

Water Needs and Quality Guidelines for Dairy Cattle

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Water constitutes approximately 87 percent of milk and 60 percent to 70 percent of body composition of livestock. Water is necessary for maintaining body fluids and proper ion balance; digesting, absorbing and metabolizing nutrients; eliminating waste material and excess heat from the body; providing a fluid environment for the fetus; and transporting nutrients to and from body tissues. Water is supplied by drinking, the feed consumed and metabolic water produced by the oxidation of organic nutrients. Water loss occurs via saliva, urine, feces and milk; through sweating; and by evaporation from body surfaces and the respiratory tract. The amount of water lost from the body of cattle is influenced by size and age of the animal, activity of the animal, air temperature, humidity, respiratory rate, water intake, feed consumption, milk production and other factors.

Water Intake and Requirements

Lactating cows: Drinking or free water intake satisfies 80 percent to 90 percent of the dairy cows' total water needs. The amount of water a cow will drink depends on her size and milk yield, quantity of dry matter consumed, temperature and relative humidity of the environment, temperature of the water, quality and availability of the water, and amount of moisture in her feed. Water is an especially important nutrient during periods of heat stress. The physical properties of water are important for the transfer of heat from the body to the environment. During periods of cold stress, the high heat capacity of body water acts as insulation by conserving body heat. Water intake for lactating cows has been predicted with several equations. The following equation generally

is accepted as the preferred equation to use, according to the 2001 Nutrient Requirements of Dairy Cattle (NRC):

$$\begin{aligned} \text{Water intake, pounds/day} &= 35.25 + 1.58 \times \text{dry matter intake (pounds/day)} \\ &+ 0.90 \times \text{milk yield (pounds/day)} \\ &+ 0.11 \times \text{sodium intake (grams/day)} \\ &+ 2.65 \times \text{weekly mean minimum temperature } (^\circ\text{F}/1.8 - 17.778) \end{aligned}$$

The equation predicts water consumption will change 1.58 pounds for each 1 pound change in dry matter (DM) consumed, 0.90 pound for each 1 pound of milk produced, 0.11 pound for each gram of sodium consumed and 1.47 pounds for each degree Fahrenheit of change in the weekly mean minimum temperature. Weekly mean minimum temperature is typically 10 F to 15 F lower than mean daytime temperature. **Table 1** lists the estimated daily water intake for lactating cows using the above equation.

Table 1. Estimated daily water consumption for a 1,500-pound lactating cow producing 40 to 100 pounds of milk daily^a.

Milk production (lbs/day)	Estimated DM intake (lbs/day)	- Weekly mean minimum temperature ^b -				
		40 F	50 F	60 F	70 F	80 F
		gallons per day ^c				
40	42	18.4	20.2	22.0	23.7	25.5
60	48	21.8	23.5	25.3	27.1	28.9
80	54	25.1	26.9	28.7	30.4	32.2
100	60	28.5	30.3	32.1	33.8	35.6

^a Sodium intake = 0.18% of dry matter (DM) intake.

^b Mean minimum temperature is typically 10 to 15 F lower than the mean daytime temperature.

^c One gallon of water weighs 8.32 pounds.

Dry cows: The major factors affecting free water intake of dry cows are concentration of dry matter in the diet, dry-matter intake and amount of protein in the diet. Water intake of dry cows can be estimated by the following equation:

$$\begin{aligned} \text{Water intake, pounds/day} &= -22.80 + 0.5062 \times \text{diet dry matter (\%)} \\ &+ 2.212 \times \text{dry-matter intake (lb/day)} \\ &+ 0.0869 \times \text{diet crude protein (\%)}^2 \end{aligned}$$

For example, a 1,500-pound nonlactating cow consuming 28 pounds of dry matter containing 12 percent moisture and 12 percent crude protein would consume 96 pounds (11.6 gallons) of water per day at air temperatures between 50 F and 80 F. Water intake may be 1.2 to two times greater during periods of heat stress.

