# Quality of Cows' Milk from Organic and Conventional Farming

Lenka KOUŘIMSKÁ[1], Veronika LEGAROVÁ[1], Zdeňka PANOVSKÁ[2] and Jan PÁNEK[2]

[1]Department of Quality of Agricultural Products, Faculty of Agrobiology, Food and Natural Resources Czech University of Life Sciences Prague, Prague, Czech Republic; [2]Department of Food Analysis and Nutrition, Faculty of Food and Biochemical Technology, Institute of Chemical Technology Prague, Prague, Czech Republic

**Abstract**

Kouřimská L., Legarová V., Panovská Z., Pánek J. (2014): **Quality of cows' milk from organic and conventional farming.** Czech J. Food Sci., **32**: 398–405.

The results of chemical and microbial analyses of raw milk samples coming from organic and conventional farming systems were statistically compared. The samples were analysed during a twelve-month period (June–May). A total of 2206 samples were collected of which 528 were organic. After raw milk was processed, sensory hedonic quality of 171 pairs of organic and conventional non-standardised pasteurised whole milk samples were evaluated using the pair comparison preference test. Four parameters in raw milk, free fatty acids, urea content, somatic cell count and coliform bacteria count, showed no significant differences between the two types of production. Significantly higher contents of protein, casein, lactose, and non-fat solids were detected in conventional milk, which also had a significantly lower freezing point. On the contrary, significantly higher contents of total mesophilic bacteria count and a higher percentage of samples with positive coliform bacteria count were found in organic milk samples. Sensory analysis of pasteurised milk showed no significant hedonic difference between organic and conventional samples.

**Keywords**: hedonic evaluation; microbiological quality; milk composition; Holsein cattle

The prosperity and development of organic agriculture has been recently noticed and the need for the objective assessment and analysis of organic products arises. Organic products, including milk, are produced in compliance with the legislative conditions of organic farming (Commission Regulation (EC) No. 889/2008 and Act No. 242/2000 in the Czech Republic). The evaluation of organic systems is focused mainly on meeting the legal conditions of production without any special assessment of the final product. Consumers buy organic because they believe it is a healthier choice. "Food naturalness" (no artificial flavours, additives or colourings), domestic origin, no use of chemical fertilisers, natural, healthy and no toxins (Hill & Lynchehaun 2002; Stolz *et al.* 2011), as well as no use of genetically modified organisms are the attributes often used by consumers to distinguish between organic and conventional products. Furthermore the gender (mainly middle-aged women with an educational level of high school or less belong to the group of likely consumers of organic food products), a higher income level, the presence of children may indicate a higher likelihood to purchase organic products (Gil *et al.* 2000; Michaelidon & Hasssan 2008). Current food research, however, cannot support extensive health benefits or harms by consuming organic vs. conventional products (Hajšlová *et al.* 2005; Schulzová *et al.* 2007; Komprda 2009). The evaluation of the influence of the milk production type on the health status of human is very controversial. According to Ellis *et al.* (2007b) and Dangour *et al.* (2010a,b), there was still lacking evidence for nutrition-related health effects resulting from the consumption of organic food. However, Kummeling *el al.* (2008) found a decreased eczema

Supported by the Ministry of Education, Youth and Sports of the Czech Republic, Project No. MSM 6046137305, and "S grant" and Project No. MSM 6046070901.

risk when children consumed organic dairy products. Popović-Vranješ *et al*. (2012) considered a better impact of organic milk on the health of consumers using holistic methods such as biocrystallisation and rising picture methods.

Comparing organic and conventional cows' milks, most of research focuses on the changes of its composition. For example, Sakowski *et al*. (2012) discuss the effect of breeding on the contents of conjugated linoleic acid (CLA) and lipophilic vitamins. In their experiment, Holstein Friesian dairy cows kept in organic herds gave milk with a higher level of antioxidants. The lower milk yield of these cows had a positive impact on the higher level of vitamins A, E, and $D_3$ as well as on the beneficial fatty acids content compared to the conventional group. Butler *et al*. (2009, 2011a,b), Prandini *et al.* (2009), O'Donnell *et al*. (2010), and Popović-Vranješ *et al*. (2011) show the positive effect of organic farming residing in increasing the content of n-3 PUFA (as α-linolenic acid), CLA, vitamin A, and antioxidants (α-tocopherol, lutein, zeaxanthin, and β-carotene) in milk; substances that are generally considered beneficial to health (Halliwell 1996; McGuire & McGuire 1999; Lemaitre e*t al*. 2003).

