, n = 93). Cow milk results were considered as reference. The herds were kept at altitude 260 m (H), 360 m (B), and 572 m above sea level (W, C) with total precipitation 449, 700 and 1200 mm per year and mean air temperatures 9.6, 7.0 and 3.7 °C. Bulk milk samples (4–8 animals in sample) from the first two thirds of the lactation and the winter and summer season were investigated. Goat milk freezing point differed from other species ($P < 0.001$), –0.6048 for C < –0.5544 W < –0.5320 H < –0.5221 °C for B. Cow milk Ca values were comparable to former results although milk yield (MY) was higher. Along lower MY the Ca was higher (1299.6 > 1172.0 $mg.kg^{-1}$; $P < 0.001$) in B than H, similar trend was in Mg (122.0 > 107.4 $mg.kg^{-1}$; $P<0.001$). Differences ($P > 0.05$) between species were in Ni and also mostly in Cu. Iodine results differed between species but not between cow breeds ($P < 0.001$; 462.8 H and 434.9 B > 126.0 W and 164.2 $\mu g.l^{-1}$ C). It could be explainable by using of I disinfection at teat treatment in cows and absence of treatment in small ruminants. Macroelements were mostly highest (Ca, P, Na, Mg) in sheep milk, with exception of K. Phosphorus values (950.1 H, 1016.9 B, 1042.6 W and 1596.7 $mg.kg^{-1}$ C) in species were linked with crude or true protein and casein values. Small ruminant milk could be good source of minerals for human nutrition, especially in the case of Ca and Mg of sheep and goat milk.

less favourable area, cow, goat, sheep, milk, chemical composition, milk freezing point, citric acid, macroelement, microelement, calcium, magnesium

Sheep and goat farming is returning back into the Czech Republic (CR) now, mostly because of confirmed positive impacts of alternative milk consumption on human health. In particular the mineral element consumption such as Ca and Mg is important for human nutrition, at first of all for good development of skeleton and tooth health, prevention against osteoporosis and for good functions of nervous system. The dramatical changes in ruminant keeping during last 20 years in the CR were described in details (Hanuš et al., 2008), including the general climatic conditions. After this period it is important to know the interspecific milk composition and quality differences in better way. The goat milk properties were also described in last time by Morand-Fehr et al. (2007) and Park et al. (2007). Therefore the aim of this paper was to carry out the evaluation of differences among milk of various biological ruminant species in terms of quality as a possible source of mineral human nutrition.

MATERIAL AND METHODS

Animals and sample material

The details of ruminant keeping were described in corresponding work (Hanuš et al., 2008) including milk sampling and climate conditions and are described only in the frame here.

Bulk milk samples ((BMS) one sample from 4 to 8 animals) were collected in 4 dairy cow herds with Czech Fleckvieh cattle (B; 3 herds; n = 93 BMS) and Holstein cows (H; 1 herd; n = 36) and 1 goat herd (W; White short–haired breed; n = 60) and 1 sheep herd (C; Tsigai; n = 60). Animals were grouped for sampling randomly. Cow results were used as reference to milk results of small ruminants. The animals were sampled in spring and summer seasons for 3 years (2005–2007). The herds were kept in altitudes 260 (H), from 360 to 475 (B) and 572 (W and C) m over the sea. Total precipitation were 449, 700 and 1200 mm per year and mean air temperatures 9.6, 7.0 and 3.7 °C. The goat and sheep herd was kept in one stable in less favourable area. The nutritions of animals and species were carried out in typical ways for the CR. The cow herds were fed by the TMR which consisted of maize silage and red clover and alfalfa silage with mineral and concentrate supplements. Feeding was performed in agreement with standard and actual daily milk yield. Goat and sheep herd was fed by the natural grass and herb pasture and by the grain supplement with daily ration 0.6 kg for goat and 0.3 kg for sheep (mixture of grains and mineral components). Animals were in 1st two thirds of the lactation and had typical milk yield for the country (H 28.11; B 20.04; W 1.75; C 0.36 kg per day). Animals were milked twice a day by machine milking. The B cows were kept in tie stable (pipeline milking equipment), H cows, goats and sheep in free stables (milking parlours).