Calves and heifers: During the liquid feeding stage, calves receive most of their water as milk or milk replacer. However, studies show that calves offered water in addition to a liquid diet gain faster and consume dry feed earlier than calves provided water only in their liquid diet. Therefore, I recommend producers provide water to calves receiving liquid diets to enhance growth and dry-matter intake. Weaned dairy heifers consume approximately 1 to 1.5 gallons of water per 100 pounds of body weight (**Table 2**). As with all livestock, water should be fresh, clean and always available and producers should ensure their cows have access to adequate water supplies during periods of heat stress.

Drinking Behavior

Providing the opportunity for livestock to consume a relatively large amount of clean, fresh water is essential. Water is consumed several times per day and is generally associated with feeding or milking. Cows may consume 30 percent to 50 percent of their daily water intake within one hour after milking. Reported rates of water intake vary from 1 to 4 gallons per minute. On the basis of farm studies, the length of water troughs should be 2 inches per cow, with an optimal height of 24 to 32 inches. Reducing the height 2 to 3 inches may be logical for small-framed Jersey cattle. Water depth should be a minimum of 3 inches to allow the animal to submerge its muzzle 1 to 2 inches. Provide at least one watering device for every 15 to 20 cows, or a minimum of 2 feet of tank space per 20 cows. At least two water locations are needed in the loafing area for each group of cows. For confinement operations, waterers should be located at the milking parlor exit and within 50 feet of the feed bunk or at every crossover in free-stall barns. For grazing operations, water also should be located at the milking parlor exit and in each paddock so that animals are always within 600 feet of a clean, fresh water source. Heifers should be provided at least one watering space per 20 animals, with a minimum of two waterers per group.

Table 2. Estimated water intake for dairy heifers.

Body Weight (lbs)	Air temperature		
	40 F	60 F	80 F
	gallons per day		
200	2.0	2.4	3.3
400	3.8	4.6	6.1
600	5.4	6.5	8.7
800	6.8	8.2	11.0
1,000	9.0	9.6	12.7
1,200	9.0	10.8	14.5

The temperature of drinking water has only a slight effect on drinking behavior and animal performance. Responses to chilling of water under most circumstances would not warrant the additional cost of cooling the water. Given a choice of water temperature, cows prefer to drink water with moderate temperatures (63 F to 82 F) rather than very cold or hot water.

Water Quality

Water quality is an important issue in the production and health of dairy cattle. The five properties most often considered in assessing water quality for both human and livestock use are organoleptic properties (odor and taste), physiochemical properties (pH, total dissolved solids, total dissolved oxygen and hardness), presence of toxic compounds (heavy metals, toxic minerals, organophosphates and hydrocarbons), presence of excess minerals or compounds (nitrates, sodium sulfates and iron) and presence of bacteria. Research on water contaminants and their effects on cattle performance are sparse. The following attempts to define some common water quality problems in relation to cattle performance.

Salinity, total dissolved solids (TDS) and total soluble salts (TSS) are measures of constituents soluble in water. Sodium chloride is the first consideration in this category. Other components associated with salinity, TDS or TSS are bicarbonate, sulfate, calcium, magnesium and silica. A secondary group of constituents, found in lower concentrations than the major constituents, consists of iron, nitrate, strontium, potassium, carbonate, phosphorus, boron and fluoride. Guidelines for TDS in water for dairy cattle are presented in **Table 3**.

Research has shown feedlot cattle drinking saline water (TDS = 6,000 parts per million, or ppm) had lower weight gains than cattle drinking normal water (TDS = 1,300 ppm) when energy content of the ration was low and during heat

Table 3. Guidelines for use of saline water for dairy cattle.

