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Economic characteristics and produced milk quality in Holstein lactating cows in organic and conventional systems

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ABSTRACT

In the past decade, a global demand for products from organic agriculture has increased rapidly. Milk quality is of major interest for all parties. Therefore, the objective of this study was to compare cow performance and product quality in conventional and organic system. Holstein dairy cows (16) were allotted to one of 3 diet groups, including a conventional diet (CON), an organic system with moderate forage (OMF) and an organic system with high forage (OHF). Multiparous cows (3rd and 4th parity) were randomly assigned to the treatments. Range forages were used as part of diets, and cows were offered concentrate and silage two times a day. Daily dry matter intake (DMI) and milk yield were measured across 200 d. Furthermore, somatic cell count, feed cost and feed efficiency were determined at 20-day intervals. MY was different for cows that treated the OHF (22.5 kg/d), OMF (24.9 kg/d), and CON (28.9 kg/d) systems, respectively. Body weights were not affected by treatments; however, differences in body condition scores were observed. Although energy corrected milk and milk urea nitrogen were higher in cows fed CON system; milk fat, phytanic acid, hippuric acid and profit to cost ratio were higher in cows fed organic systems. Additionally, lower feed efficiency, feed cost and blood urea nitrogen were observed in cows fed organic diets.

Key words: Body condition, Economic, Milk composition, Organic system

In recent years, the market for organic products has grown considerably along with the consumer's awareness of the production process. Therefore, organic farming using domestic livestock has recently become widespread around the world (Lampkin 2001). Clearly, crucial prerequisites in order to produce high quality milk are healthy cows fed with feed free from unusual materials. Organic farming defines clear rules for feeding of livestock, health management, and housing of animals (Padel *et al.* 2004). With the transition from conventional to organic dairy farming, milk yield and its composition change drastically (Slots *et al.* 2009, Sundrum 2001, Butler *et al.* 2011, Ellis *et al.* 2006, Collomb *et al.* 2008, Prandini *et al.* 2009). There is a growing body of research comparing organic and conventional farming systems. In a critical review, Sundrum (2001) demonstrated that the benefits of organic systems are more influenced by specific farm management policies than by production system itself. Although organic systems may reduce milk yield and growth rates (Bergamo *et al.* 2003, Slots *et al.* 2009, Butler *et al.* 2011), organic production methods may improve animal health and welfare, human health, and improve the environment (Ellis *et al.* 2006, Bystrom *et al.* 2002, Hamilton *et al.* 2002, Slots *et al.* 2009, Prandini *et al.* 2009). Milk yield on organic dairy farm is lower than milk yield on conventional farms (Kristensen *et al.* 1998, Bystrom *et al.* 2002, Hamilton *et al.* 2002). The reasons for lower milk yield in organic dairy herds may be due to differences in genetics, management, feeding practices, and increased subclinical mastitis (Hovi and Roderick 2000). In addition to differences in feeding and milk yield, reproductive efficiencies may also be different in organic method. Organic milk is being produced by rural and nomadic breeders of Iran for many years, and organic dairy products are available in villages and cities humid climate area (without a dry season and with temperate summers and winter) in Iran (Sharifi *et al.* 2015). However, the high demand for organic milk in recent years asks for production on a larger scale. No published studies have evaluated the effect of organic systems on the performance of dairy cows in Iran. Therefore, the objective of this study was to evaluate the use of organic systems in different levels of forage and their effects on body weight, body condition score, milk production, and milk quality of Holstein dairy cows in Iran vis-a-vis conventional systems.

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MATERIALS AND METHODS

Animals, diets and experimental design: The study was conducted at Valfajr Agricultural Research Center farm, located in the central Alborz range lands of Noshahr region

Table 1. Tillable land and major crops in organic and conventional farm

Item	Treatment[1]		
	OHF	OMF	CON
Extent of cultivation (Hectare)			
Rangeland forage	4.08	2.77	1.12
Alfalfa hay	1.00	0.80	0.40
Maize forage	0.60	0.55	0.30
Barley grain	4.65	4.65	2.00
Corn grain	1.55	2.35	1.50

	Organic farm	CON. farm
Total farm area (Hectare)	22.00	5.32
Rangeland forage (kg DM/Ha)		
Spring	1100	-
Summer	1500	-
Autumn	900	-
Winter	200	-
Alfalfa (kg DM/Ha)		
Spring	2500	3500
Summer	3500	4500
Autumn	2700	3500
Winter	1800	3000
Maize forage (kg DM/Ha)	30000	45000
Barley grain (kg DM/Ha)	2500	5000
Corn grain (kg DM/Ha)	3100	5300

[1]Treatment containing OHF, Organic system with high forage; OMF, Organic system with medium forage; CON, Conventional system.