Milk sample analyses

The analyses were performed regularly in accredited testing laboratory in Rapotin. The following abbreviations were used for investigated milk indicators (MIs): MFP milk freezing point (°C); CA citric acid concentration (mmol.l^{-1}); macroelements Ca, P, Na, K and Mg (in mg.kg^{-1}); microelements I (in µg.l^{-1}), Mn, Fe, Cu, Zn and Ni (in mg.kg^{-1}). Also main chemical milk components, health MIs, physical and technological properties and residues of inhibitory substances in milk were investigated (Hanuš et al., 2005, 2008; Genčurová et al., 2008). The statistical data processing included the determination of basic parameters and testing of interspecific differences. The cow milk results were used as reference. Milk samples were analysed on the MFP values by the top cryoscopic instrument Cry-Star automatic Funke-Gerber (Germany). The selected measurement mood was Plateau Search (with parameters: interval = 23 sec. and Δt = 0.4 m °C). The instrument was under regular calibration by the standard NaCl solutions (Funke-Gerber) and took part in the national proficiency testing with successful results regularly. Milk CA concentration was determined by the spectrophotometric measurement at 428 nm of the wavelength. Milk was coagulated by the trichloracetic acid and after it the adventitious filtrate reacted with the pyridin and acetanhydride (30 min. at 32 °C). The CA generates with the pyridin a yellow-coloured complex in acetanhydride medium. The Specol 11 was calibrated by seven points of the concentrations from 1.5 to 20.0 mmol.l^{-1}, it means from 0.03 up to 0.36 %. Macro- and microelement milk concentrations (except P) were investigated (after mineralization) by the atom absorption spectroscopy on the equipment Spectrometer Solaar S4 (Thermoelemental, England). The P content was determined as a molybdenum-blue (with ammonium, ascorbic and sulfuric acid). The Specol 11 was calibrated by the five point on the scale with increased P concentration from 2 to 20 mg.l^{-1} (at 750 nm). The main statistical characteristics of analytical results, t-test and graphs were processed by Excel 2003 programme.

RESULTS AND DISCUSSION

The interspecific differences in main milk composition and propertis of ruminant milk were shown and discussed in corrresponding paper (Genčurová et al., 2008). The main statistical characteristic of MFP, CA concentration, macroelements and microelements are shown in Tab. I. Similarly to results of other milk components and properties (Genčurová et al., 2008) the average interspecific differences in MFP, CA, macro- and microelements were mostly significant (Tab. II) under CR conditions. Goat MFP average (Tab. I) was in accordance with result another current paper by Janštová et al. (2007) and there were expressive interspecific differences ($P < 0.001$; Tab. II), –0.6048 for C < –0.5544 W < –0.5320 H < –0.5221 °C for B. There were 69.2 % of H–B significant differences (between cattle breeds) as significant, 69.2 % of H–W differences (between ruminants), 92.3 % of H–C (between ruminants), 76.9 % of B–W, 84.6 % of B–C and 69.2 % of W–C (Tab. I and II). Also the differences in used MIs between cattle breeds were similar as compared to former results by Hanuš and Foltys (1991). Today cow milk Ca average values were good comparable to former results according to breeds, although milk yields are much higher than previously.

Current macroelement values were comparable to last results (Janů et al., 2007) quite good with exception of Mg, which was higher than present averages. In this data set along lower milk yield the Ca was higher (1299.6 > 1172.0 mg.kg^{-1}; $P < 0.001$) in B cows as compared to H and similar trend existed for Mg (122.0 > 107.4 mg.kg^{-1}; $P < 0.001$) as well (Tab. I, II and Fig. 1). Insignificant differences ($P > 0.05$) between species in Ni and also in Cu were mostly smaller differences (Tab. II). Cow milk microelement averages were mostly comparable to former results (Mn, Cu and Zn; Hanuš et al., 1993).

