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Associations Between Serum Mineral Status and Sub-optimal Performance in Dairy Cows in Fars Province

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Abstract: This study was conducted on 55 dairy and dry cows with signs of Sub-Optimal Performance (SOP) to determine the relationship between serum mineral status and SOP. The herd was subjected to some changes such as renovation of mangers, rationing and removal of short comings as; dry matter and roughage deficiency. Jugular blood vein was collected before changes to management of the herd and in a 3-4 month period as the second and the third sampling. Serum calcium, sodium, potassium, magnesium, manganese, cobalt, copper, iron, zinc, phosphorous, chlorine and ceruloplasmin concentrations were measured for each blood sampling time. There was significant differences ($p<0.05$) between serum mineral concentrations and reference values before exercising the changes to the management of the herd. There was an incremental improvement ($p<0.05$) in the serum mineral concentrations and performance during the blood sampling times. The present study indicates that serum mineral status may be a valuable indicator of animal or herd status and worth watching when considering animal welfare and herd profit.

Key words: Dairy cows, sub-optimal performance and serum minerals

INTRODUCTION

The health and degree of productivity of livestock depend on balanced and adequate quantities of all the necessary nutrients to meet their requirements for a given physiological conditions. Sometimes, minor but longstanding nutritional imbalances may drive a marginally deficient animal or herd into a major problem.

Mineral nutrients are used in countless metabolic pathways within the dairy cow's body and even small mineral deficiencies can result in sub-optimal cow performance.

Mineral imbalances have been reported to inhibit ruminant production systems (Underwood and Suttle, 1999) and any marginal blood mineral deficiencies without clinically diagnosable will associate with negative effects on general immunity system, growth of animal (Radostits *et al*., 2000a) retained placenta, left displaced abomasum (Massey *et al*., 1993) and negative effect on subsequent ovulation (Johnsson *et al*., 1999).

Also, any imbalances between nutrition, metabolism, pathogens, management and environmental factors could result in sub-optimal performance and will reduce herd profit (Van Horn and Wilcox, 1992; Heuer *et al*., 2000; Smith, 2002).

The early-lactation period poses high risks for common diseases in dairy cows (Rajala and Grohn, 1998). Most of these health problems may be related directly to the abrupt physiological changes in the transition cow. During parturition, blood calcium drops to subnormal levels and this decrease in

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available body calcium may eventually continue below levels for normal function, resulting in milk fever, which is connected with reduced herd profit (Qstergaard *et al*., 2000) because of decreased milk yield (Qstergaard and Grohn, 1999), increased risk of other diseases (Klerx and Smolders, 1997) and costly interventions following the syndrome (Kossaibati and Esslemont, 1997).

The feeding system in dry period has a crucial effect on subsequent fertility, metabolic diseases and milk production (Van Horn and Wilcox, 1992; Radostits, 2001).

Balancing diet sodium and cobalt resulted in higher milk production (Chiy *et al*., 1993; Kincaid and Lefebvre, 2003). Lopez and Satter (1992) reported increase in dry matter digestibility, growth and milk production by adding copper and cobalt to heifers diet. In general, serum mineral status in most cases may be a valuable indictor of animal or herd nutritional problems (Smith, 2002).

The intention of this study was to estimate associations between serum mineral concentrations and performance in a sub-optimal performance Dairy herd after imposing changes to feeding and management systems in Fars province, Southern, Iran.

MATERIALS AND METHODS

The study was conducted in an industrial dairy herd in Shiraz, Iran, using 55 dairy and dry cows with signs of Sub-Optimal Performance (SOP) in 2006. The herd was subjected to some changes such as renovation of managements, rationing and removal of short comings such as dry matter and roughage deficiency. Dairy cows grouped as high producing (above 22 kg), low producing (lower than 22 kg) and primiparous cows. Dry cows were included in low producing group at 3 last weeks of pregnancy. For determining Dry Matter Intake (DMI) and SOP in the herd, a balanced ration was offered for 20 days. Balanced rations were offered for subsequent 20 days and up to 4 months from imposing changes in herd management. Blood samples were collected by jugular venepuncture into vacuum containers before exercising changes to management of the herd (first sampling, Table 1) and in a 3-4 months period as the second and the third sampling. Serums were separated in the same day by centrifugation at 750 g for 15 min and kept at -20°C for subsequent mineral and ceruloplasmin analysis. Any haemolysed samples discarded.