Table 2. Estimation of intake for Holstein cows (n = 6 per group)

Item	Treatment[1]		
	OHF	OMF	CON
Corn silage%40 grain (kg per day)			
Early lactation	3.98	3.78	2.36
Mid lactation	3.85	3.62	2.31
Concentrate intake (kg per day)			
Early lactation	4.16	8.13	13.55
Mid lactation	4.03	7.78	13.23
Concentrated components (g/kg)			
Wheat bran	130.4	69.80	47.60
Barley grain	347.8	346.5	317.5
Corn grain	87.00	186.0	273.0
Canola	387.0	372.1	311.1
Carbonate calcium	15.20	8.10	22.5
DCP	10.90	5.80	7.10
Limestone	10.90	5.80	14.4
Mineral-vitamin mix[2]	10.90	5.80	6.70

[1]Treatment containing OHF, Organic system with high forage; OMF, Organic system with medium forage and CON, Conventional system. [2]Mineral composition (g/kg): Ca, 180; P, 60; Mg, 50; Na, 50; Cu, 1.3; Zn, 6.0; Mn, 3.5; I, 0.06; Co, 0.032; Se, 0.02. Vitamin composition (IU/kg): vitamin A, 600,000; vitamin D3, 120,000; vitamin E, 1,300.

of Mazandaran Province, Iran, during March to September 2014. All activities were performed under the guidelines approved by the Standard Committee of the Ministry of Agriculture and Veterinary Organization of Iran. Holstein dairy cows (16) were selected for this study. The average (mean±SD) initial body weight (BW) was 495.5±39.6 kg/d, and the previous year average daily milk yield (MY) was 27.5±1.1 kg/d. Cows (as a group) were kept at all the times in the farm except at the time of milking. A completely randomized block design with 3 treatments was used and cows were randomly distributed into groups, and blocked by milk yield (MY). The three treatments during the study were a conventional system (CON), an organic system with moderate forage (OMF) and an organic system with high forage (OHF). Daily amounts of diet in conventional system were offered at morning (05:00), mid-day (13:00) and evening (21:00), and the non-consumed feed were collected and subtracted from the provided amount of feed. Organic cows were fed according to the rules of Krav (1995) and offered *ad lib.* forage. All feed ingredients in organic system contain forage, concentrate, mineral and vitamins have been produced to organic methods (Stiglbauer *et al.* 2013). For the organic system, the requirements were calculated from a predicted forage intake (2.0–2.25 kg DM/100kg LW) and predicted milk yield, while, in conventional system the requirements were calculated based on milk yield. All cows received concentrate, minerals and vitamins in relation to the expected nutritional needs for milk yield. To reduce the differences in management of the cows, all of them were milked 3–time a day at 04:00, 12:00 and 20:00 hours, and had *ad lib.* access to fresh water (Padel *et al.* 2004). The concentrate component and amount in diets are presented in Table 2. The rangeland forages (in spring, summer and autumn) used in diets contained mainly *Hordeum bulbosum* (35%), *Lolium perenne* (27%), *Prangos ferulacea* (22%), *Poa pratensis* (10%) and other species (6%).

Range management: The rangeland area was 22 hectares of grassland from the Noshahr region of Mazandaran Province, Iran. Furthermore, 5.3 hectares of agricultural land was used for production of conventional feed (Table 1). For grazing in rangeland, a paddock was divided into 4 sections and forage was grazed every 50 days. The range areas were not irrigated and the yearly average rainfall amounted to about 1, 205 mm with 16.7°C of average yearly temperature. The soil structures were classified as loam and/or sandy-loam, with a neutral pH (6.83–7.19) and 2.99–4.75% organic matter. During each 50-day, botanical characterisation was performed using the method as given by Braun-Blanquet (1964), and the percentage of each species in the samples were recorded. Pasture samples were also collected at the same time and used for chemical analysis.