Iodine contents were interesting when cow breed averages (Tab. I) were insignificantly different (Tab. II) while between species averages differed very expressively (P < 0.001; 462.8 H and 434.9 B > 126.0 W and 164.2 μg.l^{-1} C; Fig. 1). Because nutrition of species had a similar roughage basis these facts could be explainable only by using of iodine disinfection at teat treatment after milking in cows as compared to other ruminants. There this technology is not typical and olso was not used. Logically the macroelement contents were mostly highest (Ca, P, Na, Mg) in sheep milk, with exception of K (Fig. 1). The average P values (Tab. I; 950.1 H, 1016.9 B, 1042.6 W and 1596.7 mg.kg^{-1} C) in species were linked closely with typical crude or true protein and casein values respectively (according to Genčurová et al., 2008; 3.36, 3.17 and 2.66 % H, 3.33, 3.16 and 2.67 % B, 3.18, 2.91 and 2.41 % W and 6.32, 5.91 and 4.96 % C). The goat Ca, Mg and Zn averages (Tab. I) were similar as reported Hejtmánková et al. (2002), Cu was a little higher and Fe expressively lower. Ca was similar and P higher in comparison to results by Antunac et al. (2001). Also Gajdůšek and Jelínek (1992) and Gajdůšek et al. (1996) reported similar results about micro- and macroelements. Kuchtík and Sedláčková (2003) and Kuchtík et al. (2003) found lower goat milk Ca contents (930 and 980 mg.l^{-1}).

CONCLUSION

The results show that small ruminant milk could be very good source of mineral human nutrition. Especially in consideration of Ca and Mg contents of sheep and goat milk.

I: *The basic statistical characteristic of MFP, milk CA concentration and mineral composition in cows, goats and sheep*

MI	Unit	x H	sd	vx	x B	sd	vx
MFP	°C	–0.5320	0.0050	0.9	–0.5221	0.0043	0.8
CA	mmol.l^{-1}	8.76	1.228	14.0	8.35	1.338	16.0
CA	%	0.16	0.023	14.4	0.16	0.025	15.6
Ca	mg.kg^{-1}	1172.01	81.813	7.0	1299.63	191.262	14.7
P	mg.kg^{-1}	950.06	55.142	5.8	1016.94	89.478	8.8
Na	mg.kg^{-1}	452.97	30.013	6.6	395.59	79.985	20.2
Mg	mg.kg^{-1}	107.41	3.470	3.2	122.03	15.515	12.7
K	mg.kg^{-1}	1563.45	52.669	3.4	1629.53	71.796	4.4
I	μg.l^{-1}	462.84	103.916	22.5	434.91	142.754	32.8
Mn	mg.kg^{-1}	0.024	0.005	20.8	0.042	0.025	59.5
Fe	mg.kg^{-1}	0.15	0.070	46.7	0.57	0.808	141.8
Cu	mg.kg^{-1}	0.08	0.023	28.8	0.09	0.037	41.1
Zn	mg.kg^{-1}	4.20	0.616	14.7	4.65	0.540	11.6
Ni	mg.kg^{-1}	0.04	0.017	42.5	0.04	0.022	55.0

MI	Unit	x W	sd	vx	x C	sd	vx
MFP	°C	–0.5544	0.0293	5.3	–0.6048	0.0691	11.4
CA	mmol.l^{-1}	7.15	1.683	23.5	6.77	1.475	21.8
CA	%	0.13	0.031	23.8	0.13	0.027	20.8
Ca	mg.kg^{-1}	1223.90	126.877	10.4	1914.50	296.998	15.5
P	mg.kg^{-1}	1042.63	98.083	9.4	1596.73	128.234	8.0
Na	mg.kg^{-1}	438.55	98.054	22.4	740.13	157.848	21.3
Mg	mg.kg^{-1}	131.12	14.507	11.1	192.53	17.094	8.9
K	mg.kg^{-1}	2013.75	202.749	10.1	1296.75	123.843	9.6
I	μg.l^{-1}	126.02	46.963	37.3	164.18	52.179	31.8
Mn	mg.kg^{-1}	0.06	0.046	76.7	0.073	0.028	38.4
Fe	mg.kg^{-1}	0.29	0.147	50.7	0.40	0.192	48.0
Cu	mg.kg^{-1}	0.10	0.077	77.0	0.12	0.083	69.2
Zn	mg.kg^{-1}	4.30	0.720	16.7	5.23	1.070	20.5
Ni	mg.kg^{-1}	0.03	0.008	26.7	0.03	0.006	20.0

(H Holstein cows; B Czech Fleckvieh cows; W White short-haired goats; C Tsigai sheep; MI milk indicator; x arithmetical mean; sd standard deviation; vx variation coefficient (in %).)