The samples were analysed for copper, sodium, calcium, magnesium, manganese, cobalt and zinc by atomic absorption spectrophotometry (Shimadzo AA-670, Kyoto, Japan). Ceruloplusmin activity was measured according to its phenylenediamine oxidase activity (Sunderman and Nomoto, 1970). Serum chloride and phosphorus were measured by the mercuric chloride and ammonium molybdate methods, respectively.

Table 1: Comparison between some performance parameters and serum mineral and ceruloplasmin concentrations with reference values before changes to the herd management

Herd parameters	Herd values	Reference values	p-value
Daily milk production (kg)	23.82±7.65	34	0.001
Insemination/pregnancy	14.50	1.7	0.001
Days in milking	168.00	160	0.001
Ca (mmol L^{-1})	1.32±0.29	2.43-3.10	0.001
Na (mmol L^{-1})	128.90±2.30	132-152	0.001
K (mmol L^{-1})	4.14±0.08	3.9-5.8	0.001
Mg (mmol L^{-1})	0.24±0.20	0.74-0.95	0.001
Mn (nmol L^{-1})	360.00±54.0	1638	0.001
Co (µg mL^{-1})	1.11±0.38	2.00-5.00	0.001
Fe (µmol L^{-1} l)	15.73±0.86	10.2-29	0.001
Zn (µmol L^{-1})	23.41±4.59	17.6-42.9	0.001
Cu (µmol L^{-1})	5.19±3.77	5.16-5.54	0.001
P (mmol L^{-1})	1.56±0.46	1.81-2.10	0.001
Cl (mmol L^{-1})	102.21±1.20	97-111	0.001
Ceruloplasmin (g L^{-1})	0.072±0.018	0.120-0.200	0.001

Comparison between serum mineral concentration and reference values (Kaneko, 1989) was performed using one-sampled-test. The other data were analysed by one-way ANOVA and Tucky test was used to detect significant differences between means. All values were expressed as mean with Standard Deviation (SD) and the values at $p<0.05$ were accepted as statistically significant.

RESULTS AND DISCUSSION

There is trend that many dairy practitioners have exploring ways in order to prevent diseases rather than taking the time and effort-consuming of prescription and treatment (Jarret, 1999).

There were significant differences ($p = 0.001$) for all herd parameters between measured parameters and reference values (Kaneko, 1989) (Table 1) which shows sub-optimal performance and mineral deficiencies (except for K, Zn and Cl) in the experimental herd and could result in poor animal production systems (Underwood and Suttle, 1999).

The concentration of blood minerals are not fixed values and changes due to different factors such as yield, body size and ration characteristics (Shaver and Linn, 2001). Also interaction between minerals is the most factor affecting their availability (Underwood and Suttle, 1999).

Table 2 shows the serum mineral and ceruloplasmin concentrations during 3 blood sampling times. The concentration of all serum minerals showed an increasing trend ($p<0.001$) in most cases although there was no significant differences between the level of Co and Mn in the first and second sampling time.

Legumes are good source of Ca and except with rations high in legumes and/or mineral supplementation, ruminant rations are deficient in Ca during lactation (Ammerman and David, 1995). In the experimental herd, due to low feeding of legumes and lack of efficient use of mineral supplements, the level of serum Ca was lower than reference value (1.32 against 2.43-3.10 mmol L^{-1}) but after imposing balanced rations, the serum Ca concentration showed an improvement. Qstergaard and Larsen (2000) reported positive effect of blood Ca status on milk production in dairy cows.

The amount of Cobalt (Co) in legumes and brans is higher than in grasses and cereals, respectively. High amount of dietary Fe has negative effect on Co absorption (Kaneko, 1989) and in Co deficiency status, the animal is not able to produce enough glucose due to propionate metabolism impairment (Van Horn and Wilcox, 1992). After feeding balanced rations during current study, improvement in Co status was noticed (Table 2) possibly due to higher dry matter intake.

Cereals and corn silage are poor sources of sodium (Underwood and Suttle, 1999) but adding salt to the ration will improve blood sodium status and milk production of the herd (Chiy *et al*., 1993) as seen in the study.

