Profiles of energy metabolites and haptoglobin in dairy cows under organic management in Alberta farms

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ABSTRACT

Profiles of energy metabolites and haptoglobin (Hp) in dairy cows that are transitioned from conventional to organic management in various Alberta farms were compared with those of dairy cows managed conventionally at the University of Alberta dairy farm. Blood samples were collected during the following periods: Dry, 0 - 30, 30 - 60, and 60 - 90 days in milk (DIM, n = 7 cows). Concentrations of metabolites were evaluated by enzymatic colorimetric methods. Concentrations of Hp were determined by bovine ELISA kits. Data were analyzed by the mixed procedures of SAS. Concentrations of NEFA and BHBA in blood were elevated (P < 0.001) 0 to 30 d, intermediate 30 to 60, and 60 to 90 d, and lower in the dry period. In addition, BHBA was higher (P < 0.0001) at all stages of lactation in conventional than organic cows (e.g. 1289.4 ± 88.6 vs. 883.6 ± 47.5 µmol/L in conventional and organic cows at 0 - 30 d, respectively). Serum concentrations of cholesterol increased with increasing DIM and returned to nadir levels during dry period and was higher (P < 0.0001) in conventional than organic cows. Low glucose concentrations were observed 0 to 30 d, levels were intermediate 30 to 60, and 60 to 90 d, and peaked during the dry period (P < 0.0001). However, glucose concentrations did not differ (P < 0.54) between conventional and organic cows. Lactate did not (P < 0.24) vary with DIM or day × farm type but was higher (P < 0.0001) in organic cows than in conventional cows. Serum concentrations of Hp were elevated during dry period; reached peak levels 0 to 30 d and decreased gradually with increasing days postpartum and were much higher at all periods in conventional than organic cows. Overall, concentrations of Hp were 528.1 ± 45.2 µg/mL in conventional cows vs. 261.1 ± 16.9 µg/mL in organic cows (P < 0.0001). Taken together, these data indicate that metabolic changes associated with initiation of lactation are preceded by an acute phase response in dairy cows, and that cows in organic systems seem to be healthier than cows under conventional systems. These differences might be due to differences in nutritional management in the two systems.

Keywords: Organic Cows; BHBA; NEFA; Haptoglobin

1. INTRODUCTION

Increasing consumer awareness about the environment and their desire to consume healthy products, produced without utilization of pesticides, antibiotics, or other chemicals are the essential reasons behind increasing demand for organic dairy products. As such, organic dairy industry has been growing rapidly in Canada and beyond. Although there is a great interest to be involved in transitioning from conventional to organic dairying, there is also uncertainty whether this change will affect the productivity and health of dairy cows and in the end the profitability of the new establishment.

In areas where cows are housed during a significant part of the year because of adverse weather conditions, composition of feed becomes the major difference between organic and conventional dairy farming. Nevertheless, organically managed dairy cows must be fed at least 95% organically produced feed, no genetically mo-
dified products, and the total daily dry matter (DM) proportion of concentrate should not exceed 50% during the first 3 months of lactation and thereafter, not more than 40% (Council of the European Communities, 1991). However, there are major differences between organic and conventional managements regarding the use of antibiotic and chemotherapeutic treatments and in handling of the animals. These include, doubled withdrawal period for delivery of milk after treatment with registered pharmaceuticals, anti-parasite strategy without drugs, fresh milk for raising calves, access to regular exercise, and a prolonged grazing season.

Negative energy balance (NEB) during early lactation is a major concern in organic dairy herds due to restrained use of concentrates [1]. As a consequence, body energy reserves primarily body fat is mobilized leading to increased concentrations of NEFA and BHBA in plasma [2-4]. Epidemiological studies on differences in energy metabolism between organic and conventional dairy cows are scarce. However, in a study by Roesch et al. [5], no differences in the blood metabolites NEFA, BHBA, or glucose were found around 30 d postpartum, nor were any differences found in BCS before or after calving, making the authors suggest that energy intake was not abnormal in any of the groups. A clinical manifestation of NEB is ketosis, and it has previously been studied in organic dairy cows. Hamilton et al. [6] found no signs of wide spread clinical or subclinical ketosis, whereas Hardeng and Edge [1] found markedly lower incidence of clinical ketosis in organic versus conventional cows. Fall et al. [7], reported no long-term differences in mobilization of energy from body tissue between organic and conventional dairy cows and concluded that organic dairy cows adjust their milk production to feed intake.