II: *Significance of interspecific differences in milk composition and properties*

	H–B		H–W		H–C		B–W		B–C		W–C	
	t	sign.	t	sign.	t	sign.	t	sign.	t	sign.	t	sign.
MFP	11.11	***	4.50	***	6.25	***	10.39	***	11.43	***	5.16	***
CA	1.58	ns	4.94	***	6.73	***	4.85	***	6.80	***	1.30	ns
Ca	3.84	***	2.17	*	14.52	***	2.69	**	15.47	***	16.42	***
P	4.15	***	5.14	***	28.41	***	1.66	ns	32.70	***	26.36	***
Na	4.16	***	0.85	ns	10.69	***	2.95	**	17.69	***	12.47	***
Mg	5.56	***	9.54	***	29.21	***	3.60	***	26.19	***	21.04	***
K	4.98	***	12.93	***	12.14	***	16.61	***	20.87	***	23.18	***
I	1.06	ns	19.99	***	17.29	***	14.77	***	12.86	***	3.81	***
Mn	4.25	***	4.63	***	10.29	***	3.10	**	7.09	***	1.85	ns
Fe	3.09	**	5.31	***	7.44	***	2.64	**	1.59	ns	3.49	***
Cu	1.50	ns	1.50	ns	2.80	**	1.06	ns	3.02	**	1.36	ns
Zn	3.72	***	0.69	ns	5.22	***	3.00	**	3.74	***	5.54	***
Ni	0.00	ns	1.77	ns	1.79	ns	1.39	ns	1.40	ns	0.00	ns

(*, ** and *** = statistical significance (sign.) $P \leq 0.05$, < 0.01 and < 0.001; ns = $P > 0.05$; t = value of t-test criterion.)