Data collection: Forages and other feeds were evaluated according to the association of official analytical chemists (AOAC 1991) method. Samples of sun-dried forages were packaged and sent to the laboratory for analysis of dry matter, crude protein, crude fiber, ether extract, ash and neutral detergent fiber measurements. The BW of cows was recorded at 20-day intervals prior to the morning feed allotment. Cows were weighed when leaving the milking parlour using a digital scale. Body condition score (BCS) for cows was measured on a scale of 1 to 9 (Sharifi *et al.* 2016) by the same person throughout the experiment. The scoring scale ranged from 1 (for very thin) to 9 (for very fat). The BCS values were recorded 4 times which included the dry period (pre-calving), post-calving, and the early and mid-lactation. Data for daily dry matter intake (DMI) was recorded from the beginning to the end of the experiment. With data spanning 200 days, cows had DMI records for 10 periods (d1 to d20, d21 to d40, d41 to d60, etc.). Also, milk yield for each period was recorded as the average milk produced by cows in each day of the 20-day periods. Additionally, milk fat and protein contents were measured once a week and somatic cell count (SCC) and milk urea nitrogen (MUN) were analyzed every 20 days. The fat content of milk was measured using the Smart-Trac rapid fat analyzer (CEM, Matthews, NC). The Lacti-Check ultrasound milk analyzer (P&P International Ltd, Hopkinton, MA) was used to measure the protein contents, while the SCC was determined with Fossomatic 90 (Foss electric). For the MUN measurement, samples were collected every 20 days. A concentration of MUN was determined in all trials using the same diacetyl monoxime colorimetric assay adapted to a continuous flow analyzer (Sharifi *et al.* 2016). Hippuric and phytanic acid were determined with a gas chromatograph (GC–2010, Shimadzu Co., Japan) equipped with a 100 m capillary column (0.25 mm i.d., 0.20 mm film thickness), and a flame ionization detector. Furthermore, feed efficiency (FE) was estimated by dividing energy-corrected milk (ECM), {ECM (kg) = [0.327 × (milk in kg)] + [12.96 × (fat in kg)] + [7.2 × (protein in kg)]}, by the daily DMI of cows. For blood metabolite and urea nitrogen, blood samples (20 ml) were collected from the tail vein of cows at 20-day farm visits using evacuated tubes containing EDTA at a level of 1.8 g/l of blood. Samples were kept on ice for 15 min after collection and then centrifuged at 1000×g for 20 min. Plasma was harvested and stored frozen in plastic tubes at -20°C until further analysis. The plasma urea concentration was determined using the method described by Chaney and Marbach (1962). B-Hydroxi butyrate acid and non-esterified fatty acids were assayed by colorimetric method (Ranbut®, Ireland). Cortisol of serum was measured by hormonal cortisol kit using Gama counter (Kon Pron) system.

Statistical analyses: For statistical analysis, the dependent variables were BW, BCS, MY, milk components, DMI, FE, MUN, BUN and feed cost. The fixed effects were dietary treatment, parity and 20-d period nested within dietary treatment. The MIXED linear model procedure of SAS (SAS Institute 2004), in which cow was the random variable and sample sequence was the repeated measure. The autoregressive covariance [AR (1)] structure was used because it resulted in the lowest Akaike's information criterion (Littell *et al.* 1998). The GLM PROC model was also used when necessary. Results are presented as least square means and statistical differences were considered significant at $P<0.05$. Trends towards significance were considered at $0.05 \leq P<0.10$.

RESULTS AND DISCUSSION

Body weight and body condition score: The change of BW over time is shown in Table 3. There were no statistically significant differences for BW between treatment groups; however, the CON cows lost slightly more BW than the organic cows during experiment because of higher energy density. Pre-calving BCS were not different between treatment groups (Table 3); but, significant differences were observed between treatments after calving ($P<0.05$), and early ($P<0.001$) and mid-lactation ($P<0.01$). Although trends for BW change in CON cows was greater than organic systems, results showed that organic systems with high forage levels can improve body condition in cows. Across all periods, CON cows had greater BCS than organic systems except in early lactation. Also, dry cow BCS was similar for all treatment groups. Similar results were