In this study, metabolite profiles of dairy cows that are transitioned from conventional to organic management have been evaluated. The objective of the study was to compare changes in metabolites in blood of dairy cows that are transitioned from conventional to organic management in various Alberta farms with those of dairy cows managed conventionally at the University of Alberta dairy farm.

2. MATERIALS AND METHODS

2.1. Study Design and Selection of Farms and Cows

All farms in the study were located in Alberta, Canada. To be included in this study, the dairy farms must have been producing milk under Canadian regulations of the organic dairy farms and utilize total mixed ration (TMR) in feeding regimen. In addition, the farms were required to have more than 100 dairy cows, and at least 7 or more cows available for each sampling group, i.e., dry period, fresh period (0 - 30 d postpartum), early lactation (30 - 60 d postpartum), and mid-lactation (60 - 90 d postpartum). Three organic farms (ORG) fulfilled these conditions and were recruited in the study. In addition, the university farm in Edmonton, Alberta was included as a conventional farm (CON) for comparative purpose. Breed composition in organic farms were 1/3 Jersey cows and 2/3 Holstein cows. However, in the conventional farm, all cows were of Holstein origin.

Based on the time relative to parturition, clinically healthy cows were allocated to one of the 4 groups in this study (i.e., dry period, 0 - 30 d, 30 - 60 d, and 60 - 90 d postpartum). Each group contained 7 cows and, when possible, attention was paid that cows within a group have similar conditions such as lactation day, milk production, body weight. All ORG had free-stall barns, whereas the cows of CON were in tied-stalls. In all the farms, cows were fed a total mixed ration (TMR) once daily early in the morning (0700 to 0800 h). A summary of rations utilized by the farms included in this study is given in Table 1. During samplings, the cows of the ORG were restrained at the milking parlors, whereas cows of the CON were restrained in their stalls.

2.2. Sample Collection

Blood samples were obtained by tail veinupuncture in 10 mL vacutainer tubes without anticoagulant (Becton Dickinson, Franklin Lake, NJ) and allowed to coagulate at room temperature. Serum was obtained following centrifuging at 3000 × g at 4°C for 20 min (Rotanta 460 R, Hettich Zentrifugen, Tuttingen, Germany). Serum samples were stored at −20°C until analysis.

2.3. Blood Metabolites

Blood metabolites analyzed included circulating glucose, non-esterified fatty acids (NEFA), β-hydroxy-butyrate (BHBA) cholesterol, and lactate.

The concentration of glucose in the serum was quantified by an enzymatic method by commercially available kits (Diagnostic Chemicals Ltd., Charlottetown, PA). Briefly, the procedure involves phosphorylation and oxidation of glucose in samples resulting in the production of NADH which produces a color proportional to the glucose concentration in the sample. All samples were tested in duplicates and the serum glucose was then determined by reading on a microplate spectrophotometer (Spectramax 190, Molecular Devices Corporation, CA) at an optical density of 340 nm. According to the manufacturer’s instructions the lower detection limit of the testwas 0.06 mg/dL.

Quantitative determination of serum NEFA was done by an enzymatic colorimetric method using commer
Table 1. Composition of milking cow rations utilized by the farms during winter and summer periods.

