THE RELATIONSHIPS BETWEEN GOAT AND COW MILK FREEZING POINT, MILK COMPOSITION AND PROPERTIES*

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Goat milk can be an important factor of human nutrition (for people sensitive to cow milk). The comparison with cow milk, especially in relations to the milk freezing point (MFP) as an important physical milk indicator (MI), was carried out. The bulk milk samples (/BMSs/ – one sample from 4 to 8 animals) were investigated on 39 MIs. Goats (White short-haired /W/, n = 60 BMSs) and cows (Czech Fleckvieh cattle /B/, n = 93) were sampled for 3 years in winter and summer season. It is explicit that goat milk takes the lower value of MFP (–0.5544 °C; W) than cow's (–0.5221 °C; B; $P < 0.001$). It is caused by specific physiological differences between species. They influenced the contents of some MIs: fat (4.58 W vs. 3.40% B; $P < 0.001$); urea (50.6 W vs. 26.7 mg 100 ml^{-1} B; $P < 0.001$); calcium (1224 W vs. 1300 mg l^{-1} B; P < 0.01). The content of lactose (monohydrate) was 4.43% W vs. 5.06% B ($P < 0.001$). Some significant relations (correlation coefficients or indexes from linear or non linear regressions) were observed between goat MFP and: fat (–0.48, $P < 0.001$, W vs. –0.06, $P > 0.05$, B); dry matter content (–0.57, $P < 0.001$, W vs. –0.07, $P > 0.05$, B); urea (–0.57, $P < 0.001$, W vs. 0.01, $P > 0.05$, B); pH (0.75, $P < 0.001$, W vs. –0.455, $P < 0.001$, B); Ca (–0.48, $P < 0.01$ W vs 0.12, $P > 0.05$, B); casein (–0.42, $P < 0.01$, W vs. –0.10, $P > 0.0$ 5, B) etc. The compared relationships were often different between species or sometimes were opposite in terms of trends, which could be caused by interspecific differences but also by different levels of somatic cell counts of compared species.

ruminant; goat; cow; milk; milk freezing point; milk composition

INTRODUCTION

The value of goat milk in human nutrition is growing up currently because of positive effect on health condition of consumers (easily digested, better tolerated). It has impact on development of goat farming. The changes in goat keeping during last 20 years in the Czech Republic (CR) were described previously (Hanuš et al., 2008) including the CR climatic conditions. Goat numbers dropped by 67% (1990–2002) according to official statistics, but nowadays the numbers are slightly increased.

Freezing point depression (MFP) is an important physical and quality indicator of milk. After period of essential changes in the goat keeping in the CR, it is important to know the current relations of MFP to other milk components and properties. Therefore, this work was focused on evaluation and explanation of relationships between MFP and other milk indicators (MIs) in goats.

MFP is significant polyfactorial physical and technological milk indicator for control of milk foodstuff chain quality, whose chemical, physical, technological and measurement principles were mentioned in cows but not in goats (Demott, 1969; Eisses, Zee, 1980; Brouwer, 1981; Walstra, Jenness, 1984; Koops et al., 1989; Buchberger, 1990, 1991, 1994; Rohm et al., 1991; Wiedemann et al., 1993; Hanuš et al., 2003; Crombrugge, 2003; Rasmussen, Bjerring, 2005).

MATERIAL AND METHODS

Bulk milk samples ((BMSs) one sample from 4 to 8 animals) were collected in one goat herd (W; White short-haired; n = 60 BMSs) and three cow herds (B; Czech Fleckvieh cattle; n = 93). The animals were grouped for sampling by the chance and sampled during spring and summer seasons for three years (2005–2007). The herds were kept in altitudes from 360 to 475 m (B) and 572 m (W) with annual precipitation 700 (B) and 1200 mm (W and C) and annual average temperature 7.0 and 3.7 °C. Goats were fed by the natural grass and herb pasture and by the grain supplement with daily ration 0.3 kg per head (mixture of barley, maize, wheat and rape seed-oil and mineral components). The cow herds were fed by the TMR, which consisted of maize silage and red clover and alfalfa silage with mineral and concentrate supplements. Animals in the half of 1st lactation were milked twice a day with daily milk yield 1.75 (W) and 20.04 (B) kg per day. The goats were kept free and the cows in tie stable.