Total dissolved solids (ppm)	Comments
Less than 1,000	Presents no serious burden to livestock
1,000 to 2,999	Should not affect health or performance, but may cause temporary mild diarrhea
3,000 to 4,999	Generally satisfactory, but may cause diarrhea, especially upon initial consumption
5,000 to 6,999	Can be used with reasonable safety for adult ruminants; should be avoided for pregnant animals and baby calves
7,000 to 10,000	Should be avoided if possible; pregnant, lactating, stressed or young animals can be affected negatively
More than 10,000	Unsafe; should not be used under any conditions

ppm = parts per million

stress. High-energy rations and cold environmental temperatures negated the detrimental effects of high-saline water consumption. Likewise, milk production of dairy cows drinking saline water (TDS = 4,400 ppm) was not different from that of cows drinking normal water during periods of low environmental temperature, but was significantly lower during summer months. Cows offered salty water drank more water per day (36 vs. 32 gallons per cow) during a 12-month period than cows drinking normal water.

Hardness generally is expressed as the sum of calcium and magnesium reported in equivalent amounts of calcium carbonate. Other cations in water, such as zinc, iron, strontium, aluminum and manganese, can contribute to hardness, but are usually in very low concentration compared with calcium and magnesium. Hardness categories are listed in **Table 4**. The hardness of water has no effect on animal performance or water intake.

Table 4. Water hardness guidelines.

Category	Hardness, milligrams per liter ^a
Soft	0 to 60
Moderately hard	61 to 120
Hard	121 to 180
Very hard	Greater than 180

^a One grain per gallon = 17.1 milligrams per liter
One liter = 1.06 quarts

Nitrate can be used in the rumen as a source of nitrogen for synthesis of bacterial protein, but reduction to nitrite also occurs. When absorbed into the body, nitrite reduces the oxygen-carrying capacity of blood, which can lead to asphyxiation in severe cases. Symptoms of nitrate or nitrite poisoning are labored breathing, rapid pulse rate, frothing at the mouth, convulsions, blue muzzle and bluish tint around eyes, and chocolate-brown blood. Moderate levels of nitrate poisoning have been found to result in poor growth, infertility problems, abortions, vitamin A deficiencies, reduced milk production and general unhealthiness. The general safe concentration of nitrate in water is less than 44 ppm and in nitrate-nitrogen is less than 10 ppm (**Table 5**).

Table 5. Concentration of nitrates (NO₃) and nitrate nitrogen (NO₃-N) in drinking water and expected response.

NO ₃ (ppm)	NO ₃ -N (ppm)	Comments
0 to 44	10	No harmful effects
45 to 132	11 to 20	Safe if diet is low in nitrates and nutritionally balanced
133 to 220	21 to 40	Could be harmful if consumed for a long period of time
221 to 660	41 to 100	Dairy cattle at risk; possible death losses
661 to 800	101 to 200	High probability of death losses; unsafe
More than 800	More than 200	Do not use; unsafe

ppm = parts per million

In evaluating potential nitrate problems, feed also should be analyzed for nitrate since the effects of feed and water are additive.

Sulfate guidelines for water are not well-defined, but general recommendations are less than 500 ppm for calves and less than 1,000 ppm for adult cattle. When sulfate exceeds 500 ppm, the specific salt form of sulfate or sulfur should be identified because the form of sulfur is an important determinant of toxicity. Hydrogen sulfide is the most toxic form and concentrations as low as 0.1 milligram per liter can reduce water intake. Common forms of sulfate in water are calcium, iron, magnesium and sodium salts. All are a laxative, but sodium sulfate is the most potent. Cattle consuming water high in sulfates (2,000 to 2,500 ppm) initially show diarrhea, but appear to become resistant to the laxative effect. Iron sulfate has been reported to be the most potent depressor of water intake compared with other forms of sulfate. Water and feed with high sulfate contents have been linked to the development of polioencephalomalacia (PEM) in beef calves and can induce copper deficiency with or without the assistance of molybdenum.

pH is a measure of acidity or alkalinity. A pH of 7 is neutral, less than 7 is acidic and more than 7 is alkaline. Little is known about the specific effect of pH on water intake, animal health and production, or the microbial environment in the rumen. The preferred pH of drinking water for dairy animals is 6 to 8. Waters with a pH outside of the preferred range may cause nonspecific effects related to digestive upset, diarrhea, poor feed conversion, and reduced water and feed intake.