Table 3. Estimation of body condition score, body weight, dry matter intake and milk yield of cows fed organic and conventional systems in Holstein lactating

Item	Treatment[1]			SEM	P-value
	OHF	OMF	CON		
Body condition score					
Dry cow	5.95	5.97	5.94	0.03	NS
Post calving	4.90^c	5.01^b	5.08^a	0.03	*
Early lactation	4.68^a	4.70^a	4.59^b	0.03	***
Mid lactation	5.23^c	5.38^b	5.53^a	0.03	**
Body weight (kg)	483	490	472	8.47	NS
Early lactation	484	491	475	8.50	NS
Mid lactation	483	489	469	8.50	NS
Dry matter intake (kg/d)	17.8^c	18.5^b	21.2^a	0.13	**
Early lactation	18.1^b	18.9^b	21.5^a	0.15	**
Mid lactation	17.5^b	18.1^b	21.0^a	0.15	**
Milk yeild (kg/d)	22.5^c	24.9^b	28.9^a	0.09	**
Early lactation	23.3^c	25.6^b	30.1^a	0.13	***
Mid lactation	21.7^c	24.2^b	27.8^a	0.13	**
Feed efficiency (ECM/DMI)	1.33^b	1.38^a	1.41^a	0.006	*
Early lactation	1.34^c	1.40^b	1.45^a	0.008	**
Mid lactation	1.32^b	1.37^a	1.37^a	0.008	*

[1]Treatment containing OHF, Organic system with high forage; OMF, Organic system with medium forage and CON, Conventional system. $^{\dagger}P<0.10$; $^{*}P<0.05$; $^{**}P<0.01$ and $^{***}P<0.001$ for difference of treatment groups. [a,b,c]Treatments within the same row with different superscripts are significantly different ($P<0.05$).

reported by Roesch *et al.* (2005) but their finding that BCS was not different between cows fed on organic system compared to conventional system is contrary to our results. Bystrom *et al.* (2002) had found that cows fed on organic systems weighed less at the end of lactation compared to cows fed conventional system although BW and BCS change was greater for conventional cows compared to organic cows. Furthermore, Trachsel *et al.* (2000) had reported that changes in body condition score of cows fed on organic systems was lower than cows fed on conventional system.

Dry matter intake and feed efficiency: Table 3 show the DMI intake for treatment groups over the 200-day of lactation. Cows fed CON system had a greater (P<0.05) DMI than cows fed on OMF or OHF systems (21.2 kg/d vs. 18.5 and 17.8 kg/d, respectively). Normally, DMI reduction can be a result of bulkier feed intake and fewer digestibilities in OHF and OMF systems. Table 3 shows the change in FE during the trial period. Cows fed on CON system had greater (P<0.01) FE than cows fed on OHF and OMF systems (1.41 vs. 1.38, and 1.33, respectively). It may be difficult to determine how cows in different treatments converted energy into alternative components of production (i.e., body maintenance, and growth or restoration of body reserves). However, it is possible to determine how the treatment groups utilized energy from consumed feed to restore body reserves. Our observation of relatively lower DMI in organic systems is in line with many reports in the literature (Bystrom *et al.* 2002, Prandini *et al.* 2009, Butler *et al.* 2011, Stiglbauer *et al.* 2013). However, organic cows in the current study consumed more forage than conventional cows; but conventional cows consumed more concentrates than organic cows. In contrast to our study, Bystrom *et al.* (2002) found that feed efficiency was not different between animals fed conventional vis-a-vis organic systems. In contrast, Reksen *et al.* (1999) reported that feed efficiency was greater for cows fed organic systems compared to conventional system, because of the higher forage consumption of organic cows compared to conventional cows.

