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Dietary and serum biochemical analyses in a dairy herd with increased acidity of fresh milk

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Abstract. A Holstein dairy herd consisted of 24 adult lactating cows in their fourth and fifth lactation was investigated for increased acidity of bulk tank milk. The ration consisted of corn silage, coarse dry grass hay, and a grain mix of ground ear corn, soybean meal, rumen buffer, and yeast. Results of dietary analysis and analysis of various serum biochemistry parameters in 10 cows are presented in this report. Ration analysis of lactating cows showed a high fiber, low protein contents. Moreover, the ration contained lower levels of phosphorus, calcium, and magnesium and higher levels of potassium. The bulk tank fresh milk was on the acidic side of the pH meter. Serum biochemical analysis of a representative sample of cows showed that serum concentrations of phosphorus, total calcium, ionized calcium and magnesium were situated at the lower edge of the normal range. Ration analysis and serum biochemical parameters in cows with increased bulk tank acidity is being reported here for the first time as well as a possible association between increased milk acidity and hypocalcaemia (milk fever) in Holstein dairy cows.
Key Words: Acidic milk, subclinical hypocalcaemia, dietary analysis, serum biochemistry.

Introduction. Abnormal acidity of milk is detrimental to fresh milk-technological quality (Hanuš et al 2010; Chladek et al 2011). Fresh milk with abnormal acidity is considered unsuitable for the production of valuable cheese products (Johnson et al 2001; Cassandro et al 2008; Marchesini et al 2009; Masoero et al 2006). Abnormal acidity of milk is known to negatively affect acid-rennet curd formation and consequently, the textural quality of formed cheese (Hanuš et al 2010). The major components that determine fresh milk acidity are levels of milk casein and phosphorus (Johnson et al 2001; Cassandro et al 2008; Marchesini et al 2009; Masoero et al 2006). It is well established that abnormal levels of casein and phosphorus in milk are associated with various metabolic disorders, nutritional deficiencies and alimentary issues (De Marchi et al 2007, 2009). Ration analysis and serum biochemical analysis in cows belonging to a Holstein dairy farm suffering increased fresh milk acidity are being reported here for the first time in literature.

The present study aimed to determine possible relationships between acidic fresh cow milk and various nutritional factors, and the associated changes in the serum biochemical parameters in affected cows.

Material and Method

Study population. A dairy herd consisted of 24 adult lactating and 6 dry Holstein cows was investigated because of increased acidity of fresh bulk tank milk and hypocalcaemia. The average milk production was 3800 kg (8378 lb)/cow/lactation, as estimated by the producer's milk cooperative. The producer stated that production had started to go down three months prior to our visit. Although detailed records were not available, the producer stated that almost all of the fresh cows in his herd developed clinical milk fever within 1 to 2 days after freshening. Most of the affected cows were treated successfully with a single intravenous injection of 500 mL of 25% calcium gluconate with almost 10% relapse rate. Most of the cows in the herd were in their fourth or fifth lactation and were in a late stage of lactation. Although the producer said that other concurrent diseases

such as mastitis, ketosis, and displaced abomasum had not been a problem in the herd, upon further questioning, it was found that some of the fresh cows developed coliform mastitis. No problems related to the reproductive system had been reported by the producer. The cows in this herd were winter housed in a 4-row freestall barn, with periods of turning out into a dry lot. In the spring time the cows were put on pasture. Dry cows were kept with the lactating cows in the barn, although in the spring they were kept on a separate pasture. The lactating herd was fed corn silage, coarse dry grass hay, and a grain mix that consisted of ground ear corn, soybean meal, rumen buffer, and yeast. Corn silage was offered to the cows in a 10 m (30 feet) long feed bunk, and hay was offered in a round bale feeder, while 2.7 kg (5 lbs) of the grain mix was fed in the parlor at milking. Dry cows were fed the same ration except when they were turned out into the pasture. At that time only ground corn was fed. No mineral supplements had been offered to the cows, except for free choice white salt (NaCl).

Laboratory analysis. To perform serum biochemistry analyses, whole blood samples were collected from 10 cows via jugular veinpuncture and placed in plain blood tubes. Samples were submitted to Purdue University Veterinary Teaching Hospital Clinical Pathology Laboratory for testing. The following parameters were evaluated: glucose, blood urea nitrogen, creatinine, total protein, albumin, total calcium, ionized calcium, blood pH, carbon dioxide, phosphorus, potassium, magnesium, sodium and chloride. In addition, a fresh milk sample was taken to determine milk pH using electric pH meter (WTW Inolab pH 720, Germany).

