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Growth performance and health of dairy calves given water treated with a reverse osmosis system compared to municipal city water

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ABSTRACT

Our objective was to determine effects of drinking reverse osmosis water (RW) versus municipal city water (MW) on growth, nutrient utilization, and health scores of calves. Twenty-four Holstein calves (14 females, 10 males; 2 d old; 44.6 ± 6.10 kg of body weight), housed in individual hutches, were used in a 10-wk randomized complete block design study. Calves were blocked by birthdate and sex. Treatments were RW (Culligan Water Filtration System, Brookings, SD) versus MW (Brookings Municipal Utilities, Brookings, SD) that contained 13 and 387 mg/L of total dissolved solids, respectively. Milk replacer (28% crude protein; 18% fat) was fed twice daily during wk 1 through 5 and then once daily during wk 6. At each feeding, 0.45 kg of dry milk replacer was mixed with 2.83 L of the respective water type according to treatment. Calves were fed water, respective to treatment, and calf starter pellets ad libitum throughout the study. All intakes were recorded daily. Daily total respiratory scores (healthy ≤3, sick ≥5) were calculated from the sum of scores for rectal temperature, cough, and ocular and nasal discharges. Fecal consistency scores (0 = firm, 3 = watery) were also recorded daily. Body weights and frame growth were measured 2 d every 2 wk and jugular blood samples were collected 1 d every 2 wk at 3 h after the morning feeding. Fecal grab samples were collected 5 times per day for 3 d during wk 10 for analysis of apparent total-tract digestibility of nutrients. We found treatment by week interactions for dry matter intake and gain-to-feed ratio, and total dry matter intake increased more during the study for RW than MW. Gain-to-feed ratio was greater during the first few weeks of the feeding period for RW compared with MW and then comparable during the rest of study. Water intake was less in RW than MW, potentially indicating more efficient water use by calves. Frame growth, body weight, average daily gain, serum glucose, plasma urea nitrogen, β-hydroxybutyrate, total-tract digestibility of dry matter, and crude protein were similar. Fecal scores tended to be lower (firmer) in calves on RW, with an interaction by time. Respiratory scores decreased during the weaning period when calves drank RW. Results demonstrated calves drinking RW had similar growth and improved health scores with treatment by time interactions compared with MW.

Key words: reverse osmosis water, growth performance, dairy calf

INTRODUCTION

Water is the most important essential nutrient, and although calves are fed milk replacer or milk, they still need drinking water for their metabolism and wellbeing. Adequate water consumption is essential for optimal growth and is associated with DMI. Kertz et al. (1984) observed that calves ate more calf starter and had greater BW when limited amounts of milk and ad libitum water were offered. The importance of water is demonstrated by the fact that it is 70 to 75% (Davis and Drackley, 1998) or, according to more recent research, 69.5 to 71.6% (Chapman et al., 2017) of the BW of the calf. In the body, water maintains thermoregulation, osmoregulation, and is used as a solvent of nutrients (Davis and Drackley, 1998). In addition, greater water consumption has been shown to increase early starter intake (Appleman and Owen, 1975). Primarily, the water requirement for calves is affected by DMI, moisture content in the feed (Dahlborn et al., 1998), environmental temperatures (Murphy et al., 1983), physiological stage of the animal, and age of the animal (Meyer et al., 2004). Senevirathne et al., (2016) reported in a taste preference study that when weaned calves were offered water treated with a reverse osmosis or by a municipal city water treatment plant compared with untreated well water, they preferred reverse osmosis first followed by municipal city water. Young calves require a greater amount of water per unit of body size than mature animals (Maynard et al., 1979). Feeding calves ad libitum milk during the preweaning period is one method to provide more water to the calves at an

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early stage (Jasper and Weary, 2002); however, feeding greater amounts of milk have been shown to decrease postweaning calf growth and decrease starter intake (Bar-Peled et al., 1997).