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Organic Farm</th>
<th>Conventional Farm</th>
<th>Winter</th>
<th>Summer</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unit of DM</td>
<td>Amount</td>
<td>Amount</td>
<td>Amount</td>
<td>Amount</td>
<td>Amount</td>
</tr>
<tr>
<td>Crude Protein</td>
<td>%</td>
<td>16.79</td>
<td>16.02</td>
<td>17.88</td>
<td>17.78</td>
<td></td>
</tr>
<tr>
<td>RUP</td>
<td>% of CP</td>
<td>29.32</td>
<td>36.08</td>
<td>34.26</td>
<td>34.49</td>
<td></td>
</tr>
<tr>
<td>ADF</td>
<td>%</td>
<td>19.97</td>
<td>20.15</td>
<td>20.83</td>
<td>21.38</td>
<td></td>
</tr>
<tr>
<td>NDF</td>
<td>%</td>
<td>31.2</td>
<td>31.25</td>
<td>31.67</td>
<td>32.43</td>
<td></td>
</tr>
<tr>
<td>NELact.</td>
<td>MCal/Kg</td>
<td>1.71</td>
<td>1.68</td>
<td>1.84</td>
<td>1.81</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>%</td>
<td>0.9</td>
<td>1.04</td>
<td>1.00</td>
<td>1.03</td>
<td></td>
</tr>
<tr>
<td>Phosphorous</td>
<td>%</td>
<td>0.38</td>
<td>0.34</td>
<td>0.46</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>%</td>
<td>0.3</td>
<td>0.32</td>
<td>0.35</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>%</td>
<td>0.13</td>
<td>0.43</td>
<td>0.30</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>%</td>
<td>1.64</td>
<td>1.53</td>
<td>1.44</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>ppm</td>
<td>25.91</td>
<td>26.27</td>
<td>43.63</td>
<td>42.19</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>ppm</td>
<td>111.7</td>
<td>119.92</td>
<td>81.81</td>
<td>79.11</td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>ppm</td>
<td>137.45</td>
<td>126.04</td>
<td>125.44</td>
<td>121.31</td>
<td></td>
</tr>
<tr>
<td>Vitamin A</td>
<td>KIU/Kg</td>
<td>7.3</td>
<td>7.08</td>
<td>8.73</td>
<td>8.44</td>
<td></td>
</tr>
<tr>
<td>Vitamin D</td>
<td>KIU/Kg</td>
<td>1.37</td>
<td>1.37</td>
<td>1.53</td>
<td>1.48</td>
<td></td>
</tr>
<tr>
<td>Vitamin E</td>
<td>IU/Kg</td>
<td>47.08</td>
<td>45.71</td>
<td>59.99</td>
<td>58.02</td>
<td></td>
</tr>
</tbody>
</table>

1Diets were fed as TMR once daily early in the morning from 0700 to 0800 h.

Cialy available kits (Wako Chemicals, Richmond, VA). The principle of the test involves acylation of coenzyme A by fatty acids in the sample in presence of acyl-CoA synthetase and production of hydrogen peroxide in presence of acyl-CoA oxidase. Hydrogen peroxide, in presence of peroxidase, permits the oxidative condensation of 3-methyl-N-ethyl-N-β-hydroxyethyl-O-aniline (MEHA) with 4-aminoantipyrine to form a purple colored adduct which is proportional to the NEFA in the sample. Samples were tested in duplicates and the optical density was measured at 550 nm on a microplate spectrophotometer (Spectramax 190, Molecular Devices Corporation, CA). The lower detection limit of the assay was 0.50 mEq/L.

Enzymatic quantitation of BHBA by β-hydroxybutyrate dehydrogenase was used for quantifying serum concentration of BHBA using a commercially available kit (Stanbio Laboratory, Boerne, TX). The principle of the test involves conversion of BHBA in the samples to acetoacetate and NADH at pH 8.5 by β-hydroxybutyrate dehydrogenase in the presence of NADH. The NADH produced reacts with INT in the presence of diaphorase to produce a color proportional to the concentration of BHBA in the sample. Serum BHBA was measured in duplicates by reading on a microplate spectrophotometer (Spectramax 190, Molecular Devices Corporation, CA) at an optical density of 505 nm. The lower detection limit of the assay was 125 mmol/mL.

Serum cholesterol was measured using commercially available kits (Diagnostic Chemicals Ltd., Charlottetown, PA). The colorimetric method is based on the principle of hydrolyzing the cholesterol esters to free cholesterol and oxidation of free cholesterol to choleste-4ene-3-one with simultaneous production of hydrogen peroxide. The hydrogen peroxide couples with 4-aminoantyrine and p-hydroxybenzoate, in the presence of peroxidase to yield a chromogen whose intensity is proportional to concentration of cholesterol in the sample. All samples were tested in duplicates and serum cholesterol was determined by reading the optical density values on a microplate spectrophotometer (Spectramax 190, Molecular Devices Corporation, CA) at 505 nm.

