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A COMPARISON OF SELECTED MILK INDICATORS IN ORGANIC HERDS WITH CONVENTIONAL HERD AS REFERENCE

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ABSTRACT

In a historical sense, current organic farming is an old-new alternative under changed world conditions. Organic dairying (O) is an alternative of friendly use of the environment in time of presupposed global climate changes. Potential impact of organic farming on raw cow-milk quality, composition and properties, as compared to conventional milk production (C), were evaluated in this paper on the basis of selected milk indicators (MIs). Total solids, whey volume, pH of milk fermentation ability (FAM-pH), FAM streptococci, FAM noble lactic acid bacteria, I and Cu were higher in C milk ($P < 0.05$). The alcohol stability (AS), titration acidity, curd firmness (CF), FAM titration acidity (FAM-T), Ca, P, Mg, K and Fe were higher in O milk ($P < 0.05$). No differences ($P > 0.05$) were observed in pH, rennet coagulation time, curd quality, FAM lactobacilli and streptococci/lactobacilli, Na, Mn and Zn. In general, the differences were a little more advantageous for O milk from both technological and nutritional point of view, particularly because of AS (0.46 < 0.58 ml, C vs. O), CF (1.88 > 1.81 mm), FAM-T (27.3 < 33.8 ml of 0.25 mol.l^{-1} NaOH.100ml^{-1}), FAM-pH (5.1 > 4.6), Ca (1172 < 1257 mg.kg^{-1}), P (950 < 1004 mg.kg^{-1}) and Mg (107.4 < 112.0 mg.kg^{-1}) results. Organic milk can also produce better environment for yoghurt fermentation. Nevertheless, the results obtained should not be overestimated as both sources produced milk of good quality. Additional results are needed to prove organic milk benefits.

Key words: conventional farming; cow; environment; Holstein; macroelement; microelement; milk yield; organic farming; technological property

INTRODUCTION

In a historical sense, current organic farming is an old-new alternative under changed world conditions. The importance of organic farming in less favourable areas was described by Šarapatka *et al.* (18). Organic dairying (O) is an alternative ofr friendly use of the environment in time of the presupposed global climate changes (1, 2, 3, 4, 5, 6, 13, 14, 15, 19). There is a lack of information about quality of raw milk from organic farms. One opinion is that milk quality has not changed under environmentally friendly, natural dairy management on organic farms (16). It has been felt that organic farming improves animal welfare and health.

Hlásný (10, 11) predicted an increase in milk Mg content (also milk Ca and Na concentrations) up to the former level due to general decrease in artificial NPK soil fertilization under conditions in the Czech Republic (CR) resulting in relevant changes in mineral composition of fodder crops. In this way he identified the higher milk Mg content as a potential indicator of higher ecology level in agriculture. This hypothesis was derived from the well known antagonistic relationships between K soil fertilization (if higher), consecutive Mg (also Ca and Na) level (lower) in cultural plants (roughage) and cow feed rations and possible transfer of Mg ions into milk.

The present study focused on evaluation of potential impact of organic farming on raw cow-milk quality, composition and properties as compared to the current conventional milk production.

MATERIALS AND METHODS

The altitude of investigated farms was 361.5 ± 121.2 m for O herds and 257 m for C herd. Bulk milk samples (BMSs; each from eight dairy cows) were obtained regularly every two weeks in winter and spring seasons of one year from one conventional (C) Holstein (H) herd (150 cows; n = 36 BMSs, 8 cows in one BMS) and two times in winter and summer seasons of one year from four organic dairy herds (O; n = 16 whole BMSs). The number of cows (H) in the four investigated O herds ranged between 25 and 400. The cows were fed in a way typical of O herds under the CR conditions (alfalfa, clover and grass silage, hay, concentrate and mineral mixtures in the form of total mixed rations (TMR) according to relevant milk yield (MY) and standard demands). The O herds were kept in free stables and grazed during summer as it is stipulated by law on organic farming in the CR. The C herd was kept in free stable and fed TMR throughout the year (maize, alfalfa, clover and grass silage, hay, concentrate and mineral mixtures according to relevant milk yield (MY) and standard demands). All cows were milked twice a day. Other farm characteristic about MYs and herds were recorded as well.