Ration evaluation. Representative feed samples from the corn silage, ground ear corn, grain mix and from the dry cow pasture hay were collected. Feed samples were submitted for nutrient analysis by wet chemistry technique, except for the ground ear corn sample, which was analyzed by the near-infrared reflectance spectroscopy (NIRS) technique. Macrominerals in feed samples were assayed by wet chemistry technique. In addition, a sample of shelled corn was taken for mycotoxins (aflatoxin and T-2) analysis.

Results. At the time of the visit, cows appeared dull, depressed, and had rough hair coats. However, they were in good body condition with body condition scores ranging from 3.25 to 3.5, on a scale of 1 to 5. Inspection of the milk bulk tank conditions revealed appropriate storage temperature and agitation.

Table 1

Mean ± SD of serum biochemistry analysis (n=10)

Parameter	*References range[1] and units*	*Mean*	*SD*	*Range*
Glucose	2.5–4.2 (mg/dL)	63	4.4	55-77
Creatinine	50-110 (mg/dL)	1.13	0.084	0.9-1.2
Blood urea nitrogen	6-22 (mg/dL)	6.9	2.3	3-12
Total protein	5.8-7.5 (g/dL)	7.68	0.44	6.3-8.3
Albumin	2.4-3.5 (g/dL)	2.82	0.20	2.0-3.0
Phosphorus	4.7-9.0 (mg/dL)	6.0	0.85	4.3-7.7
Calcium	8.2-10.0 (mg/dL)	8.77	0.45	7.8-9.6
Magnesium	2.0-2.8 (mEq/L)	1.96	0.292	1.6-2.7
Sodium	134-144 (mEq/L)	143	2.58	137-147
Potassium	4.0-5.7 (mEq/L)	4.89	0.19	4.7-5.5
Chloride	96-104 (mEq/L)	102	2.3	95-108
Carbon dioxide	19-29 (mEq/L)	31.6	1.52	29-36
Ionized calcium	1.06-1.2 (mg/dL)	1.007	0.09	0.70-1.12
Blood pH	7.3-7.5	7.47	0.03	7.39-7.52

[1] Adapted from the university clinical pathology laboratory's reference range.

Table 1 show the mean ± SD and ranges of the serum biochemistry parameters from a representative sample from the herd. Serum biochemical analysis showed that serum

concentrations of total calcium and ionized calcium were on the lower edge of the normal range while serum magnesium concentrations were lower than normal. The blood pH indicated a trend towards alkalinity. Milk pH was on the acidic side of the scale.

Table 2 shows the nutrient analysis of the lactating cow ration, formulated by the feed company, on a dry matter basis. The ration was dry, high in fiber content, and low in protein for lactating cows. No minerals or vitamins were included in the ration.

Table 2

Wet chemistry analysis of the lactating cow ration based on dry matter basis (DM)

Nutrient	*DM%*	*NRC requirement***
Dry matter	74	45-55
Moisture	26	45-55
Protein (CP)	16	17
ADF	23	17-21
NDF	41	25-33
Fat	4	6-7
NEL (Mcal/cwt)	71	70

ADF - Acid Detergent Fiber, NDF - Neutral Detergent Fiber, NEL - Net energy for lactation, ** - NRC 2001.

Wet chemistry and NIRS analysis of the corn silage and the ground ear corn feed samples are shown in Tables 3 & 4, respectively.

Table 3

Wet chemistry analysis of the corn silage on dry matter basis (DM)

Nutrient	*DM%*
Dry matter	41.0
Moisture	59.0
Crude protein	6.0
ADF	17.0
NDF	33.0
Phosphorus	0.20
Calcium	0.30
Potassium	0.90
Magnesium	0.13
Sulfur	0.08
Sodium	0.02
NFC	55.0
NEL (Mcal/kg)	1.85

NFC - Non-fiber carbohydrate.