Analyses were performed in the Testing laboratory No. 1340 (Research Institute of Cattle Breeding, LTD., Rapotín), with certificate of accreditation. The following abbreviations were used for MIs: F = fat (g 100 g^{-1}, %); L = lactose (monohydrate %); DM = dry matter (%); SNF = solid non fat (%); SCC = somatic cell counts (thousand ml^{-1}); U = urea concentration (mg 100 ml^{-1}); A = acetone concentration (mg l^{-1}); CA = citric acid concentration

* This paper was supported by projects MSM 2678846201 and LA 331 (INGO), both MSMT.

(mmol l^{-1} or %); EC = electrical conductivity (mS cm^{-1}); MFP = milk freezing point (°C); SW = specific weight (g cm^{-3}); AS = alcohol stability (ml of 96% ethanol at milk titration /5 ml/ up to visible precipitation); TA = titration acidity (in ml × 2.5 mmol l^{-1} NaOH solution); pH = active acidity; RCT = rennet coagulation time (s); CF = curds firmness (depth of stick plastic body penetration into curds cake in mm after its fall under standard conditions – firmness in the contrary sense, the lower number the higher firmness); CQ = curds quality (in classes, from 1 = good to 4 = poor); WV = whey volume (in ml; whey was ejected during rennet curds cake creation for 60 minutes); CP = crude protein content (Kjeldahl, total N×6.38, %); CAS = casein content (casein N×6.38, %); TP = true protein content (protein N×6.38, %); WP = whey protein content (difference TP-CAS, %); NPN = non protein nitrogen matters (CP nitrogen-TP nitrogen × 6.38, %); UNR = urea nitrogen ratio in non protein N in %; F/CP = fat/crude protein ratio; the casein numbers were calculated on the basis of CP and TP = CAS-CP and CAS-TP in %; macroelements such as Ca, P, Na, K and Mg (in mg kg^{-1}); microelements such as I (in g l^{-1}) and Mn, Fe, Cu, Zn and Ni (in mg kg^{-1}); RIS = residues of inhibitory substances in milk = antibiotic drugs (positive, negative).

The processing of the results included calculation of basic statistical parameters, regression analysis and correlation coefficients were calculated by Microsoft Office Excel 2003 programme. The B results were used as reference.

RESULTS AND DISCUSSION

The main statistical characteristics of investigated MIs were shown in our previous papers in all details (H a n u š et al., 2008; G e n č u r o v á et al., 2008). This work is focused on the explanation of relationships between MFP and other MIs in goat milk. All RIS investigations were negative. It means that the residues of inhibitory substances did not influence the results of milk technological properties. The average goat MFP was –0.5544 ± 0.0293 C (similar value reported by J a n š t o v á et al., 2007; –0.5513 ± 0.0046 C) and differed (P < 0.001) from B cow MFP –0.5221 ± 0.0043 (also from –0.532 ± 0.005; H a n u š et