Serum concentration of lactate was determined using commercially available lactate assay kits (Biomedical Research Service Center, Buffalo, NY). The principle of the test involves reduction of tetrazolium salt INT in a NADH-coupled enzymatic reaction to formazan which
exhibits a red color whose intensity is proportional to concentration of lactate. The lactate standard provided in the kit was diluted to set a detection range of 125 to 1000 μM. All samples were tested in duplicates and the lactate concentration was determined by reading the optical density values on a microplate spectrophotometer (Spectramax 190, Molecular devices Corporation, CA) at 492 nm.

2.4. Haptoglobin

Concentrations of haptoglobin (Hp) in the samples were determined by using commercially available bovine ELISA kits Catalog number TP801 (Tridelta Development Ltd., Greystones, Co. Wicklow, Ireland). According to the manufacturer, the minimum detection limit of the assay was 2.5 mg/mL as defined by the linear range of standard curves. All samples were tested in duplicate, and the optical density at 630 nm was measured on a microplate spectrophotometer (Spectramax 190, Molecular Devices Corporation).

3. STATISTICAL ANALYSES

All data were analyzed using the mixed procedures of SAS (SAS Institute Inc., Cary, NC) according to the model shown below:

\[
Y_{ijklm} = \mu + \alpha_i + \beta_j + (\alpha \beta)_ij + \chi_k + (\chi \beta)_kj + \delta(O)_i + (\delta \alpha)_ij + (\delta \beta)_k + \epsilon_{ijklm}
\]

where \(Y_{ijklm}\) is the observations for dependent variables, \(\mu\) is the overall population mean, \(\alpha_i\) is a population parameter corresponding to the type of farm (CON. vs. ORG), \(\beta_j\) is the fixed effect of stage of lactation \(j\), \(\chi_k\) is the fixed effect of season \(k\), \(\delta(O)_i\) is the fixed effect of breed \(m\) within organic farms \(O\), \((\alpha \beta)_ij\), \((\chi \beta)_kj\), \((\delta \alpha)_ij\), \((\delta \beta)_k\) are the effects of a two-way interaction between stage of lactation and farm type, season, and breed, respectively, and \(\epsilon_{ijklm}\) is the residual error. The model was reduced when interactions involving breed were not observed. Significance was declared at \(P \leq 0.05\).

4. RESULTS

4.1. Non-Esterified Fatty Acids (NEFA)

Serum concentrations of NEFA were affected by breed \((P < 0.05)\), and the interaction of season by stage of lactation \((P < 0.002)\). In addition, concentrations of NEFA tended \((P = 0.06)\) to be affected by season but not by farm type, stage of lactation or their two way interactions \((P < 0.36)\).

Jersey cows had lower whereas Holstein cows had higher \((P < 0.05)\) serum concentrations of NEFA \((198.2 \pm 22.2\) vs. \(240.3 \pm 13.9\) mEq/L, respectively). In addition, concentrations of NEFA were numerically higher \((P < 0.06)\) in cows during winter than in the summer season \((236.4 \pm 16.5\) vs. \(202.1 \pm 18.7\) mEq/L, respectively). During the summer months, concentrations of NEFA were higher between 0 to 30 d postpartum, intermediate between 30 to 60 d and dry period, but lower between 60 to 90 d postpartum. However, for winter season, concentrations of NEFA were higher between 60 to 90 d postpartum but remained fairly constant during the other periods of study (Figure 1).

4.2. β-Hydroxy-Butyrate (BHBA)

Farm type \((P < 0.01)\), stage of lactation \((P < 0.0001)\) and farm type by stage of lactation \((P < 0.0001)\) affected serum concentrations of BHBA of the cows. In addition, season also tended \((P = 0.06)\) to affect serum concentrations of BHBA of the cows.

Serum concentrations of BHBA of cows under conventional management were higher \((P < 0.01)\) than those of cows under organic systems \((989.5 \pm 61.7\) vs. \(813.8 \pm 24.6\) μmol/L, respectively). Concentrations of BHBA were greater \((P < 0.0001)\) in the conventional than organic cows at 0 to 30 and 60 to 90 d postpartum, but remained lower during the dry period (Figure 2). No differences \((P < 0.3)\) were observed between the groups at 30 to 60 d. During summer season, serum concentrations of BHBA in cows tended \((P = 0.06)\) to be lower than those observed during winter \((863.1 \pm 43.2\) vs. \(940.3 \pm 37.6\) μmol/L, respectively).