Milk yield and composition: Means and standard error of means for MY for each period and across to the 200 days is given in Table 3. Changes in DMI and MY of cows were similar from beginning to the end of experiment. Also, the changes of milk fat and protein, ECM, SCC, hippuric and phytanic acid in the study periods are shown in Table 4. Milk yield was different among treatment groups, especially in early lactation periods (P<0.001). Across the lactation period, cows fed CON systems had greater (P<0.01) MY than cows fed OMF or OHF systems (28.9 kg vs. 24.9 and 22.5 kg/d, respectively). Fat percentage was higher for cows fed OHF and OMF systems as compared to the CON system (3.73 and 3.69% vs. 3.56%, respectively). For protein content, cows fed CON diets had greater (P<0.05) value than OMF and OHF diets (3.51% vs. 3.42% and 3.36%, respectively). Furthermore, Table 4 shows that CON system was associated with significantly (P<0.05) greater SCC than other systems at early and mid-lactation periods with a tendency for CON system to have fairly higher (P<0.10) SCC than organic systems for mean of periods. The milk yield and milk composition of the current study are in agreement with finding of others (Bergamo *et al.* 2003, Butler *et al.* 2011, Bystrom *et al.* 2002, Ellis *et al.* 2006, Hamilton *et al.* 2002, Prandini *et al.* 2009, Roesch *et al.* 2005, Stiglbauer *et al.* 2013) who reported that MY was greater for conventional cows than organic cows. While in contrast to our results, Reksen *et al.* (1999) reported that milk yield was not significantly different between cows fed on organic or conventional systems. No difference could be related to the same rate of forage or energy density in both treatments. Butler *et al.* (2011) and Roesch *et al.* (2005) had reported that percentages of milk protein was equal between groups, but

Table 4. Estimation of milk composition of cows fed organic and conventional systems in Holstein lactating

Item	Treatment[1]			SEM	P-value
	OHF	OMF	CON		
Energy corrected milk (kg/d)	23.7[c]	26.1[b]	30.5[a]	0.09	**
Early lactation	24.3[c]	26.6[b]	31.2[a]	0.14	**
Mid lactation	23.1[c]	25.6[b]	28.9[a]	0.14	***
Milk fat percentage	3.73[a]	3.69[a]	3.56[b]	0.006	**
Early lactation	3.68[a]	3.64[a]	3.56[b]	0.007	*
Mid lactation	3.79[a]	3.75[a]	3.57[b]	0.007	**
Milk protein percentage	3.36[b]	3.42[b]	3.51[a]	0.007	*
Early lactation	3.33[b]	3.36[b]	3.50[a]	0.008	**
Mid lactation	3.39[b]	3.41[b]	3.51[a]	0.008	*
Somatic cell count (10^3 cells/ml)	228.0	228.4	238.4	42.2	†
Early lactation	238.7[b]	234.4[b]	243.6[a]	45.1	*
Mid lactation	217.3[c]	222.4[b]	233.3[a]	45.1	*
Milk urea nitrogen (mg/dl)	15.0[b]	15.8[b]	19.0[a]	0.06	**
Early lactation	14.6[b]	15.8[b]	19.6[a]	0.11	***
Mid lactation	15.5[b]	15.9[b]	18.5[a]	0.11	**
Blood urea nitrogen (Mmol/lit)	4.28[b]	4.36[b]	4.79[a]	0.01	*
Early lactation	4.30[b]	4.35[b]	4.78[a]	0.03	**
Mid lactation	4.27[c]	4.38[b]	4.81[a]	0.03	*
Hippuric acid (mg/lit)	31.3[a]	28.3[b]	18.9[c]	0.10	***
Early lactation	29.3[a]	26.3[b]	17.7[c]	0.15	***
Mid lactation	33.4[a]	30.3[b]	20.1[c]	0.15	***
Phytanic acid (mg/100g fat)	215[a]	187[b]	139[c]	3.29	**
Early lactation	191[a]	154[b]	123[c]	4.11	**
Mid lactation	240[a]	221[b]	155[c]	4.11	**

[1]Treatment containing OHF, Organic system with high forage; OMF, Organic system with medium forage and CON, Conventional system. †P<0.10; *P<0.05; **P<0.01 and ***P<0.001 for difference of treatment groups. [a,b,c]Treatments within the same row with different superscripts are significantly different (P<0.05).