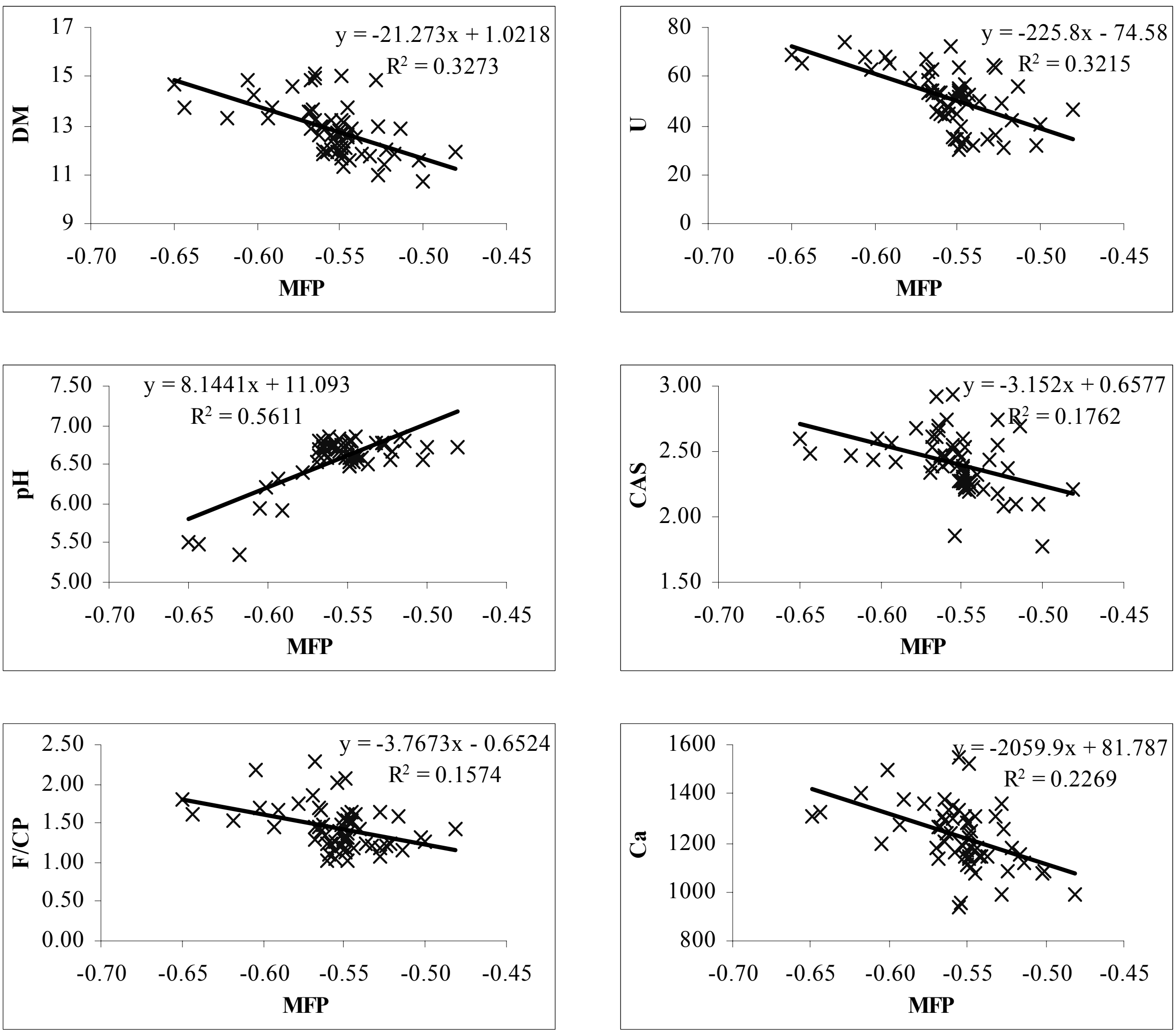

Fig. 1. Selected significant regressions and correlations between MFP (°C) and DM (%), U (mg 100 ml^{-1}), pH, CAS (%), F/CP and Ca (mg kg^{-1})

Table 1. Significant regressions and correlations between MFP and other MIs

MI	Regression equation	R^2	r, Significance
F	$y = -15.946x - 4.2657$	0.2342	–0.48***
SNF	$y = -5.3269x + 5.2875$	0.1282	–0.36**
DM	$y = -21.273x + 1.0218$	0.3273	–0.57***
U	$y = -225.8x - 74.58$	0.3215	–0.57***
TA	$y = -18.485x - 2.5963$	0.0968	–0.31*
pH	$y = 8.1441x + 11.093$	0.5611	0.75***
RCT	$y = 575.78x + 409.12$	0.1030	0.32*
WV	$y = 55.961x + 61.661$	0.0896	0.30*
CP	$y = -2.5736x + 1.7576$	0.0947	–0.31*
CAS	$y = -3.152x + 0.6577$	0.1762	–0.42**
TP	$y = 2.0496e^{-0.6266x}$	0.0635	0.25*
WP	$y = 1.4478x + 1.3054$	0.1490	0.39**
NPN	$y = -0.8494x - 0.1938$	0.1536	–0.39**
F/CP	$y = -3.7673x - 0.6524$	0.1574	–0.40**
CAS–CP	$y = -38.838x + 53.967$	0.1133	–0.34**
CAS–TP	$y = -60.61x + 49.071$	0.2150	–0.46**
Ca	$y = -2059.9x + 81.787$	0.2269	–0.48**
Fe	$y = 1.3638x + 1.0413$	0.0737	0.27*