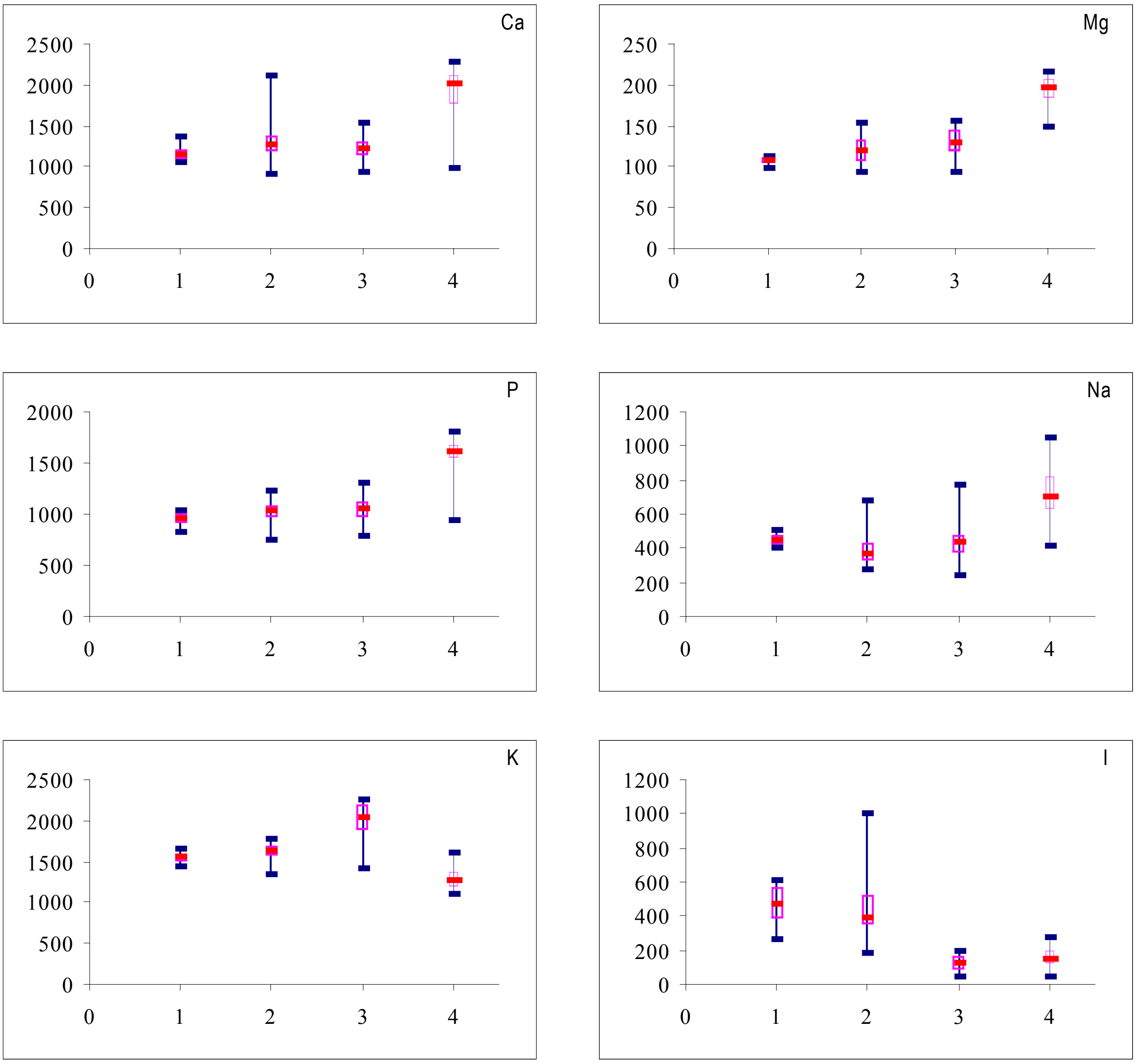
SUMMARY

Sheep and goat farming is returning back into the Czech Republic (CR) because of positive effects of alternative milk consumption on human health. After this period the changes in keeping of small ruminants it is important to know the interspecific milk composition and quality differences in better way. Especially the elements Ca and Mg are important for nutrition. Paper presents the comparison of mineral milk composition of goats (White short–haired–W, n = 60), sheep (Tsigai–C, n = 60) and cows (Holstein–H, n = 36; Czech Fleckvieh cattle–B, n = 93). The goat and sheep herd was kept in one stable in less favourable area. The nutritions of animals and species were carried out in typical ways for the CR. The cow herds were fed by the TMR which consisted of maize silage and red clover and alfalfa silage with mineral and concentrate supplements. Feeding was performed in agreement with standard and actual daily milk yield. Goat and sheep herd was fed by the natural grass and herb pasture and by the grain supplement with daily ration 0.6 kg for goat and 0.3 kg for sheep (mixture of grains and mineral components). Animals had typical milk yield for the country. Cow milk results were considered as reference. The herds were kept at altitude 260 m (H), 360 m (B), and 572 m above sea level (W, C) with total precipitation 449, 700 and 1200 mm per year and mean air temperatures 9.6, 7.0 and 3.7 °C. Bulk milk samples (4–8 animals in sample) from the first two thirds of the lactation and the winter and summer season were investigated. Goat milk freezing point differed from other species ($P < 0.001$), –0.6048 for C < –0.5544 W < –0.5320 H < –0.5221 °C for B. Cow milk Ca values were comparable to former results although milk yield (MY) was higher. Along lower MY the Ca was higher (1299.6 > 1172.0 $mg.kg^{-1}$; $P < 0.001$) in B than H, similar trend was in Mg (122.0 > 107.4 $mg.kg^{-1}$; $P < 0.001$). Differences ($P > 0.05$) between species were in Ni and also mostly in Cu. Iodine results differed between species but not between cow breeds ($P < 0.001$; 462.8 H and 434.9 B > 126.0 W and 164.2 $\mu g.l^{-1}$ C). It could be explainable by using of I disinfection at teat treatment in cows and absence of treatment in small ruminants. Macroelements were mostly highest (Ca, P, Na, Mg) in sheep milk, with exception of K. Phosphorus values (950.1 H, 1016.9 B, 1042.6 W and 1596.7 $mg.kg^{-1}$ C) in species were linked with crude or true protein and casein values. Small ruminant milk could be good source of minerals for human nutrition, especially in the case of Ca and Mg of sheep and goat milk.