a greater fat percentage was seen with organic feeding compared to the conventional feeding because of more forage intake. Conversely, Rozzi *et al.* (2007) showed that conventionally kept cows had greater milk, fat and protein content in milk than organically managed cows. Muller and Helga (2010) reported that SCC was not significantly different between an organic vs. conventional feeding. In contrast, Hovi and Roderick (2000) reported that average individual cow SCC levels were significantly higher in organic herds (135,000 cells/ml) compared to conventional herds (84,000 cells/ml), most likely resulting from higher subclinical mastitis levels in organic herds (individual cow SCC> 200,000 cells/ml in 34% of all measurements). Moreover, Table 4 indicates that consumption of organic systems especially OHF had drastically (P<0.01) higher phytanic acid than CON system. Similarly, content of hippuric acid was more in (P<0.001) OHF and OMF systems than CON system (31.3 and 28.3 vs. 18.9 mg/lit). Cows on organic systems consume more forage than CON system. Therefore, they consume more phytol (part of chlorophyll) which is broken down in ruminant's stomach to phytanic acid. This study found that, on average, organic milk had double the phytanic acid levels than conventional. Dietary intake of phytanic acid have been suggested to be involved in both health and disease promoting processes, thus some researchers have suggested that it can prevent diabetes and metabolic diseases, while others have suggested that it promotes development of prostate cancer (Werner *et al.* 2011). The potential health-promoting properties is based on the fact that animal and *in vitro* studies have shown that phytanic acid might have preventive effects on metabolic dysfunctions, since it in animal studies increase expression of genes involved in fatty acid oxidation, enhance glucose uptake and metabolism in hepatocyte and potentially reduce metabolic efficacy through increased differentiation of brown adipocyte differentiation and expression of uncoupling protein–1 (Werner *et al.* 2011). Hippuric acid such as phytanic acid could be a marker to distinguish organic milk from cows fed on different feeding system. However, it is necessary to check if the HA content comes from fresh forage or from organic handling.

Milk urea nitrogen and blood urea nitrogen: Across the 200 days, CON cows had significantly greater (P<0.01) MUN than OMF and OHF cows (19.0 vs. 15.8 and 15.0 mg/dl) groups respectively (Table 4). Similarly, CON cows had greater (P<0.05) BUN (Table 4) than OMF and OHF cows (4.79 vs. 4.36 and 4.28 mmol/lit, respectively). This finding is in accordance to the works of Busato *et al.* (2000), Bystrom *et al.* (2002) and Roesch *et al.* (2005) who had found that high forage diets compared to high concentrate diets appear to significantly decrease MUN levels. Furthermore, results of this study are similar to those reported by Roesch *et al.* (2005), Reist *et al.* (2003) and Trachsel *et al.* (2000) who reported BUN levels were greater in CON cows compared to organic cows. BUN reduction in the OHF and OMF cows can be due to the lower crude protein in diets. It can lead to a decreased ammonia production in the rumen and consequently decreased urea production in the liver. Our study provide support to other studies that the participating systems adequately reflect the performance level for the two management systems and are not due to biased selection of systems. Consequently, MUN a fraction of milk protein that is derived from BUN may be the useful criteria (for quality of milk) that may help monitoring of any change required in the feeding and management of a herd.

Blood metabolite: Regarding the blood serum parameters, non-esterified fatty acids (NEFA) showed the highest levels at 10 days of parturition for organic systems (Fig. 1), whereas CON cows had higher (P<0.01) NEFA concentration on days 60 and 90. Blood serum beta-hydroxybutyrate (BHBA) increased in CON cows after 20 days of parturition above 0.4 mmol/l and reached maximum