4.3. Cholesterol

Serum concentrations of cholesterol of the cows were
affected by farm type (P < 0.0001), breed (P < 0.0001), stage of lactation (P < 0.0001) and season (P < 0.0001). In addition, interactions of farm type by stage of lactation (P < 0.0001) and tendency (P < 0.07) for season by stage of lactation were also observed.

Cholesterol was higher (P < 0.0001) in conventional dairy cows compared to cows managed under organic systems (240.3 ± 6.1 vs. 128.9 ± 2.3 mmol/L, respectively). Concentrations of cholesterol were also higher (P < 0.0001) in Holsteins compared to Jerseys (195.8 ± 3.2 vs. 173.3 ± 4.8 mmol/L, respectively). In addition, cholesterol was also higher (P < 0.0001) in the cows during winter than in summer (191.8 ± 3.6 vs. 177.3 ± 4.0 mmol/L, respectively).

Cholesterol concentrations were lower (P < 0.0001) during the dry period, began an upward trend from 0 to 30 d and peaked between 60 to 90 d postpartum (Figure 3). The concentrations were also greater (P < 0.0001) in most stages of lactation in conventional cows than organic cows except for the dry period (Figure 3). In addition, concentrations of cholesterol in cows tended (P < 0.07) to be more elevated in winter at day 0 to 30 and 30 to 60 postpartum than in summer (Figure 4).

4.4. Lactate

Farm type (P < 0.0001), season (P < 0.0001), breed (P < 0.03) affected serum concentrations of lactate of the cows. Neither stage of lactation (P < 0.2) nor its two way interactions with other factors affected concentrations of lactate in the cows.

Greater (P < 0.0001) concentrations of lactate were observed in cows under organic management than in those under conventional system (4.00 ± 0.13 vs. 2.20 ± 0.33 µmol/L, respectively, Figure 5). In addition, concentrations of lactate were also greater (P < 0.0001) in cows during winter than in summer (4.28 ± 0.20 vs. 1.92 ± 0.23 µmol/L, respectively, Figure 5). Among breeds, concentrations of lactate were higher (P < 0.03) in Holstein cows than in Jersey cows (3.37 ± 0.17 vs. 2.83 ± 0.26 µmol/L, respectively, Figure 5).

4.5. Glucose

Season (P < 0.001), breed (P < 0.001), and stage of lactation (P < 0.0001) affected concentrations of glucose in the cows. Two way interactions involving farm type or stage of lactation with the other factors did not (P < 0.5)
Concentrations of glucose were greater in the cows during winter than in the summer season, and also in the Holsteins than in Jerseys (Figure 6). Concentrations were also greater during the dry period and intermediate between 30 to 60 and 60 to 90 days postpartum. However, least concentrations of glucose were observed during 0 to 30 days postpartum (Figure 6).

4.6. Haptoglobin

Haptoglobin concentrations in cows were affected by farm type (P < 0.0001) and season (P < 0.001). However, interactions of farm type by day tended (P = 0.06) to affect haptoglobin levels in cows.

Conventional cows had higher concentrations of haptoglobin compared to cows in organic systems (528.1 ± 45.1 vs. 261.1 ± 16.9 µg/mL, respectively, Figure 7). In addition concentrations of haptoglobin were higher in cows during summer than winter (448.1 ± 30.8 vs. 341.1 ± 27.2 µg/mL, respectively, Figure 7). Concentrations of haptoglobin tended to greater in conventional than organic cows throughout the periods of study. A steady increase in haptoglobin was evident in conventional cows at initiation of lactation that remained much more elevated 30 to 60 and 60 to 90 d postpartum than in organic cows (Figure 8).