Organic milk has a dominant position among organic foods. There are a number of comparative studies on the composition and properties of organic and conventional cows' milks. According to some authors, milk from organically certified systems contains more polyunsaturated fatty acids including n-3 polyunsaturated fatty acids and CLA (Ellis *et al.* 2006; Bloksma *et al.* 2008; Popović-Vranjes *et al.* 2010; Butler *et al*. 2011b), vitamins, and calcium (Bergamo *et al.* 2003; Butler *et al.* 2008). The more favourable fatty acids profile of organic milk in these studies has been mainly associated with organic diets richer in fresh grass and clover which conventional diets are based on silage and concentrates. Slots *et al.* (2009) and Stergiadis *et al.* (2012) also confirmed that the composition of milk is associated with the feeding strategy of the farm.

On the contrary, Rey-Crespo *et al.* (2013) found significantly lower essential trace element concentrations (Cu, Zn, I, and Se) in organic milk because these elements are routinely supplemented at high concentrations in the conventional concentrate feed.

Many consumers appreciate sensory hedonic aspects in organic products, which can also be explained on the ground of differences in the feeding regimes commonly used in organic farming herds (Croissant *et al.* 2007; Kalač 2011). Milk from dairy cows fed on grass and legumes silage (organic farming) has a different flavour compared to that of milk from cows fed on maize silage (conventional farming), that may affect sensory characteristics (Mogensen *et al.* 2010).

Although there are many papers comparing basic milk composition and other parameters of organic vs conventional milk, there are no studies in the Czech Republic on casein, free fatty acids, freezing point values, and microbiological safety reflected by coliform bacteria as well as on the sensory quality of organic and conventional milks. The aim of this study was therefore to determine whether there is any difference between organic and conventional systems in the composition parameters of raw milk from the same area and time of the year as well as in the sensory evaluation.

## MATERIAL AND METHODS

***Milk samples.*** Bulk tank samples of raw cows' milk (Holstein breed) delivered for analysis to the central milk laboratory over the period of one year (June–May) were compared. The samples were collected from farms in the middle of each month throughout the year. A total of 2206 samples of milk were collected, 528 of which were from organic farming systems certified in compliance with Act No. 242/2000. Basic milk components (fat, protein, lactose, non-fat solids, and casein) were monitored, as well as other quality indicators (total mesophilic bacteria count, coliform bacteria, somatic cell count, freezing point, urea and free fatty acid contents). Non-standardised samples of pasteurised homogenised whole milk were used for the sensory evaluation.

***Instrumental analysis.*** The analyses of raw milk samples were carried out on the following instruments: Bentley 2300, 2500 (Bentley Instruments, Inc., Chaska, USA) and MilcoScan FT 6000 (Foss-Electric, Hillerød, Denmark) were used for fat, proteins, casein, lactose, and non-fat solids contens; Ureakvant (Agroslužby Olomouc, s.r.o., Czech Republic) for urea content; Somacount 300, 500 (Bentley Instruments, Inc.) and Fossomatic FC (Foss-Electric, Hillerød, Denmark) for somatic cell count; BactoCount IBC (Bentley Instruments, Inc.) for total mesophilic bacteria count, and CryoStar automatic (Bentley Instruments, Inc.) for freezing point determination. The coliform bacteria count was determined by cultivation at 30°C for 24 h (ISO 4832:2006).

***Sensory analysis.*** The sensory hedonic quality of 171 pairs of organic and conventional non-standardised pasteurised whole milk samples was evaluated using the pair comparison preference test (ISO 5495:2005). The pair comparison test was used because this method is effective for determining whether any perceptible differences exist. The ISO standard for this test was reprinted in 2005 and describes a new statistical approach.

The sensory panel comprised employees and students of the Department of Quality of Agricultural Products, Czech University of Life Sciences Prague. The panellists were selected, trained, and monitored after ISO 8586-1:1993 and had special sessions for training in the evaluation of milk and dairy products (ISO 22935-1:2009). According to the new pair comparison test methodology, the values of $p_d$, α, and β were chosen as: α = 0.05; $p_d$ = 40%, and β = 0.001. In this case, there is a 95% confidence level that a high proportion of the assessors will be able to perceive the difference. Therefore the number of assessors should be at least 132.

