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The Relationship among Total Dissolved Solid in Water and Blood Macro Mineral Concentrations and Health Status of Dairy Cattle in Qom Area

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Abstract

Dairy farms in some arid areas around the world have to use drinking water that contained elevated total dissolved solids (TDS); however, very limited data is available concerning water TDS effects on health status and blood mineral levels of cattle. The aim of this study was to compare 3 dairy cattle groups in several dairy farms with different drinking water TDS: High (HTDS; >4000 ppm), Medium (MTDS; 1500-3000 ppm), and Low (LTDS; ≈ 490 ppm). Metabolic disorders record and some management information of each herd during five years were collected and some Holstein dairy herd in Qom (n = 10) were assigned to 3 groups. Moreover, six same dairy cows were selected from each TDS group and blood and feed samples were collected twice a week. Urine samples were taken from the dry cows and urine pH was measured. Data were analyzed using the MIXED procedure of SAS. Although water TDS range was between 500 and 4500 ppm, dry cows urine pH was unaltered by water TDS and health problems are not common in this area. Blood calcium concentrations increased linearly as TDS increased ($P < 0.05$). Similarly, blood potassium concentrations were affected by TDS, whereas blood Mg and Na contents were unaltered by TDS. Negligible elevated some mineral concentrations in blood whereas the water TDSs are dramatically different show necessity of revision of mineral supplementation or providing high quality water to decrease metabolic stress in dairy cattle.

Key words: Water TDS, metabolic disorders, blood mineral, dairy cattle, arid area

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Introduction

Low rainfall and high temperature, evaporation intensity in most parts of the world causes concentration increase of solute and water quality reduction (Arjomandfar et al., 2010; Shapasand et al., 2010). In arid zones around the world supplying qualify drinking water supply for dairy farms is a concern and that's while dairy cows need for water is greatest among other farm animals (Kabuga and Alhassan, 1983; Sanchez et al., 1994). Total dissolved solids (TDS) is physicochemical characteristics of water is used for evaluation of water quality. It is proven that water with low TDS can be helpful for dairy cows under heat stress (Sanchez et al., 1994; Meyer et al., 2009; Shapasand et al., 2010). Results of reviewing 3651 water samples show that consuming water with 250 ppm sulphur, resulted in receiving 30 g additional sulfur per day (Socha et al., 2003). Indeed, increasing sulphur intake from 0.20% to 0.60% due to consumption of high sulphur water reduces Cu absorption coefficient by 50% (NRC, 2001).

Recently, scientists have shown that blood potassium levels increases significantly by high TDS in water (Arjomandfar et al., 2010). Despite the importance of drinking water minerals there is no independent research about effects of concentrations of water minerals on health status, urea pH and blood macro mineral concentrations in dairy cows at arid areas of Iran. Therefore, this study was conducted regarding to these goals.

Materials and Methods

This study was conducted in Qom area, Iran at Southern and Western Asia. Due to being located near an arid region, it recognized as a dry climate, with low humidity and scanty rainfall (133 mm). The first classification was based on locations which were lots of dairy farms, generally these locations are places like complex of dairy farms built close together or most of the people were farmers. These zones were as following: 1) Damshahr Animal Complex; 2) Laban Animal Complex; 3) Masoom-Abad Animal Complex; 4) Haji Abad Village; 5) Qomrood Village; 6) Isfahan road region and 7) Arak road region.

The next step was measuring the amount of TDS with TDS meter and the final classification was based on TDS levels which 10 dairy farms were selected from these 7 locations regarding to TDS levels. After measuring TDS levels in different regions of Qom province each dairy farm belongs to one of the three main groups; I. Dairy farms which used desalted water and the TDS of their drinking water was < 500 ppm (LTDS: Low TDS); II. Dairy farms which TDS of their drinking water was between 1500-3000 ppm (MTDS: Medium TDS) and III. Dairy farms which the TDS of their drinking water were 3100- 4000 ppm (HTDS: High TDS). Then, they were all provided with the designed questionnaire and all the needed information such as prevalence health problems (milk fever, retained placenta) during five last years.

Three water samples were taken in different times of the day. Samples were taken on January, March, April and all of the samples were sent to Central Laboratory of Water Organization of Qom province.

There were three index dairy farms selected for each LTDS, MTDS, and HTDS groups. Objective dairy farms were herd no. 2 (Khalighi dairy herd; 490 ppm), herd no. 4 (Buddy dairy herd; 2100 ppm) and herd no. 9 (Koohi dairy herd; 4300 ppm). In each dairy farm six dairy cows were selected for the sampling. These cows were similar in terms of production (milk production = 30-35 kg/d), parity and body condition scoring. Blood sampling was performed approximately five hours after feeding. Blood sampling was repeated in three days; also at the same time of blood sampling samples of the feed were taken, too. Feed samples were taken from thoroughly total mixed ration (TMR) and were sent to laboratory (Karaj, Iran) to be analyzed for macro mineral concentrations. In all ten dairy farms urine samples were taken for determination of pH levels in dry cows' urine.

This experiment was assigned in a completely randomized design. The data were analyzed using the MIXED procedure of SAS (1999). A threshold of significance was set at $P < 0.05$.

Results and Discussion

In terms of amount of elements and TDS there was a significant difference between dairy farms in the region (Table 1). At the beginning the distributed questionnaire between ten dairy farms was collected and general information about reproduction and metabolic disorders were reviewed. Questionnaire gave a general view to this experiment and was determined that despite the dispersion of TDS in domain of 500 to 4500 ppm, metabolic disorders is not as prevalent in this region. One point should be noted in this regard. Adaptation of dairy cows to existing conditions can be one of the main reasons of it; however the metabolic stress cows should not be forgotten on the other hand.