Microbiological analysis of water for coliform bacteria and other microorganisms is necessary to determine sanitary quality. Since some coliform bacteria are soil-borne or nonfecal, a fecal coliform test may be used to determine if the source of total coliform is at least in part from feces. A fecal streptococci test may be run on fresh samples to determine if the contamination is from animal or human sources. If fecal coliforms exceed fecal streptococci, human sources of pollution may be the cause. If fecal streptococci exceed fecal coliform, animal sources of pollution are indicated. For animal consumption, especially young calves, total and fecal coliform counts should be less than 1 per 100 milliliters. For adult animals, total and fecal coliform counts should be less than 15 and 10 per 100 milliliters, respectively. Fecal streptococci counts should not exceed 3 or 30 per 100 milliliters for calves and adult cattle, respectively.

Total bacteria count measures virtually all pathogenic as well as noninfectious bacteria that use organic nutrients for growth. Total bacteria counts in excess of 500 per 100 milliliters may indicate water quality problems. Water sources with total bacteria counts in excess of 1 million per 100 milliliters should be avoided for all classes of livestock. Most water supplies continuously will have counts below 200 per 100 milliliters.

Blue-green algae have been reported to cause illness when cattle are allowed to consume water containing this organism. Although the causative agent has not been identified specifically, cattle should be prevented from drinking water with heavy algae growth. Symptoms of blue-green algae poisoning include ataxia or incoordination of voluntary muscle movement, bloody diarrhea, convulsions and sudden death. This is an occasional problem in free-standing water, such as farm ponds. Shading of water troughs and frequent sanitation will minimize algae growth.

Other potentially toxic compounds and organisms sometimes are found in water and can pose a health hazard to cattle. For safe consumption, water contaminants should not exceed the guidelines in **Table 6**. However, many dietary, physiologic and environmental factors affect these guidelines, so determining precisely the concentrations at which problems may occur is impossible.

Table 6. Generally considered safe concentrations of some potentially toxic nutrients and contaminants in water for cattle.

Item	Upper-limit guidelines (ppm)
Aluminum	0.50
Arsenic	0.05
Barium	10.0
Boron	5.0
Cadmium	0.005
Chromium	0.010
Cobalt	1.0
Copper	1.0
Fluoride	2.0
Iron	2.0
Lead	0.015
Manganese	0.05
Mercury	0.01
Nickel	0.25
Selenium	0.05
Vanadium	0.10
Zinc	5.0

ppm = parts per million

Water Sampling and Testing

Typically, 1 or 2 quarts of water from the source in question should be adequate to complete any needed tests. Samples may be sent to any accredited commercial or state operated laboratory for analyses.

In our state, the North Dakota Veterinary Diagnostic Laboratory, Van Es Hall, P.O. Box 5406, Fargo, ND 58105, conducts analysis for TDS, nitrates and sulfates. For more information, call (701) 231-8307 or see its Web site at www.vdl.ndsu.edu. You also may contact the North Dakota Department of Health Division of Water Quality, 918 East Divide Ave., 4th Floor, Bismarck, ND 58501-1947. Call (701) 328-5210 or visit the laboratory services section Web site at www.health.state.nd.us/WQ.

In all cases, be sure to submit samples in a thoroughly cleaned container. Producers should consult with their herd veterinarian or cooperative Extension personnel for assistance in selecting a laboratory, as well as for assistance in selecting appropriate tests and interpreting test results.

Summary

Water availability and quality are important to animal health and productivity. Limiting water availability to cattle will lower production rapidly and severely. The most common water quality problems affecting livestock production include high concentrations of minerals (excess salinity), high nitrogen content (nitrates and nitrites), bacterial contamination, heavy growth of blue-green algae, and accidental contamination by petroleum, pesticides or fertilizer products. Monitoring of water quality during periods of reduced production or nonspecific diseases should be one aspect of an investigation of herd health and production problems.

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