***Statistical analysis.*** Raw milk samples results that did not meet the standard limits for milk (TMBC more than 100 × $10^3$ CFU/ml, SSC more than 400 × $10^3$/ml, fat less than 3.3 g/100 g, and the CBC more than 1500 CFU/ml) were excluded from statistical processing (Commission Regulation (EC) No 1662/2006; ČSN 57 0529). The remaining data were checked for the values below or above the given limits. Such observations were excluded from the analysis. In the case of positively skewed distribution, logarithmic transformation was used to adjust the data to normal distribution. First, the data were characterised using the mean and the standard deviation (SD). The impact of the factors "type of agriculture" and "month" was evaluated using two-way analysis of variance (ANOVA). In the case of significant difference, Scheffe's method was used to provide the multiple comparisons. To evaluate whether a relation occurrs between the type of agriculture and presence of coliform bacteria on a scale yes (1–1500 CFU/ml) or no (no colony detected), Pearson's chi-square test was used. All the analyses were performed using statistical software IBM SPSS Statistics, vers. 20 (IBM. Armonk, USA). For all statistical tests, 5% level of significance was used.

## RESULTS AND DISCUSSION

***Raw milk evaluation***. The results of analyses of raw cows' milk samples coming from organic and conventional farming are summarised in Table 1. Two-way ANOVA results of both types of farming are given in Table 2. Comparing the various components of milks from organic and conventional farming there was a statistically significant difference in the fat content of milk as well as in the effect of month. Milk from conventional agriculture had on average a lower fat content which is in line with Zagorska and Ciprovica (2008). The fat content shows certain seasonality during the year (the lowest content in summer and highest in winter) (results not shown). The average values are in accordance with other studies comparing organic and conventional milks (Toledo *et al.* 2002; Bergamo *et al.* 2003; Butler

Table 1. Chemical and microbiological analyses of raw milk samples from organic farming

| Milk component | Organic farming | | | | | Conventional farming | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | mean | SD | min | max | *n* | mean | SD | min | max |
| Fat (g/100 g) | 258 | 4.03 | 0.37 | 3.37 | 6.61 | 1265 | 3.99 | 0.33 | 3.31 | 7.00 |
| Proteins (g/100 g) | 258 | 3.28 | 0.18 | 2.90 | 3.87 | 1265 | 3.33 | 0.17 | 2.66 | 3.92 |
| Lactose (g/100 g) | 258 | 4.80 | 0.11 | 4.22 | 5.03 | 1265 | 4.84 | 0.13 | 3.92 | 5.11 |
| Non-fat solids (g/100 g) | 258 | 8.66 | 0.20 | 7.71 | 9.24 | 1265 | 8.74 | 0.23 | 7.47 | 9.32 |
| Casein (g/100 g) | 248 | 2.61 | 0.16 | 2.20 | 3.18 | 1181 | 2.66 | 0.16 | 2.00 | 3.09 |
| FFA (mmol/100 g fat) | 130 | 0.89 | 1.20 | 0.01 | 6.90 | 645 | 0.58 | 0.40 | 0.01 | 2.67 |
| Urea (mg/100 g) | 18 | 18.49 | 7.32 | 8.70 | 35.20 | 1265 | 25.70 | 8.30 | 6.00 | 57.50 |
| FP (°C) | 258 | –0.526 | 0.006 | –0.470 | –0.542 | 1265 | –0.529 | 0.008 | –0.427 | –0.592 |
| SSC (× $10^3$/ml) | 258 | 218 | 81 | 52 | 397 | 1265 | 230 | 78 | 38 | 400 |
| TMBC (× $10^3$ CFU/ml) | 218 | 28 | 22 | 5 | 100 | 1168 | 19 | 16 | 5 | 100 |
| CBC (× $10^1$ CFU/ml) | 101 | 45 | 36 | 10 | 141 | 473 | 48 | 36 | 11 | 147 |

FFA – free fatty acids; FP – freezing point; SSC – somatic cell count; TMBC – total mesophilic bacteria count; CBC – coliform bacteria count; *n* – number of samples; SD – standard deviation

Table 2. Two-way ANOVA results of raw milk samples from organic and conventional farming (*P*-values)

| Milk component | Farming system (FS) | Month (M) | Interaction FS×M |
|---|---|---|---|
| Fat | 0.030 | < 0.001 | 0.310 |
| Proteins | < 0.001 | < 0.001 | 0.153 |
| Lactose | < 0.001 | < 0.001 | 0.356 |
| Non-fat solids | < 0.001 | < 0.001 | 0.197 |
| Casein | < 0.001 | < 0.001 | 0.222 |
| FFA | 0.655 | < 0.001 | 0.024 |
| Urea | 0.080 | < 0.001 | 0.639 |
| FP | 0.001 | 0.069 | 0.025 |
| SSC | 0.060 | 0.001 | 0.504 |
| TMBC | < 0.001 | 0.159 | 0.088 |
| CBC | 0.682 | 0.070 | 0.415 |