Table 2: Serum minerals and ceruloplusmin concentrations during blood sampling in dairy herd (N = 55, Mean±SD)

Blood sampling times	Ca (mmol L^{-1})	Na (mmol L^{-1})	K (mmol L^{-1})	Mg (mmol L^{-1})	Mn (nmol L^{-1})	Co (μg mL^{-1})
1	1.32 ± 0.29^a	128.90 ± 2.30^a	4.14 ± 0.08^a	0.24 ± 0.20^a	360 ± 54^a	1.11 ± 0.38^a
2	1.59 ± 0.25^b	133.82 ± 2.37^b	4.31 ± 0.09^b	0.59 ± 0.30^b	540 ± 360^a	1.62 ± 0.54^a
3	1.95 ± 0.50^c	139.87 ± 2.23^c	4.55 ± 0.16^c	0.98 ± 0.34^c	1080 ± 900^b	2.61 ± 2.32^b

Table 2: Continued

Blood sampling times	Fe (μ mol L^{-1})	Zn (μ mol L^{-1})	Cu (μ moL^{-1})	P (mmol L^{-1})	Cl (mmol L^{-1})	Ceruloplasmin (g L^{-1})
1	15.73 ± 0.86^a	23.41 ± 4.59^a	5.19 ± 3.77^a	1.56 ± 0.46^a	102.21 ± 1.20^a	0.072 ± 0.018^a
2	22.62 ± 1.36^b	38.71 ± 6.27^b	9.24 ± 3.45^b	2.16 ± 0.71^b	104.27 ± 1.12^b	0.105 ± 0.036^b
3	26.21 ± 2.60^c	45.75 ± 5.35^c	17.87 ± 9.41^c	3.11 ± 1.04^c	106.34 ± 1.23^c	0.172 ± 0.046^c

a-c: Means in the same column with the same letter(s) are not significantly different ($p>0.05$)

Ceruloplasmin concentration have been considered as reliable indicators to copper status (Jain, 1993). Eighty to ninty percent of the serum copper is transported by ceruloplasmin (Larson and Arthington, 1995) and any copper deficiency will result in lower cerutoplasmin synthesis (Arthington *et al*., 1996). In the current study, serum copper and ceruloplasmin concentration deficiencies was detected (Table 1) before changes to the feeding management of the herd but showed an improving trend (Table 2) after imposing feeding system. High levels of dietary Zn, phytate, cadmium, molybdate and sulfate will decrease copper bioavailability (Kaneko, 1989). Legumes and oil meals are excellent sources of copper (Underwood and Suttle, 1999) and possibly the use of cotton seed meal and lucerne hay in the herd diet was effective in improving serum copper status (Table 2).

Magnesium in ruminants is often considered as the third important macro mineral following Ca and P because of its dominant role in anatomical, physiological, enzymatic activities and reproductive performance. Cattle serum Mg concentration varied by nutrition (Radostits *et al*., 2000b), age (Mulei and Daniel, 1988), season (Vajda, 1997), milk yield (Payne, 1977), hypocalcaemia (Radostits *et al*., 2000a), diarrhea (Cabello and Michel, 1977) and respiratory syndrome (Planski and Abashev, 1987).

Bran, soybean and cotton seed meal are good sources of Mg (Underwood and Suttle, 1999). Table 1 shows that cows had low serum Mg concentration (0.24 versus 0.74-0.95 mmol L^{-1}) which could be considered as sub-clinical hypomagnaesemia, but after incorporating wheat bran and cotton seed meal in the diet, reached to a normal concentration (Table 2).

Malnutrition, sudden changes in quality and quantity of diet and low rumination time result in lower food intake and higher incidence of Mn deficiency (Kaneko, 1989). Low dietary energy and high ruminal NH_3 concentration lower Mn absorption (Kaneko, 1989).

Diet is the most important source of phosphorus deficiency. Also, high dietary calcium and low vitamin D (Smith, 2002) and Ca:P ratio can affect the availability of dietary phosphorus (Ammerman and David, 1995). Concentrates are rich in phosphorous. Loss of appetite is the first sign of phosphorus deficiency and diets low in phosphorus lower rumination and feed and energy intake. Feeding adequate roughage and concentrate is essential for improving phosphorus status of the herd (Underwood and Suttle, 1999).

Mean daily milk yield was not different between before, after 3 and 7 months (24.15, 22.94 and 24.57 kg, respectively) of imposing changes to feeding and management of the herd, but Days In Milking (DIM) increased from 168 to 204 days (data are not shown) which shows the positive effect of improved mineral status on herd performance (Kincaid and Lefebvre, 2003).

CONCLUSIONS

A planned approach to mineral nutrition is essential to ensure efficient and profitable milk production. The findings of the current study highlights the importance of the good feeding management in preventing sub-optimal performance of dairy herd which is crucial in animal welfare and herd profit.

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