R^2 – determination coefficient; r – correlation coefficient; *, ** and *** – statistical significance $P \leq 0.05$, ≤ 0.01 and ≤ 0.001, ns – $P > 0.05$

al., 2008; Holstein cows) and from C ewe MFP –0.6048 ± 0.0691 C (M a c e k et al., 2008). MFP was influenced by contents of some indicators: fat (4.58 W vs. 3.40% B; $P < 0.001$); urea (50.6 W vs. 26.7 mg 100 ml^{-1} B; $P < 0.001$); calcium (1224 W vs. 1300 mg kg^{-1} B; $P < 0.01$). L was 4.43 W vs. 5.06% B ($P < 0.001$).

There are shown the significant relationships of goat MFP to other MIs in Table 1 and some selected relationships in Fig. 1. The regression equations, the coefficients and indexes of determination and correlation were included. We can observe the statistical significant relations between MFP and: F –0.48; SNF –0.36; DM –0.57; U –0.57; pH 0.75; CAS –0.42; WP 0.39; NPN –0.39; F/CP –0.40; Ca –0.48. However, very surprising was finding that the relationship between MFP x L was not significant and the same was confirmed for MFP x EC. This fact is not in agreement with results of K o o p s et al. (1989). D e m o t t (1969) and B r o u w e r (1981) reported that lactose content causes 53.8% of the MFP depression in cows. Further, in declining approx. order, K^+ 12.7%, Cl^- 10.5%, Na^+ 7.2%, citrates 4.3%, urea 1.9% and other components 6.9%. One of the most related indicators such as Na was not correlated significantly ($P > 0.05$) as well. According to our results relationships between MFP and Ca (–0.48, $P < 0.01$) and MFP and Fe (0.27, $P < 0.05$) were statistically significant. It means that MFP is improved with higher Ca content and is worsened with increased Fe.

It is apparent that in goat milk are not confirmed the rules valid in cow milk. We supposed that MFP will be modified with EC because EC is growing with deteriorated health state of mammary gland. High content of SCC in goat herd (G e n č u r o v á et al., 2008) in this case can indicate milk secretion disorders, which is combined with lactose shortage and higher concentration of sodium ions.

MFP is depending on animal nutrition (that means all forms of nitrogen, fat etc). The lower (better) MFP was connected with higher DM. The dependence of MFP on crude protein was confirmed (–0.31, $P < 0.05$), the relationships between MFP and TP , and MFP and WP were 0.25 ($P < 0.05$) and 0.39 ($P < 0.01$), respectively. The casein numbers were in negative correlations to MFP ($P < 0.01$). The better MFPs are connected with higher values of CAS, CAS-CP, CAS-TP. NPNs were related to MFP in negative way (–0.39, $P < 0.01$), that means MFP values are better when NPNs are higher. The same tendency is apparent from correlations MFPxU (–0.57, $P < 0.001$). That means the high urea concentrations (which is one of components in non-protein matter fraction) can cause better value of MFP. 32.7 and 32.2% of variations in MFP could be explained by variations in DM and U. Milk urea is one of the indicator of animal nutrition and together with milk fat and F/CP ratio is good indicator of energy balance during lactation. Higher milk U could cause better goat MFP directly by its chemical and physical (osmotic) influence in milk and of course, also in link with relative surplus of nitrogen matters as compared to the energy dotation in goat nourishment. Also C h l á d e k and Č e j n a (2005) calculated statistically significant correlation coefficients $r = -0.34$ for H and –0.39 for B breed and K i r c h n e r o v á and F o l t y s (2005) found correlation coefficient r = –0,45. The ratio F/CP was related to MFP in negative way (–0.40, $P < 0.01$), similar relation is mentioned above for relationship between MFP and F.

The higher MFP was connected with higher pH. 56.1% of variation in MFP can be explained by pH variations.