5. DISCUSSION

Data from this study showed that NEFA was higher in Holstein cows than Jersey cows and that it was also numerically higher during winter than in summer. We have also shown that during summer months cows in their initial stages of lactation (0 to 30 d) were forced to mobilize more body fat than their counterparts during winter.
behind this observation remain obscure. However, we are disturbed by this observation than from organic cows during the summer season, serum concentrations of BHBA tended to be lower than those observed in the cows during winter. This might indicate fewer incidences of metabolic disturbances during summer than winter. Mechanisms behind this observation remain obscure. However, we are tempted to speculate that because most organic systems incorporated summer grazing in their nutritional programs; it might have resulted in lower usage of grains in their diets during summer months, hence reduced incidences of metabolic disturbances. Contrary to these observations, previous work on metabolic health status of organic dairy herds in the United Kingdom reported tendencies for more subclinical ketosis in organic cows [13]. By observing higher concentrations of BHBA in milk from organic vs. conventional cows, the authors concluded that BHBA content in milk increased when cows were not fed to meet their energy requirements. However, the authors also concluded that in the end, organic cows adjust their milk production to adapt to a lower level of feeding. Similarly, Andersen et al. [14] found greater concentrations of BHBA in dairy cows fed diets low energy density diets in early lactation.

Another observation obtained from this study was that concentrations of cholesterol in plasma of cows varied between conventional and organic cows. In fact, cholesterol was higher in conventional dairy cows throughout most of the study periods compared to cows managed under organic systems. In addition, greater concentrations of cholesterol in cows were also observed during winter at 0 to 30 and 30 to 60 postpartum than in summer. Cholesterol is a component of lipoproteins and its concentrations in serum is an indication of overall lipoprotein concentrations. The significance of cholesterol concentration in serum is somewhat controversial. Reduced lipoprotein concentrations are characteristic of the prepartum period [15] and are associated with liver metabolism and increased incidences of diseases [16]. Ametaj et al. [9] reported reduced levels of cholesterol in dairy cows fed diets steeped with 45% grain and postulated that cholesterol was being used to sequester endotoxemia resulting from the high grain feeding. Hypercholesteremia may be associated with an improvement in energy balance [17]. In that study, severe losses in BCS were observed in dairy cows around parturition when cholesterol concentrations in circulation were low. Thus, greater cholesterol levels observed in conventional cows and again in early lactating cows during winter might indicate some degree of improvement in their energy balance.

Our results also indicated greater concentrations of lactate in organic vs. conventional cows, and in winter than summer, as well as in Holsteins than in Jersey cows. This higher lactate in organic dairy cows was unexpected. Previous reports that have associated increased plasma lactate in dairy cows to prevailing conditions of endotoxemia [9,18,19]. Therefore, it could be speculated that during feeding regimen during winter might have contributed to the observed differences in lactate concentrations in these cows. Similarly, Holstein cows are to
known consume more feed per unit body weight compared to Jersey cows and in turn produce more milk than Jersey cows too. These inherent traits make Holsteins more prone to metabolic disturbances than Jerseys, hence the difference in the plasma lactate levels. Just like in lactate, higher concentrations of glucose in cows were also observed during winter and in Holsteins. Increased concentrations of glucose in cows during winter allude to the fact that more gluconeogenic diets were probably used during that time. Ametaj et al. [9] reported increased plasma glucose in cows when fed ≥30% grains in the diet. Similarly, Van Knevel et al. [4] observed higher concentrations of glucose and decreased risk of metabolic disorders in transition dairy cows fed diets rich in fermentable carbohydrates.

A drastic increase in haptoglobin was evident in conventional cows at initiation of lactation that remained much more elevated 30 to 60 and 60 to 90 d postpartum than in organic cows. A similar pattern of haptoglobin secretion has been reported in dairy cows and is believed to be in response to the traumatic experience during calving and acute phase response preceding calving [20-22]. It is also possible to speculate that variability of diets fed between the systems might contribute to this observed pattern on haptoglobin secretion in the cows. Indeed grains make up 30% to 45% of most conventional diets fed between the systems might contribute to this phenomenon.

6. CONCLUSION

Taken together, these data indicate that metabolic changes associated with initiation of lactation are preceded by an acute phase response in dairy cows, and that cows in organic systems seem to be healthier than cows under conventional systems. These differences might be due to differences in nutritional management in the two systems. However, more studies might be required to fully understand this phenomenon.

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