SOUHRN

Rozdíly některých ukazatelů vlastností syrového mléka a zejména minerálního složení mezi malými přežvýkavci ve srovnání s kravami v České republice

Chov ovcí a koz se vrací zpět do České republiky (CR) pro pozitivní vlivy spotřeby alternativního mléka na lidské zdraví. Je významné znát lépe mezidruhové rozdíly ve složení a kvalitě mléka po období těchto změn v chovu malých přežvýkavců. Zejména prvky Ca a Mg jsou významné pro výživu. Prá-



1: *Examples of MI data distribution (Ca, Mg, P, Na, K and I) for various kinds of milk*
(Box graph: median (the central short horizontal line); top edge of 1^{st} and 3^{rd} quartile (the tetragon); variation range, maximum–minimum (the vertical line); 1 H; 2 B; 3 W; 4 C; Ca, Mg, P, Na and K in $mg.kg^{-1}$; I in $\mu g.l^{-1}$.)

ce uvádí srovnání minerálního složení mléka koz (bílá krátkosrstá–W, n = 60), ovcí (cigája–C, n = 60) a krav (holštýn–H, n = 36; český strakatý skot–B, n = 93). Stádo koz a ovcí bylo chováno v jedné stáji v méně využitelné oblasti. Výživy zvířat a druhů byly prováděny typickým způsobem pro ČR. Stáda krav byla krmena TMR, která sestávala z kukuřičné siláže a jetelové a vojtěškové siláže s přídavky jadrných krmiv a minerálií. Krmení bylo prováděno v souladu s normami a aktuální denní mléčnou užitkovostí. Stádo koz a ovcí bylo krmeno přirozenou travní a bylinnou pastvou a přídavky jadrného krmiva s denní dávkou 0,6 kg pro kozy a 0,3 kg pro ovce (směs zrnin a minerálních složek). Zvířata měla pro zemi typickou mléčnou užitkovost. Kravské mléko bylo použito jako referenční. Stáda byla chována v nadmořské výšce 260 m (H), 360 m (B), a 572 m (W, C) s úhrnnými vodními srážkami 449, 700 a 1200 mm za rok a průměrnými ročními teplotami 9,6, 7,0 a 3,7 °C. Byly vyšetřeny bazénové vzorky mléka (4–8 zvířat ve vzorku) z prvních dvou třetin laktace a zimní a letní sezony. Bod mrznutí kozího mléka se lišil od ostatních druhů ($P < 0{,}001$), –0,6048 pro C < –0,5544 W < –0,5320 H < –0,5221 °C pro B. Hodnoty Ca kravského mléka byly srovnatelné k dřívějším výsledkům, ačkoliv mléčná užitkovost (MY) byla vyšší. S nižší MY byl Ca vyšší (1299,6 > 1172,0 $mg.kg^{-1}$; $P < 0{,}001$) u B než H, podobný trend byl v Mg (122,0 > 107,4 $mg.kg^{-1}$; $P < 0{,}001$). Mezidruhové rozdíly ($P > 0{,}05$) byly u Ni a také většinou u Cu. Výsledky I se lišily mezi druhy, ale ne mezi plemeny krav ($P < 0{,}001$; 462,8 H a 434,9 B > 126,0 W a 164,2 $\mu g.l^{-1}$ C). To by mohlo být vysvětlitelné použitím jodové dezinfekce

při ošetření struků krav a absencí tohoto ošetření u malých přežvýkavců. Makroprvky byly většinou nejvyšší (Ca, P, Na, Mg) v ovčím mléce, s výjimkou K. Hodnoty fosforu (950,1 H, 1016,9 B, 1042,6 W a 1596,7 mg.kg^{-1} C) u druhů byly spojeny s hodnotami hrubých nebo čistých bílkovin a kaseinu. Mléko malých přežvýkavců může být dobrým zdrojem minerálií pro lidskou výživu, zejména v případě Ca a Mg ovčího a kozího mléka.

méně využitelná oblast, kráva, koza, ovce, mléko, chemické složení, bod mrznutí mléka, kyselina citrónová, makroprvek, mikroprvek, vápník, hořčík

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