Milk analyses were performed regularly by an accredited testing laboratory in Rapotin (n. 1340, EN ISO 17025, Accreditation certificate No. 124/2004) according to standard operation manuals currently in force. The following abbreviations and units were used for the investigated milk indicators: TS = total solids (%); AS = alcohol stability (ml, consumption of 96 % ethanol for protein coagulation in 5 ml of milk); TA = titration acidity according to Soxhlet-Henkel (ml 0.25 $mol.l^{-1}$ NaOH solution for the titration of 100 ml of milk); pH = actual milk acidity; RCT = rennet coagulation time (second); CQ = subjective estimation of curd cake quality determined by examination and palpation and graded from 1 (excellent) to 4 (poor); CF = cheese curd firmness = depth of penetration of the corpuscle falling into curd cake in a standard way, the value is the opposite to firmness (mm); WV = whey volume, obtained during the process of enzymatic cheesemaking from the curd cake (ml); FAM-T = fermentation ability of milk, i. e. the yoghurt test (incubation with thermophilic yoghurt culture YC-180-40-FLEX = *Streptococcus thermophilus*, *Lactobacillus delbrueckii* subsp. *lactis* and *L. d.* subsp. *bulgaricus* at 43 °C for 4 hours) with microbial culture (by the titration of yoghurt acidity in ml of 0.25 $mol.l^{-1}$ NaOH.100 ml^{-1}); FAM-pH (actual acidity of yoghurt, pH); FAM-LAB (noble lactic acid bacteria in $CFU.ml^{-1}$; CFUs were counted on plates with GTK M (Milcom Tábor) agar with glucose monohydrate, triptone-peptone, dehydrated yeast extract and skim milk powder after conventional incubation at 30 °C for 72 hours); FAM-L (lactobacilli in $CFU.ml^{-1}$); FAM-S (streptococci in $CFU.ml^{-1}$); FAM-RSL (ratio streptococci/lactobacilli), all the previous indicators for FAM were measured after the yoghurt test fermentation; residues of inhibitory substances (+/-; by microbiological Delvo-test, mostly antibiotic drugs); Ca, P, Na, Mg, K and I, Mn, Fe, Cu and Zn as milk macro- and microelements were expressed in $mg.kg^{-1}$ (with the exception of I = $\mu g.l^{-1}$).

TS was determined by means of MilkoScan 130 B (Foss Electric, Denmark) with regular calibration according to relevant reference method results. Active acidity was measured by a pH-meter CyberScan 510 (Eutech Instruments) at 20 °C. The instrument was regularly calibrated by standard buffer solutions (pH 4.0 and 7.0 Hamilton Duracal Buffer, Switzerland) for measurement of each milk sample set. Chemical elements were determined by atomic absorption spectrophotometer SOLAAR S4 plus GFS97 (Graphite Furnace). Milk iodine (I) concentration was determined photometrically at 420 nm using alkaline mineralization (KOH), brucine (modified Sandell-Kolthoff reaction) and an apparatus Spekol 11 (Carl Zeiss, Jena, Germany).

Statistical processing of data included determination of basic statistical parameters and testing of differences. C milk results were used as a reference for comparison with O milk. To ensure more accurate statistical evaluation, the milk quality indicators with abnormal frequency distribution of values were transformed logarithmically.

RESULTS AND DISCUSSION

The MY of the C herd was 8 900 kg and average MY of O herds was 7037 ± 422 kg per lactation. The C herd milk yield was higher by 26.5 %. The MY was higher by 17 % in the C herds in the Czech Republic (17). All Delvo-test results were negative, i. e. investigation of milk technological properties was carried out on milk samples free of residues of inhibitory substances (mostly antibiotics) which is important for validation of results of fermentation tests.