The observed relationships of MFP to the milk technological properties were slight, but significant ($P < 0.05$), MFP influenced TA and some cheeseability indicators (RCT, WV) indicated the effects with respect to MFP variations. Some relations were observed in comparison to cows (B) between goat MFP and: fat (–0.48, $P < 0.001$, W vs. –0.06, $P > 0.05$, B); dry matter content (–0.57, $P < 0.001$, W vs. –0.07, $P > 0.05$, B); urea (–0.57, $P < 0.001$, W vs. 0.01, $P > 0.05$, B); pH (0.75, $P < 0.001$, W vs. –0.46, $P < 0.001$, B); Ca (–0.48, $P < 0.01$ W vs. 0.12, $P > 0.05$, B); casein (–0.42, $P < 0.01$, W vs. –0.10, $P > 0.05$, B). There were not stated the significances ($P > 0.05$) for relationships of MFP to row of goat MIs: L; SCC and log SCC; A and log A; AS; EC; CQ; CF; SW; UNR; CA; P; Na; Mg; K; I; Mn; Cu; Zn; Ni.

CONCLUSIONS

More relations between MFP and other MIs in goats were investigated, the selected ones are presented here. Interspecific comparison of relationships between milk indicators showed often different or sometimes opposite dependencies in terms of trends, what could be caused by interspecific physiological differences but also by different levels of somatic cell counts of compared data sets (species). On the basis of obtained results the surprising finding is that MFP was not influenced by L, Na (the main components created MFP in cow milk), there is not correlation between MFP x EC, MFP x log SCC. However, these data are important for estimation of the correct value of goat MFP under CR conditions and some illogical relationships between MFP and some indicators and properties could be still confirmed. By obtained results probably it could be possible to derive the more effective rules for better monitoring and prevention against milk quality problems in small ruminants.

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Received for publication on August 6, 2008
Accepted for publication on September 8, 2008

GENČUROVÁ, V. – HANUŠ, O. – VYLETĚLOVÁ, M. – LANDOVÁ, H. – JEDELSKÁ, R. (Agrovýzkum Rapotín, Vikýřovice, Česká republika; Výzkumný ústav pro chov skotu, Rapotín, Vikýřovice, Česká republika):

Vztahy mezi bodem mrznutí, složením a vlastnostmi kozího a kravského mléka.

Scientia Agric. Bohem., *39*, 2008: 324–328.

V lidské výživě může být kozí mléko alternativou pro ty, kteří mají problémy s trávením kravského mléka. Proto bylo provedeno srovnání s mlékem kravským, zejména ve vztahu k bodu mrznutí mléka (MFP) jako důležitému fyzikálnímu ukazateli (MI). Byly vyšetřeny bazénové vzorky mléka (/BMSs/ – jeden vzorek od 4 až 8 zvířat) na 39 MIs. Kozy (bílá krátkosrstá /W/, n = 60 BMSs) a krávy (český strakatý skot /B/, n = 93) byly vzorkovány po tři roky v zimní a letní sezoně. Z výsledků je zjevné, že kozí mléko má nižší hodnotu MFP (–0,5544 °C; W) než kravské (–0,5221 °C; B; P < 0,001). Je to způsobeno specifickými fyziologickými rozdíly mezi druhy. Ty ovlivnily obsahy některých MIs: tuk (4,58 W vs. 3,40 % B; P < 0,001); močovina (50,6 W vs. 26,7 mg 100 ml^{-1} B; P < 0,001); kalcium (1224 W vs. 1300 mg l^{-1} B; P < 0,01). Obsah laktózy (monohydrát) byl 4,43 W vs. 5,06 % B (P < 0,001). Některé významné vztahy (korelační koeficienty nebo indexy z lineární nebo nelineární regrese) byly pozorovány mezi kozím MFP a: tukem (–0,48, P < 0,001, W vs. –0,06, P > 0,05, B); obsahem sušiny (–0,57, P < 0,001, W vs. –0,07, P > 0,05, B); močovinou (–0,57, P < 0,001, W vs. 0,01, P > 0,05, B); pH (0,75, P < 0,001, W vs. –0,455, P < 0,001, B); Ca (–0,48, P < 0,01 W vs. 0,12, P > 0,05, B); kaseinem (–0,42, P < 0,01, W vs. –0,10, P > 0,05, B) atd. Srovnávané vztahy se často lišily mezi druhy nebo byly někdy opačné ve smyslu trendů, což by mohlo být zapříčiněno mezidruhovými rozdíly, ale také různými úrovněmi somatických buněk srovnávaných druhů.

přežvýkavec; koza; kráva; mléko; bod mrznutí mléka; složení mléka

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