FFA – free fatty acids; FP – freezing point; SSC – somatic cell count; TMBC – total mesophilic bacteria count; CBC – coliform bacteria count; statistically significant differences are indicated in bold

*et al.* 2008). In contrast to our results, some studies indicate a lower fat content in organic milk (Olivo *et al.* 2005; Nauta *et al.* 2006; Hanuš *et al.* 2008a; Kuczynska *et al.* 2012). These results between studies might be due to different breeds included in these experiments (Winter *et al.* 2002; Kühn *et al.* 2004) or to differences in nutrition of the cows whose milk was compared: high quality, coarsely chopped feed, provided in sufficient amounts available in organic farms (Zagorska & Ciprovica 2008).

The protein content was significantly lower in organic than in conventional milk. The seasonal difference was found mainly between the periods March to August and October to December (results not shown). Our findings agree with other studies focused on the comparison of the protein content between the two types of production (Olivo *et al.* 2005; Nauta *et al.* 2006; Hanuš *et al.* 2008a; Battaglini *et al.* 2009; Kuczynska *et al.* 2012). There was also a significant difference in the content of casein in milk (lower content in organic milk and late spring and summer months when compared with organic and winter months, respectively), which is also consistent with some published results (Hanuš *et al.* 2008a). Kuczynska *et al.* (2012) found higher concentrations of beneficial whey proteins in organic than in conventional milk. However, there are some studies present contradictory results. Butler *et al.* (2008) found a higher protein content in organic than in conventional milk but Toledo-Alonzo (2003), Zagorska and Ciprovica (2008), and Stergiadis *et al.* (2012) showed no difference in protein and/or casein contents between organic and conventional milks. The lower content of protein in organic milk can be explained by the lower amount of starch in organic diets which results from the lower amounts of concentrate feeds provided to cows. Another reason can be the lack of sugar-rich juicy feed, which stimulates the production of butyric acid used for protein synthesis (Zagorska & Ciprovica 2008). On the other hand, the alternative breeds used in organic farming (e.g. Jersey cows) might be able to compensate the loss of protein content by having the potential to produce milk with a high protein content (Carroll *et al.* 2006; Stergiadis *et al.* 2013).

Our analysis also showed a higher lactose content in conventional and winter milk which is in line with the findings of Kuczynska *et al.* (2012) but not in agreement with many previously published studies (Toledo *et al.* 2002; Olivo *et al.* 2005; Hanuš *et al.* 2008b; Battaglini *et al.* 2009). The content of lactose could be affected by the higher concentrations of sugar in cows' feeding (Zagorska & Ciprovica 2008) but according to Sutton (1989), only very small changes in lactose concentration occur in the response to diet. Another possible reason for the differences between the studies is the comparison of a smaller number of samples or samples from different breeds. Sabbioni *et al.* (2012) concluded that the effect of management system on different breeds is not the same. Higher protein and lactose contents in conventional milk additionally resulted in a statistically significant difference in non-fat solids in milk.

There is a lack of literature data comparing free fatty acid (FFA) content and freezing point (FP) of milks from organic and conventional farming. In our experiment, no significantly higher content of free fatty acids was detected in organic milk in comparison to conventional milk but there was a significant effect of month and the system by month interaction. The lowest FFA content was detected in milk coming from December. This may indicate a lower degree of lipolysis in winter caused by the enzyme lipase produced by rumen microorganisms (Bylund 1995). Higher levels of FFA in summer than in winter relating with different lipolytic activity can be explained by later stages of lactation occurring in summer (Chazal & Chilliard 1996). Organic milk also had a higher freezing point (–0.526°C) than conventional milk (–0.529°C) which depends mainly on the content of lactose, chlorides and other salts (Fox & McSweeny 1998). The variations in the freezing point of milk have been attributed to many factors including the feed, water intake, heat stress etc. A lower urea content in milk from organic farming was previously reported (Toledo *et al.* 2002; Toledo-Alonzo 2003; Hanuš *et al.* 2008a; Zagorska & Ciprovica 2008) but although the urea values were numerically smaller, this difference was not statistically significant probably due to the small number of samples analysed ($n$ = 18).