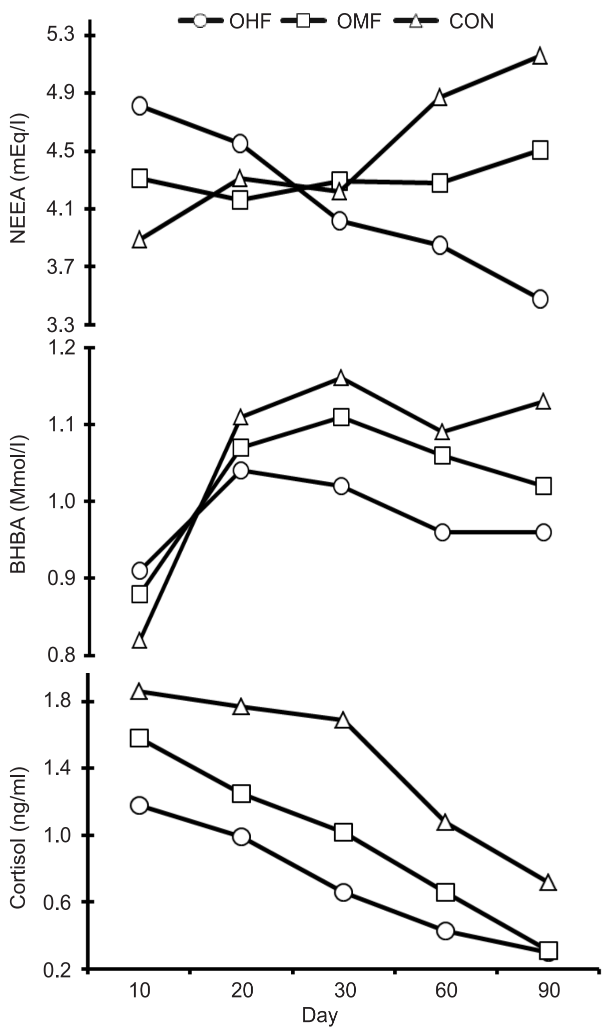

Fig. 1. Time courses of non esterified fatty acids (NEFA), β-hydroxy butyrate acid (BHBA), and cortisol in an OHF (Organic system with high forage), OMF (Organic system with medium forage), OLF (Organic system with low forage) and conventional system (CON) during the observation periods. Means of NEFA, BHBA and cortisol were significantly different (P<0.05) among treatments for all periods. Overall SEM for NEFA= 0.08, BHBA= 0.03, and cortisol= 0.06.

levels at 20-day in OHF and on days 30 in OMF cows (Fig. 1). NEFA serum concentration is an indicator of the lipid mobilization degree from reserve adipose tissue and, in conclusion, of the negative energy balance in ruminants (Ellis *et al.* 2006). Altogether, earlier studies had demonstrated that organic system is not more prone to develop a negative energy balance than conventional system (Roesch *et al.* 2005, Rozzi *et al.* 2007, Kristensen and Kristensen 2008, Muller and Sauerwein 2010, Stiglbauer *et al.* 2013). Contrary to our results, Fall *et al.* (2008) showed that the profiles of all tested metabolic variables NEFA, and BHBA were very similar between organic and conventional systems. Roesch *et al.* (2005) compared NEFA and BHBA at 30 days post-partum without discovering any differences. But, there have been concerns that the high energy demands of early lactation cannot be satisfied in organic management. The results showed that the cortisol level on days 10 was higher in CON cows than OMF and OHF cows (1.86 vs. 1.58 and 1.18 ng/ml, respectively, Fig. 1), and that the cortisol levels on days 20, 30, 60 and 90 were significantly different for all treatments. Cortisol, often referred to as the "stress hormone", is a glucocorticoid secreted by the hypothalamic-pituitary-adrenal (HPA) axis (Katharina *et al.* 2015). Levels of cortisol are known to increase in response to physical or psychological stress. Cortisol plays an important role in the body and primarily affects metabolic and immune function (Katharina *et al.* 2015). Improved animal welfare is considered one of the key benefits of converting to the organic system (Rosati and Aumaitre, 2004) which logically should equate to reduced cow stress.

Feed cost (FC) and income over feed cost (IOFC): Across the 200 days, cows fed CON system had significantly higher FC than cows fed on OMF and OHF systems (7.81 vs. 7.33 and 6.09 $/day, respectively). Cows fed CON system had higher IOFC compared to cows on fed OMF and OHF systems (Table 5). Also, FC and IOFC such as profit to cost ratio (Table 5) were equal in OMF and CON systems in early and mid-lactation. On the other hand, the average cost of production for each of the 3 treatments with organic and conventional systems is listed in Table 5. Production costs were greater in the CON systems than other groups because of the greater use of transport, chopping silage, worker, harvesting and electricity costs. The results of this study indicate that the highest profit to cost ratio (PCR=Total revenue/Total expenses) was related to the dairy cow of OHF (1.64), OMF (1.54), and CON (1.51) systems, respectively. Economy of animal production is closely associated with the efficiency of breeding. Profit to cost ratio is usually used as the indicator of the economic efficiency (Michalickova *et al.* 2014). The higher values of profit to cost ratio of milk production was reported by Arbel *et al.* (2001) in spite of the comparable value of market prices of milk and of costs per cow and feeding day. High level of milk yield which finally reduced the unit cost per kg of milk was the main determinant of difference in this case. Michalickova *et al.* (2014) noted