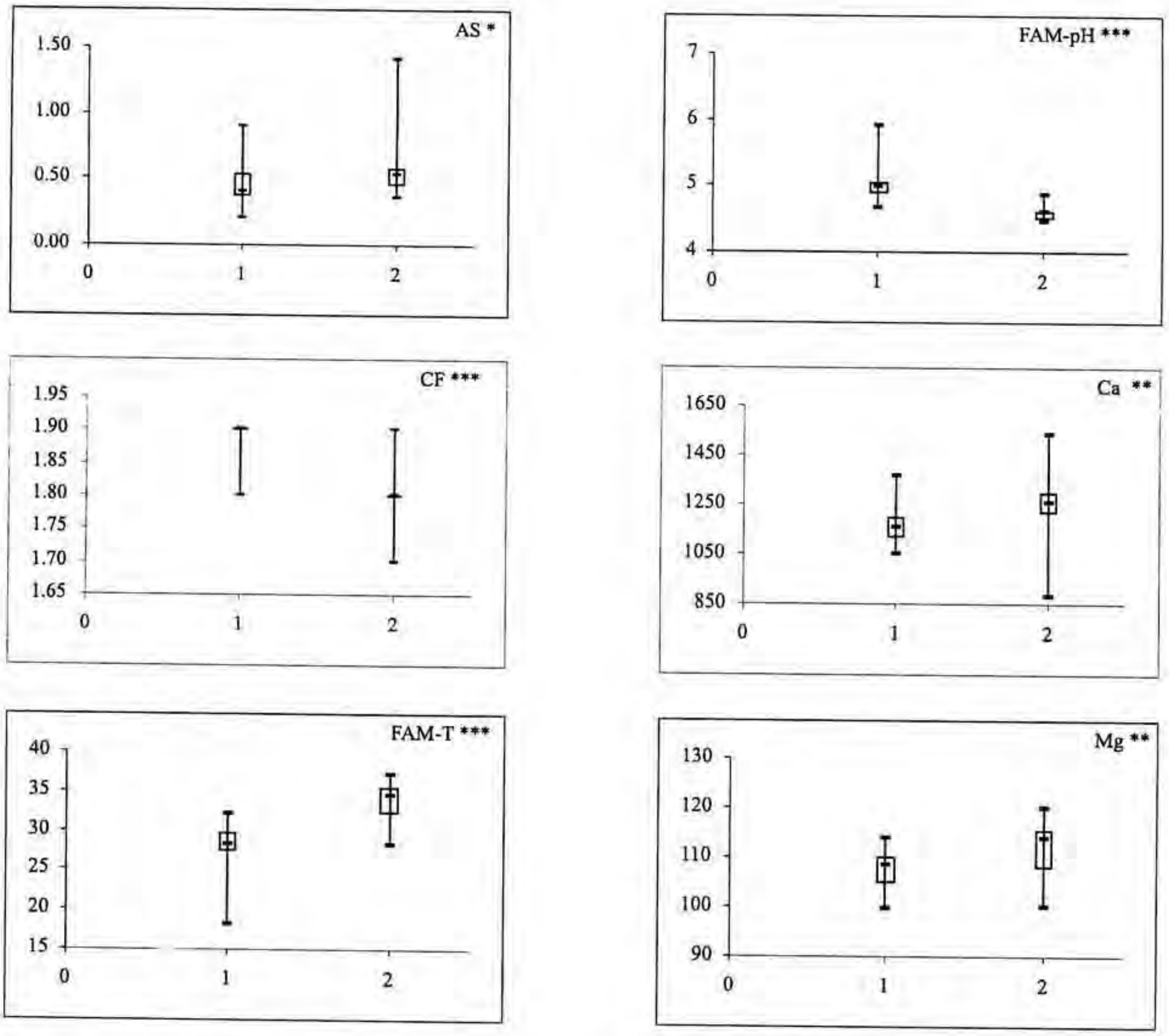
Table 1 shows that TS, WV, FAM-pH, FAM-S, FAM-LAB, I and Cu were significantly higher in C milk. On the other hand AS (Fig. 1), TA, CF, FAM-T, Ca, P, Mg, K and Fe were significantly higher in O milk. There were no significant differences in pH, RCT, CQ, FAM-L, FAM-RSL, Na, Mn and Zn between C and O milk. Overall, the differences mentioned were slightly more advantageous for O milk from both technological and nutritional point of view, particularly because of AS (0.46 < 0.58 ml, C vs. O), CF (1.88 > 1.81 mm), FAM-T (27.3 < 33.8 ml of 0.25 $mol.l^{-1}$ NaOH.100ml^{-1}), FAM-pH (5.1 > 4.6), Ca (1172 < 1257 $mg.kg^{-1}$), P (950 < 1004 $mg.kg^{-1}$) and Mg (107.4 < 112.0 $mg.kg^{-1}$) results. The difference in iodine (Tab. 1) could be ascribed to regular use of iodine disinfectant for the treatment of teats on C farms to prevent mastitis. Such treatment is less frequent in O herds.