No statistically significant difference was found in the somatic cell count (SCC) in different types of milk production, being in consistency with Rosati and Aumaitre (2004), Battaglini *et al.* (2009) and Cicconi-Hogan *et al*. (2013). Other studies have, however, shown the opposite conclusion. Higher SCC in organic milk was found by Nauta *et al.* (2006) or Kuczynska *et al*. (2012) while Toledo *et al*. (2002), Olivo *et al.* (2005), and Cermanova *et al.* (2011) found a lower SCC in organic milk. These controversial findings may suggest that SCC could depend mainly on the hygiene and health status of dairy cows and not so much on the farming system. On the other hand SCC in bulk tank milk is not a clear indicator of mastitis incidences in the farm because cows treated for mastitis (high SCC) would be milked separately and their milk would not end up in the bulk tank samples.

Hygienically inferior environmental conditions (shortcomings in daily cleaning and disinfection of all milking equipment) are usually the main reason for poorer microbiological quality of milk (Bylund 1995). In our case the milk from organic farming had a higher total mesophilic bacteria count as well as a higher percentage of samples with positive coliform bacteria count (46.1% for organic and 37.4% for conventional milk, Pearson's chi-squared test, $P$ = 0.014). The comparison of coliform bacteria counts in the case of positive samples (CBC to 1500 CFU/ml), however, did not show differences between the types of farming or months. Previous studies from several countries showed no difference in bacteria count between organic and conventional milks (Sato *et al.* 2005; Ellis *et al.* 2007a; Muller & Sauerwein 2010). One possible reason could be the difference in the size of farm and the way of milking equipment disinfection.

***Pasteurised milk evaluation***. During the sensory analysis of whole pasteurised organic and conventional milks, panellists had to answer whether there is a difference between the samples. If so, they should have decided which sample of milk from the pair they preferred. There were a total of 171 pairs for the evaluation. The assessors responded that there was no difference between samples in 52 pairs (30%). Organic milk was preferred in 65 cases (38%) and conventional in 54 cases (32%) but these results did not differ significantly. According to Croissant *et al.* (2007) and Mogensen *et al.* (2010), maize silage, fresh grass, and other feed components that are routinely fed in different amounts in organic and conventional herds are the main factors affecting the sensory quality of milk. However, Croissant *et al*. (2007) showed that the trained panellists may be able to identify different flavours in pasture-based milk (grassy, mothball) but these are unlikely to change the overall consumers' acceptance of pasture based organic or conventional milks.

## CONCLUSIONS

Eleven parameters of raw organic and conventional milks including casein and free fatty acids contents, freezing point and coliform bacteria count together with sensory evaluation of pasteurised milk could bring a more comprehensive comparison of these management systems. There were higher contents of protein, casein, lactose, and non-fat solids in conventional milk, which also demonstrated a lower freezing point. On the contrary, a higher content of fat, a higher total mesophilic bacteria count, and a higher percentage of samples with positive coliform bacteria count were found in organic milk. The majority of these analytical parameters could have been affected by the feeding composition which differs between organic and conventional farming systems. Sensory analysis of pasteurised milk did not show any hedonic difference between organic and conventional milks. Organic farming brings a potential form of friendly approach to exploitation of natural resources in agriculture. However, further research is still needed for a better understanding of organic milk benefits.

***Acknowledgement***. Special thanks to Pavel Hering, Zuzana Pacáková, and Zuzana Vejvodová for collecting and statistically analysing the data as well as to Stephen J. Sangwine for the correction of English.

## References

Battaglini L.M., Renna M., Garda A., Lussiana C., Malfatto V., Mimosi A., Bianchi M. (2009): Comparing milk yield, chemical properties and somatic cell count from organic and conventional mountain farming systems. Italian Journal of Animal Science, **8**: 384–386.

Bergamo P., Fedele E., Iannibelli L., Marzillo G. (2003): Fat-soluble vitamin contents and fatty acid composition in organic and conventional Italian dairy products. Food Chemistry, **82**: 625–631.

Bloksma J., Adriaansen-Tennekes R., Huber M., de Vijver L.P.L.V., Baars T., de Wit J. (2008): Comparison of organic and conventional raw milk quality in the Netherlands. Biological Agriculture & Horticulture, **26**: 69–83.

Butler G., Nielsen J.H., Slots T., Seal C., Eyre M.D., Sanderson R., Leifert C. (2008): Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. Journal of the Science of Food and Agriculture, **88**: 1431–1441.

Butler G., Collomb M., Rehberger B., Sanderson R., Eyre M., Leifert C. (2009): Conjugated linoleic acid isomer concentrations in milk from high- and low-input management dairy systems. Journal of the Science of Food and Agriculture, **89**: 697–705.