Table 5. Estimation of feed cost, income over feed cost (IOFC) and profit to cost ratio of cows fed organic and conventional systems in Holstein lactating

Item	Treatment[1]			SEM	P-value
	OHF	OMF	CON		
Feed cost ($/d)	6.09[c]	7.33[b]	7.81[a]	0.07	*
Early lactation	6.19[c]	7.49[b]	7.92[a]	0.09	**
Mid lactation	5.99[c]	7.17[b]	7.74[a]	0.09	*
IOFC (%)	54.1[b]	58.8[a]	60.0[a]	0.39	**
Early lactation	53.1[b]	58.4[a]	58.5[a]	0.44	*
Mid lactation	55.1[c]	59.2[b]	61.8[a]	0.44	**
Income[2]					
Total milk (kg)	27,000.0	29,880.0	34,680.0	-	-
Total milk (kg/per cow)	4,500.0	4,980.0	5,780.0	-	-
Price of total milk ($)	13,499.6	14,939.6	15,606.0	-	-
Price of total milk ($/per cow)	2,249.9	2,489.9	2,601.0	-	-
Gross revenue ($/Farm)[3]	5,309.0	5,276.8	5,296.1	-	-
Profit to cost ratio[4]	1.64[a]	1.54[b]	1.51[b]	0.03	*
Feed cost					
Total feed consumption (kg DM)	21,360.0	22,200.0	25,440.0	-	-
Gain consumption (kg DM)	4,912.8	9,546.0	16,027.2	-	-
Forage consumption (kg DM)	16,447.2	12,654.0	9,412.8	-	-
Feed intake cost ($)	7,307.2	8,793.4	9,377.2	-	-
Grain intake cost ($)	2,702.0	5,250.3	7,212.2	-	-
Forage intake cost ($)	4,605.2	3,543.1	2,164.9	-	-
Fixed cost ($)[5]	883.3	869.4	932.7	-	-
Production cost					
Field preparation ($)	2565.6	4239.0	4965.0	-	-
Seeds ($)	312.6	418.9	555.8	-	-
fertilizer and pesticides ($)	0.0	0.0	1239.4	-	-
Machinery ($)	1240.5	2949.4	2463.3	-	-
Storage feed ($)	1012.6	870.7	706.5	-	-
Harvesting ($)	1501.1	1267.5	1164.3	-	-
Transport ($)	789.3	740.8	732.2	-	-
Electricity and fuel ($)	197.2	173.5	136.1	-	-
Chopping ($)	186.1	150.0	103.5	-	-
Worker ($)	1212.3	1152.5	931.1	-	-
Laboratory ($)	499.2	576.2	517.3	-	-
Animal health ($)	356.5	493.9	827.7	-	-

[1]Treatment containing OHF, Organic system with high forage; OMF, Organic system with medium forage and CON, Conventional system. *P<0.05 and **P<0.001 for difference of treatment groups. [a,b,c]Treatments within the same row with different superscripts are significantly different (P<0.05). [2]Income, minus income from calf production has been reported. [3]Aggregation of income from the sales of farm outputs (GR= ΣN RxiYi). [4]Profit to cost ratio (PCR): PCR=Total revenue/Total expenses.

comparable value for the profit to cost ratio in milk production in spite of extremely low milk yield per cows reared in mountain and foothill regions.

By focusing on different levels of evaluation, we conclude that Holstein cows fed on organic systems differ from conventional system. Gradual replacement of concentrate to forage in the experiments clearly showed the difference in productivity and efficiency. DMI and MY were higher in cows fed CON system compared to those fed on other systems. But, profitability is likely to be higher for cows fed on OHF system, because cows fed on OMF and CON systems had significantly higher FC and IOFC than OHF system. However, despite the lower MY in OHF system, this system is comparable with conventional system on the profit to cost parameter with conventional. Feed efficiency was the greatest for CON cows compared to organic cows. Furthermore, the results indicate that the maximum BUN and MUN in CON can be effective in reducing milk quality. Moreover, cows of OHF and OMF systems had higher phytanic and hippuric acids contents than cows of CON system during experiment.

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