The results (Tab. 1 and Fig. 1) also showed that with regard to FAM, O milk could produce slightly better environment for yoghurt fermentation than C milk because of acidity results (FAM-pH (4.60 < 5.08; $P < 0.001$) and FAM-T (33.76 > 27.27 ml; $P < 0.001$)) despite the fact that counts of noble bacteria (FAM-L, FAM-S and FAM-LAB) were a little lower. It could be related to higher metabolic activity under the mentioned conditions. However, also the basic initial TA was higher in O milk, so the obtained results should not be overestimated. Nevertheless, in terms of basic quality, both sources of milk were good.

Table 1. Differences in cow milk mineral composition and properties between conventional (C) herd and organic (O) herds

MI	Unit	C			O			sign.
		x	sd	vx	x	sd	vx	
TS	%	12.83	0.472	3.7	12.49	0.293	2.3	*
AS	ml	0.46	0.169	36.7	0.58	0.240	41.4	*
TA	ml	7.17	0.521	7.3	8.71	0.476	5.5	***
pH		6.70	0.052	0.8	6.68	0.028	0.4	Ns
RCT	sec.	177	33.739	19.1	163	37.725	23.1	Ns
CQ	class	2.81	0.786	28.0	2.63	0.806	30.6	Ns
CF	mm	1.88	0.038	2.0	1.81	0.057	3.1	***
WV	ml	32.78	1.758	5.4	30.38	4.870	16.0	*
FAM-T	ml	27.27	4.000	14.7	33.76	2.303	6.8	***
FAM-pH		5.08	0.331	6.5	4.60	0.118	2.6	***
FAM-L	$CFU.ml^{-1}$	43702778	24120785	55.2	32437500	15248907	47.0	Ns
Log		7.5524	0.3139		7.4674	0.2022		Ns
FAM-S	$CFU.ml^{-1}$	1345277778	961417068	71.5	718125000	235633013	32.8	*
Log		9.0303	0.3052		8.8289	0.1689		*
FAM-LAB	$CFU.ml^{-1}$	1388980556	979634387	70.5	750562500	242431837	32.3	*
Log		9.046	0.3032		8.8492	0.165		*
FAM-RSL		33.0771	13.828	41.8	25.8927	14.510	56.0	Ns
Ca	$mg.kg^{-1}$	1172.01	81.813	7.0	1257.25	138.502	11.0	**
P	$mg.kg^{-1}$	950.06	55.142	5.8	1004.44	74.138	7.4	**
Na	$mg.kg^{-1}$	452.97	30.013	6.6	467.06	75.834	16.2	Ns
Mg	$mg.kg^{-1}$	107.41	3.470	3.2	112	5.955	5.3	**
K	$mg.kg^{-1}$	1563.45	52.669	3.4	1682.56	58.516	3.5	***
I	$\mu g.l^{-1}$	462.84	103.916	22.5	174.31	116.274	66.7	***
Mn	$mg.kg^{-1}$	0.02	0.005	25.0	0.02	0.007	35.0	Ns
Fe	$mg.kg^{-1}$	0.15	0.070	46.7	0.27	0.206	76.3	**
Cu	$mg.kg^{-1}$	0.08	0.023	28.8	0.06	0.008	13.3	**
Zn	$mg.kg^{-1}$	4.20	0.616	14.7	3.86	0.583	15.1	Ns