Butler G., Nielsen J.H., Larsen M.K., Rehberger B., Stergiadis S., Canever A., Leifert C. (2011a): The effects of dairy management and processing on quality characteristics of milk and dairy products. NJAS – Wageningen Journal of Life Sciences, **58**: 97–102.

Butler G., Stergiadis S., Seal C., Eyre M., Leifert C. (2011b): Fat composition of organic and conventional retail milk in northeast England. Journal of Dairy Science, **94**: 24–36.

Bylund G. (1995): Dairy Processing Handbook. Tetra Pak, Lund: 55–56.

Carroll S.M., DePeters E.J., Taylor S.J., Rosenberg M., Perez-Monti H., Capps V.A. (2006): Milk composition of Holstein, Jersey, and Brown Swiss cows in response to increasing levels of dietary fat. Animal Feed Science and Technology, **131**: 451–473.

Cermanova I., Hanuš O., Roubal P., Vyletělová M., Genčurová V., Jedelská R., Kopecký J., Dolínková A. (2011): Effect of organic farming on selected raw cow milk components and properties. Acta Universitatis Agriculturae et Silviculturea Mendelianae Brunensis, **59** (6): 81–92.

Chazal M.P., Chilliard Y. (1986): Effect of stage of lactation, stage of pregnancy, milk yield and herd management on seasonal variation in spontaneous lipolysis in bovine milk. Journal of Dairy Research, **53**: 529–538.

Cicconi-Hogan K.M., Gamroth M., Richert R., Ruegg P.L., Stiglbauer K.E., Schukken Y.H. (2013): Associations of risk factors with somatic cell count in bulk tank milk on organic and conventional dairy farms in the United States. Journal of Dairy Science, **96**: 3689–3702.

Croissant A.E., Washburn S.P., Dean L.L., Drake M.A. (2007): Chemical properties and consumer perception of fluid milk from conventional and pasture-based production systems. Journal of Dairy Science, **90**: 4942–4953.

Dangour A.D., Allen E., Lock K., Uauy R. (2010a): Nutritional composition & health benefits of organic foods – using systematic reviews to question the available evidence. Indian Journal of Medical Research, **131**: 478–480.

Dangour A.D., Lock K., Hayter A., Aikenhead A., Allen E., Uauy R. (2010b): Nutrition-related health effects of organic foods: a systematic review. American Journal of Clinical Nutrition, **92**: 203–210.

Ellis K.A., Innocent G., Grove-White D., Cripps P., McLean W.G., Howard C.V., Mihm M. (2006): Comparing the fatty acid composition of organic and conventional milk. Journal of Dairy Science, **89**: 1938–1950.

Ellis K.A., Innocent G.T., Mihm M., Cripps P., McLean W.G., Howard C.V., Grove-White D. (2007a): Dairy cow cleanliness and milk quality on organic and conventional farms in the UK. Journal of Dairy Research, **74**: 302–310.

Ellis K.A., Monteiro A., Innocent G.T., Grove-White D., Cripps P., McLean W.G., Howard C.V., Mihm M. (2007b): Investigation of the vitamins A and E and β-carotene content in milk from UK organic and conventional dairy farms. Journal of Dairy Research, **74**: 484–491.

Fox P.F., McSweeney P.H.L. (1998): Dairy chemistry and biochemistry. Blackie Academic & Professional, London: 444–445.

Gil J.M., Gracia A., Sanchez M. (2000): Market segmentation and willingness to pay for organic food products. International Food and Agribusiness Management Review, **3**: 207–226.

Hajšlová J., Schulzová V., Slanina P., Janné K., Hellenäs K.E., Andersson Ch. (2005): Quality of organically and conventionally grown potatoes: Four-year study of micronutrients, metals, secondary metabolites, enzymic browning and organoleptic properties. Food Additives and Contaminants, **22**: 514–534.

Halliwell B. (1996): Antioxidants in human health and disease. Annual Review of Nutrition, **16**: 33–50.

Hanuš O., Brychtová J., Genčurová V., Pesl J., Hulová I., Vyletělová M., Jedelská R., Kopecký J. (2008a): Effect of conversion from conventional to organic dairy farm on milk quality and health of dairy cows. Folia Veterinaria, **52**: 140–148.

Hanuš O., Vorlíček Z., Sojková K., Rozsypal R., Vyletělová M., Roubal P., Genčurová V., Pozdíšek J., Landová H. (2008b): A comparison of selected milk indicators in organic herds with conventional herd as reference. Folia Veterinaria, **52**: 155–159.