During the preweaning period, when calves consume whole milk or milk replacer it bypasses the rumen and goes to the abomasum via the esophageal groove. This process also prevents a large portion of consumed water from entering the rumen and may influence bacterial growth and the start of rumen fermentation. Therefore, providing clean fresh drinking water to calves is essential for rumen and microbiome development (Ensminger et al., 1990; Church, 1991). However, despite the vital importance of water, limited recent research is available specifically related to calves and the effects of different water sources or quality on water intake, nutrient utilization, and health during the preweaning and postweaning periods. As newborn calves have developing immune and digestive systems, improved water quality may affect calf health and performance. Therefore, we hypothesized that feeding milk replacer reconstituted with reverse osmosis water as well as offering reverse osmosis water ad libitum to the calves would increase feed efficiency and enhance growth performance and health compared with municipal water. Objectives of our experiment were to determine the effects of drinking reverse osmosis versus municipal water on growth performance, nutrient utilization, and general health scores of dairy calves.

MATERIALS AND METHODS

The research was conducted under approved experimental procedures by the South Dakota State University Institutional Animal Care and Use Committee under animal welfare assurance number A3958–01 and protocol number 15–058E.

To test our hypothesis and meet our objectives, 24 newborn Holstein calves (14 females and 10 males) were used in a randomized complete block design experiment. Calves were blocked by birth date and sex and then randomly assigned to 1 of 2 treatments. Treatments were (1) municipal city water (**MW**; Brooking Municipal Water Treatment Facility, Brookings, SD), and (2) treated reverse osmosis water (**RW**; Culligan Water System, Rosemont, IL). The project was conducted from August to December 2015 at the South Dakota State University Dairy Research and Training Facility in Brookings. Calves were housed in individual hutches (Calf-Tec, Hampel Animal Care, Germantown, WI) measuring 223 cm long, 98 cm wide, and 133 cm high. Hutches were placed on the ground and bedded with wheat straw. The overall average birth weight of the calves was 44.6 ± 6.10 kg. Calves were fed 3.78 L of first colostrum from the dam immediately at birth and 2.83 L was offered in a second feeding, 6 ± 0.5 h later. Brix 0 to 32% optical refractometer (JO351B; Jorgensen Laboratories Inc., Loveland, CO) was used to determine colostrum quality. Colostrum that had brix score 22% or greater was considered as good-quality colostrum. Calves were fed colostrum replacer (Agri-Tech, Watertown, SD) when quality colostrum was not available. Calf total serum protein (6.4 ± 0.8 g/dL) was checked with a refractometer (J-351; Jorgensen Laboratories Inc.) to provide adequate transfer of maternal immunoglobulins at approximately 24 h of age.

The 2 water types were both obtained for daily use at the South Dakota State facility. The MW was received from the municipal water system. The city of Brookings receives water from underground aquifers, which are equivalent to approximately 20 square miles. The initial step at the water treatment plant is aeration, which removes hydrogen sulfide, iron, and manganese. Water then enters the solid contact basin. Lime and alum are added to remove the minerals, which settle to the bottom of the solid contact basin. This bottom sludge is then pumped to drying beds. The cleaned water is removed from the surface and sent through sequential gravity filters. These gravity filters remove remaining particles. Chlorine and fluoride are added before delivery to the distribution system (Brookings Municipal Utilities, 2012). A household-size reverse osmosis water system was installed at the South Dakota State University Dairy Research and Training Facility. The RW system was used to further purify the MW water received at the dairy unit. With the RW system, water first entered the sediment tank, which removed sediment sand, dirt, and some chlorine. Sodium chloride was then added as water softener (S/N 148211; Culligan Water System). After adding softener, water ran through a carbon filter cartridge (S/N 01015013CJL09). It then passed through the carbon filter and was filtered through the reverse osmosis membrane (S/N 01015013CJL09); the minimum filtration particle size of the membrane was 10 μm. The capacity of the reverse osmosis membrane was 757 L of RW per day. Water flowing through the RW membrane was controlled by a flow restrictor (S/N VK06016203). The purified RW was stored in a 250-L bulk tank until feeding time.

The total experimental period was 10 wk consisting of pre- (first 6 wk) and postweaning periods (last 4 wk). The farm portion of the study took 5 mo to complete due to the number of calvings per month. During the preweaning period, milk replacer (**MR**) was fed to calves on both treatments at the same rate (0.45 kg of MR/2.83 L of water), but was reconstituted with water according to treatments. Milk replacer (Hubbard Inc., Mankato, MN) was fed twice daily until 5 wk of