MI – milk indicator; x – arithmetical mean; sd = standard deviation; vx = variation coefficient (in %); statistical significance: *, **, ***, ns = $P \leq 0.05$, ≤ 0.01 and ≤ 0.001, $P > 0.05$, resp.; TS = total solids; AS = alcohol stability; TA = titration acidity; pH = milk acidity; RCT = rennet coagulation time; CQ = curds cake quality; CF = curd firmness; WV = whey volume; FAM-T = fermentation ability of milk by titration; FAM-pH (at determined acidity); FAM-LAB (noble lactic acid bacteria); FAM-L (lactobacilli count); FAM-S (streptococci count); FAM-RSL (ratio streptococci/lactobacilli)



Box graph: median (the central short horizontal line); top edge of 1st and 3rd quartile (the tetragon); variation range, maximum – minimum (the vertical line); AS = alcohol stability; CF = curd firmness; FAM-T = fermentation ability of milk by titration; FAM-pH (at determined acidity))

Fig. 1. Example of data distribution in sets of AS, CF, FAM-T, FAM-pH, Ca and Mg in conventional (1) herd and organic (2) herds

The results mentioned above (increase in Ca and Mg) are in agreement with our previous results (7, 8, 9) and more or less (Mg increase) with the results reported by Janů *et al.* (12). Hlásný (10, 11) mentioned higher Mg content in milk in the period with lower use of mineral NPK fertilization in the fifties of the past century. Between 1980 and 1989 the level of NPK fertilization was relatively high in the CR (1986–1989, 230.4 kg of mineral nutrients per hectare without natural organic fertilizers) and was comparable or a little lower compared to the present level in many developed countries. After 1989 the mineral NPK fertilization in CR was reduced dramatically (by 68.3 %) due to economic reasons (1991–2000, 73.1 kg). Also the current application of NPK artificial fertilizers on O farms (0 kg according to relevant law on organic farming) is completely different as compared to C farms (2005–2006, 95.6 kg). The results obtained showed that the system of rearing of dairy cows can influence significantly milk mineral composition and properties and that the above mentioned hypothesis (10, 11) about possible mineral composition change (increase in milk Mg and Ca) stands on a real basis.

Another explanation of increased content of Ca could be related to the fact that organic dairy cows spend more time on pasture exposed to solar radiation as compared to C herds in cowsheds. Thus organic cows may utilize Ca from feedstuffs more effectively than dairy cows in conventional herds with respect to physiological presumption of better calciferol production.

CONCLUSIONS

The results obtained showed that organic milk could be a slightly better source of calcium, phosphorus and magnesium in human nutrition at comparable milk yield of dairy cows and low NPK soil fertilization, but also inferior source of iodine as compared to conventional milk. Organic milk can also produce slightly better environment for yoghurt fermentation. In general, the changes detected in organic milk were more advantageous for human nutrition and dairy technology. Nevertheless, there is still lack of results which prevents us to draw final conclusions and therefore the results presented should not be overestimated. Both sources produced milk of good quality. More research is needed to asses unambiguously organic milk benefits.

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