Hill H., Lynchehaun F. (2002): Organic milk: attitudes and consumption patterns. British Food Journal, **104**: 526–542.

ISO 4832 (2006): Microbiology of food and animal feeding stuffs – Horizontal method for the enumeration of coliforms – Colony-count technique. International Organization for Standardization, Geneva.

ISO 5495 (2005): Sensory analysis – Methodology – Paired comparison test. International Organization for Standardization, Geneva.

ISO 8586-1 (1993): Sensory analysis – General guidance for the selection, training and monitoring of assessors. Part 1: Selected assessors. International Organization for Standardization, Geneva.

ISO 22935-1 (2009): Milk and milk products – Sensory analysis – Part 1: General guidance for the recruitment, selection, training and monitoring of assessors. International Organization for Standardization, Geneva.

Kalač P. (2011): The effects of silage feeding on some sensory and health attributes of cow's milk: A review. Food Chemistry, **125**: 307–317.

Komprda T. (2009): Comparison of quality and safety of organic and conventional foods. Chemické Listy, **103**: 729–732.

Kuczynska B., Puppel K., Golebiewski M., Metera E., Sakowski T., Sloniewski K. (2012): Differences in whey protein content between cow's milk collected in late pasture and early indoor feeding season from conventional and organic farms in Poland. Journal of the Science of Food and Agriculture, **92**: 2899–2904.

Kühn C., Thaller G., Winter A., Bininda-Emonds O.R.P., Kaupe B., Erhardt G., Bennewitz J., Schwerin M., Fries R. (2004): Evidence for multiple alleles at the DGAT1 locus better explains a quantitative trait locus with major effect on milk fat content in cattle. Genetics, **167**: 1873–1881.

Kummeling I., Thijs C., Huber M., van de Vijver L.P.L., Snijders B.E.P., Penders J., Stelma F., van Ree R., van den Brandt P.A., Dagnelie P.C. (2008): Consumption of organic foods and risk of atopic disease during the first 2 years of life in the Netherlands. British Journal of Nutrition, **99**: 598–605.

Lemaitre R.N., King I.B., Mozaffarian D., Kuller L.H., Tracy R.P., Siscovick D.S. (2003): n-3 Polyunsaturated fatty acids, fatal ischemic heart disease, and nonfatal myocardial infarction in older adults: the cardiovascular health study. American Journal of Clinical Nutrition, **77**: 319–325.

McGuire M.A., McGuire M.K. (1999): Conjugated linoleic acid (CLA): A ruminant fatty acid with beneficial effects on human health. Proceedings of the American Society of Animal Science, **50**: 1–8.

Michaelidou N., Hassan M. (2008): The role of health consciousness, food safety concern and ethical identity on attitudes and intentions towards organic food. International Journal of Consumer Studies, **32**: 163–170.

Mogensen L., Vestergaard J.S., Frette X., Lund P., Weisbjerg M.R., Kristensen T. (2010): Effect of toasting field beans and of grass-clover: Maize silage ratio on milk production, milk composition and sensory quality of milk. Livestock Science, **128**: 123–132.

Muller U., Sauerwein H. (2010): A comparison of somatic cell count between organic and conventional dairy cow herds in West Germany stressing dry period related changes. Livestock Science, **127**: 30–37.

Nauta W.J., Baars T., Bovenhuis H. (2006): Converting to organic dairy farming: Consequences for production, somatic cell scores and calving interval of first parity Holstein cows. Livestock Science, **99**: 185–195.

O'Donnell A.M., Spatny K.P., Vicini J.L., Bauman D.E. (2010). Survey of the fatty acid composition of retail milk differing in label claims based on production management practices. Journal of Dairy Science, **93**: 1918–1925.

Olivo C.J, Beck L.I., Gabbi A.M., Charao P.S., Sobczak M.F., Uberty L.F.G., Dürr J.W., Filho R.A. (2005): Composition and somatic cell count of milk in conventional and agro-ecological farms: a comparative study in Depressão Central, Rio Grande do Sul state, Brazil. Livestock Research for Rural Development, **17**: Article #72. Available at http://www.lrrd.org/lrrd17/6/oliv17072.htm (accessed May 3, 2013).

Popović-Vranješ A., Savić M., Pejanović R., Jovanović S., Krajinović G. (2011): The effect of organic milk production on certain milk quality parameters. Acta Veterinaria (Beograd), **61**: 415–421.

Popović Vranješ A.P., Krajinović M., Kecman J., Trivunović S., Pejanović R., Krajinović G., Mačak G. (2010): Usporedba sastava masnih kiselina konvencionalnog i organskog mlijeka. Mljekarstvo, **60**: 59–66.