Table 4

NIRS analysis of the ground corn on dry matter basis (DM)

Nutrient	*DM%*
Dry matter	87.0
Moisture	123
Crude protein	8.0
ADF	5.0
NDF	12.0
Phosphorus	0.26
Calcium	0.04
Potassium	0.35
Magnesium	0.10
NE/L(Mcal/kg)	2.0

ADF - Acid Detergent Fiber, NDF - Neutral Detergent Fiber, NEL - Net energy for lactation.

High energy, dry corn silage with low fiber and low mineral contents was indicated by the analysis. Ground ear corn was low in protein, high in fiber content, and had average mineral content as indicated by the analysis. Analysis of the dry cow pasture hay revealed high potassium content and marginal calcium content (Table 5).

Table 5

Wet chemistry analysis of the dry cow pasture hay on dry matter basis (DM)

Nutrient	*DM%*
Dry matter	16.0
Moisture	84.0
Crude protein	24.0
ADF	26.0
NDF	41.0
Phosphorus	0.24
Calcium	0.90
Potassium	2.80
Magnesium	0.20
Sulfur	0.20
Sodium	0.05
Chloride	0.60
Relative feed value	194.0
NEL(Mcal/kg)	1.60

ADF - Acid Detergent Fiber, NDF - Neutral Detergent Fiber, NEL - Net energy for lactation.

None of the common mycotoxins (Aflatoxin, T-2) were detected by the mycotoxin screening test of the shelled corn.

Discussion. Proper acidity of fresh milk is considered a key factor in cheese making industry (Formaggioni et al 2001). Different research have determined that milk acidity can be influenced by many factors such as milk physical and chemical properties, somatic cell count, protein contents especially casein, calcium and phosphorus levels (Formaggioni et al 2001; Summer et al 2002). In addition, several cow (breed, age, stage of lactation) and environment (season, ambient temperature) related factors have been found to affect acidity of milk (Ikonen et al 2004; Malacarne et al 2006; Tyriseva et al 2004). In this study, although we were unable to determine the exact cause for the increased acidity of fresh bulk tank milk, all cows in the farm were of Holstein breed, which are known to have increased acidity of milk (De Marchi et al 2007, 2009; Cassandro et al 2008; Chladek et al 2011).

Nutritional analysis revealed several important dietary deficiencies. The ration was dry, high in fiber content, and low in protein for lactating cows. No minerals or vitamins were included in the ration. Several macrominerals were low according to NRC (2001) requirements for lactating dairy cows while in the dry cow ration, high potassium content and marginal calcium content were detected. All these findings suggested an associated nutritional/metabolic disorder as the main cause for the poor production in the herd and may be, although could not be ascertained, milk acidity problem (Bani Ismail et al 2011).

During the walkthrough of the farm, by careful questioning of the owner, it was made clear that many of the periparturient cows in this herd suffered clinical hypocalcaemia and were treated with intravenous calcium solutions, some of them would relapse and require multiple calcium injections. Indeed, blood biochemistry analyses results confirmed that most cows in the herd suffered to some extent from subclinical hypocalcemia. In fact, the low to marginal serum calcium levels are consistent with stage I clinical disease which is characterized by depression and dullness (DeGaris & Lean 2008; Goff 2008; Bani Ismail et al 2011). Moreover, low potassium level, normal glucose level, and slight metabolic alkalosis are all common findings in cows with milk fever (DeGaris & Lean 2008; Goff 2008; Bani Ismail et al 2011). An exception was low blood magnesium concentration which was mainly, in this case, due to lack of magnesium

supplementation in the diet. Nevertheless, hypomagnesemia is considered as one of the risk factors for developing milk fever in lactating dairy cows (DeGaris & Lean 2008; Goff 2008).

The association between the increased incidence of hypocalcaemia and increased acidity of fresh milk in the herd could not be ascertained and further research is warranted to determined their relationships, however, both problems were solved by correcting certain dietary deficiencies detected in our ration analyses and by the implementation of a milk fever preventative program.

Ration analysis and serum biochemical parameters in cows with increased bulk tank acidity is being reported here for the first time as well as a possible association between increased milk acidity and hypocalcaemia (milk fever). Further clinical studies to investigate this association are warranted.

Conclusions. Ration analysis and serum biochemical parameters in cows with increased bulk tank acidity is being reported here for the first time as well as a possible association between increased milk acidity and subclinical hypocalcaemia. Further clinical studies to investigate this association are warranted.

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