Interestingly a significant difference in water quality in a small region is expected to affect the performance parameters of milking cows. Despite the 18 times difference of water calcium concentrations between LTDS and HTDS farms and also no significant difference between the calcium percentages in their feed, in terms of levels of calcium in blood there was a significant negligible difference between several dairy farms (Table 2). It seems that animal body tries to keep blood calcium levels relatively constant. Therefore there is lots of metabolic stress on the kidneys and other organs which may result reduction in production or decline in longevity of the livestock in the region. With the review of available phosphorus in feed was determined that there is no significant difference between three studied dairy farms and the percentage in the dry matter was 0.35, 0.57, 0.43 respectively in LTDS, MTDS and HTDS groups.

Due to variance of waters phosphorus, measuring of this element wasn't performed. Accumulated P from dairy farms can leach into groundwater or cause eutrophication of surface waters due to run-off from agricultural land (Arriaga et al., 2009). There was a significant difference in blood phosphorus levels, most likely it was because of phosphorus level in water (6.25 and 6.35 versus 8.1 mg/dl blood phosphorus, respectively for MTDS, LTDS versus HTDS; $P < 0.05$).

Appropriate level of phosphorus in dairy cows blood is estimated from 4-8 mg/dl (NRC, 2001). Moreover, Arriaga et al. (2009) concluded that the correct match between the ingested and required N and phosphorus, together with an increase in milk productivity, may be feasible strategies for decreasing N and phosphorus excretion by lactating herds on commercial farms. The outcome of this study is that cows are exposed to high levels of phosphorus and in this case should be more careful.

When it comes to feed's sodium and also water there was a significant difference between the studied dairy farms. Although it seems that the feed's sodium was more effective than waters sodium for changing the blood levels sodium. Accordingly, the following regression equation was proposed:

$$\text{Blood Na} = 135+2.91 \text{ Feed Na } (R2 = 0.71; P < 0.05)$$

Interestingly water's Magnesium and feed of studied dairy farms were different. However this difference has no effect on Magnesium concentration of blood. It seems that dairy cattle's body homeostasis have the ability to keep the adequate blood Magnesium at the desired level despite the environmental changes. In a recent conducted research potassium was the only element which was affected by water elements (Arjomandfar et al., 2010). This confirms the different metabolism of various elements in dairy cows and maybe because of different levels of these elements in water consumed in these experiments. Similarly in Arjomandfar et al. (2010) despite the amount of water's Magnesium which was double the normal amount, there was no significant difference between two groups. In current experiment blood Potassium level has significant changed, however there was not a dramatically difference (4.3, 4.6, and 4.5 mEq/L respectively for HTDS, MTDS, and LTDS).

There was no difference observed in urine pH between dry cows from different farms which is presumably due to adaptation of animal to existing conditions and consuming water with fixed TDS in both milking and dry period. In total not seeing prevalence of metabolic disorders is maybe because of

Table 1. Chemical analysis of experimental water (mean ± SEM)

	Dairy Herd							
	1	2	3	4	5	6 & 7	8	9 & 10
TDS (ppm)	458 ± 1.66[c]	486 ± 3.30[c]	490 ± 5.77[c]	2048 ± 9.50[b]	2108 ± 4.40[b]	2473 ± 8.81[a]	3800 ± 5.62[a]	4303 ± 3.33[a]
Ca (mg/l)	42 ± 1.66[d]	20 ± 0.57[d]	26 ± 0.88[d]	57.6 ± 1.45[d]	160 ± 0.00[c]	265 ± 0.33[b]	141 ± 1.33[c]	369 ± 1.00[a]
Na (mg/l)	154 ± 1.85[c]	131 ± 0.66[c]	129 ± 1.00[c]	860 ± 2.88[a]	625 ± 2.40[b]	708 ± 4.40[b]	610 ± 1.20[b]	990 ± 3.75[a]
K (mg/l)	1.50 ± 0.10[c]	1.50 ± 0.00[c]	1.50 ± 0.00[c]	1.50 ± 0.00[c]	7 ± 0.00[b]	1.50 ± 0.00[c]	2.7 ± 0.00[c]	9.33 ± 0.33[a]
Cl (mg/l)	137 ± 9.80[d]	145 ± 1.45[d]	135 ± 1.00[d]	335 ± 2.64[c]	568 ± 10.0[b]	696 ± 2.08[b]	1027 ± 1.20[a]	1479 ± 3.17[a]
Mg (mg/l)	19.6 ± 1.60[d]	11 ± 0.66[d]	6.66 ± 0.59[d]	32.6 ± 1.45[c]	94.3 ± 1.45[b]	55 ± 0.00[c]	135 ± 0.66[a]	158 ± 1.33[a]

Means within a row with different superscript letters differ ($P < 0.05$).

Table 2. Concentration of calcium (mg/dl) in drinking water, total mixed ration and blood samples

	Water	Feed	Blood
Groups[1]			
LTDS	20.0[c]	0.47	9.12[a] ± 0.13
MTDS	160.0[b]	0.47	9.45[ab] ± 0.19
HTDS	370.0[a]	0.40	9.70[b] ± 0.15

[1]TDS = Total dissolved solids; High TDS (HTDS > 4000 ppm), Medium TDS (MTDS = 1500-3000 ppm), and Low TDS (LTDS ≈ 490 ppm). Means within a row with different superscript letters differ ($P < 0.05$).

animal adaptation, however according to effects of major cations available in drinking water on concentration of these elements in blood and also high levels of blood Phosphorus in HTDS animals, shall reconsider the usage of mineral supplements in this region. It appears that part of the animals need to minerals can be supplied by drinking water and there would be less metabolic stress on animals.

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