Popović-Vranješ A., Pejanović R., Cvetanović D., Jevtić M., Popović M., Glavas-Trbić D., Jez G. (2012): Primjena holističkih metoda u analizi organskog mlijeka. Mljekarstvo, **62**: 284–290.

Prandini A., Sigolo S., Piva G. (2009): Conjugated linoleic acid (CLA) and fatty acid composition of milk, curd and Grana Padano cheese in conventional and organic farming systems. Journal of Dairy Research, **76**: 278–282.

Rey-Crespo F., Miranda M., López-Alonso M. (2013): Essential trace and toxic element concentrations in organic and conventional milk in NW Spain. Food and Chemical Toxicology, **55**: 513–518.

Rosati A., Aumaitre A. (2004): Organic dairy farming in Europe. Livestock Production Science, **90**: 41–51.

Sabbioni A., Beretti V., Tardini L., Vezzali S., Paini V., Superchi P. (2012): Milk production and lactation curves of Bianca Val Padana and Italian Friesian dairy cows in relation to the management system. Italian Journal of Animal Science, **11**: 141–144.

Sakowski T., Kuczyńska B., Puppel K., Metera E., Sloniewski K., Barszczewski J. (2012): Relationships between physiological indicators in blood, and their yield, as well as chemical composition of milk obtained from organic dairy cows. Journal of the Science of Food and Agriculture, **92**: 2905–2912.

Sato K., Bartlett P.C., Erskine R.J., Kaneene J.B. (2005): A comparison of production and management between Wisconsin organic and conventional dairy herds. Livestock Production Science, **93**: 105–115.

Schulzová V., Hajšlová J., Botek P., Peroutka R. (2007): Furanocoumarins in vegetables: influence of farming system and other factors on levels of toxicants. Journal of the Science of Food and Agriculture, **87**: 2763–2767.

Slots T., Butler G., Leifert C., Kristensen T., Skibsted L.H., Nielsen J.H. (2009): Potentials to differentiate milk composition by different feeding strategies. Journal of Dairy Science, **92**: 2057–2066.

Stergiadis S., Leifert C., Seal C.J., Eyre M.D., Nielsen J.H., Larsen M.K., Slots T., Steinshamn H., Butler G. (2012): Effect of feeding intensity and milking system on nutritionally relevant milk components in dairy farming systems in the north east of England. Journal of Agricultural and Food Chemistry, **60**: 7270–7281.

Stergiadis S., Seal C.J., Leifert C., Eyre M.D., Larsen M.K., Butler G. (2013): Variation in nutritionally relevant components in retail Jersey and Guernsey whole milk. Food Chemistry, **139**: 540–548.

Stolz H., Stolze M., Janssen M., Hammb M. (2011): Preferences and determinants for organic, conventional and conventional-plus products – The case of occasional organic consumers. Food Quality and Preference, **22**: 772–779.

Sutton J.D. (1989): Altering milk composition by feeding. Journal of Dairy Science, **72**: 2801–2814.

Toledo-Alonzo P. (2003): Studies of raw milk from sustainable/organic production systems. [Licentiate Thesis.] Swedish University of Agricultural Sciences, Uppsala: 24–25.

Toledo P., Andren A., Bjorck L. (2002): Composition of raw milk from sustainable production systems. International Dairy Journal, **12**: 75–80.

Winter A., Krämer W., Werner F.A.O., Kollers S., Kata S., Durstewitz G., Buitkamp J., Womack J.E., Thaller G., Fries R. (2002): Association of a lysine-232/alanine polymorphism in a bovine gene encoding acyl-CoA:diacylglycerol acyltransferase (DGAT1) with variation at a quantitative trait locus for milk fat content. Proceedings of the National Academy of Sciences of the United States of America, **99**: 9300–9305.

Zagorska J., Ciprovica I. (2008): The chemical composition of organic and conventional milk in Latvia. In: Proceedings 3rd Baltic Conference on Food Science and Technology Foodbalt-2008, Latvia University of Agriculture, Jelgava: 10–14.

Received for publication November 30, 2012
Accepted after corrections October 29, 2013

*Corresponding author:*

Doc. Ing. Lenka Kouřimská, Ph.D., Česká zemědělská univerzita v Praze, Fakulta agrobiologie, potravinových a přírodních zdrojů, Katedra kvality zemědělských produktů, Kamýcká 129, 165 21 Praha 6-Suchdol, Česká republika; E-mail: kourimska@af.czu.cz