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THE EFFECT OF THE AMOUNT AND QUALITY OF POTABLE WATER ON DAIRY CATTLE

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ABSTRACT

Water is an essential nutrient that is necessary after oxygen for the maintenance of life, growth, milk production and pregnancy for both humans and animals. Water is a nutrient that has generally been neglected and disregarded for the alimentation of livestock. Daily consumption of water for dairy cattle (approximately 90-100 L) is more than that of any other nutrient. Water is a perfect solvent and a number of composites dissolved in water affect the appearance, odor, taste, physical and chemical features and thus the health and the performance of the animal. Supply of inadequate or poor quality water reduces milk production and feed consumption and negatively affects the health of the cow. However, quality water supply may not increase milk production and feed consumption. Sustainable dairy cattle will be possible with the supply of water having the necessary amount and quality. Therefore, it is also important to know the animal's need and water quality for an evaluation of chemical and biologic (microorganisms) agents and adequately planning the water management. In this paper, data will be supplied for water nutrition, water requirement, water consumption prediction, elements influencing water consumption and water quality evaluation for dairy cattle.

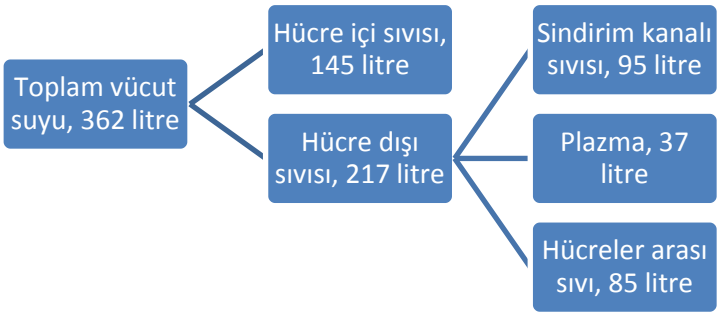
Key words: Dairy cattle, water requirement, water consumption, water quality.

INTRODUCTION

Water is of great importance for digestion of nutrients, their transportation, normal maintenance of all metabolic activities, transportation of the products after the metabolic activity to cells via blood, their passage from cells into blood, removal of end-products through urine, feces and respiration, preservation of the body ions, body fluid and temperature balance, the development of fetus, perspiration and milk production (1). Because nearly 87% of milk is water and the amount produced is a lot greater, the water need of dairy cattle with high milk capacity is greater than that of other mammals per unit live weight.
When we say body fluid, we mean the total water present inside and outside cells, in which vital events take place. Intracellular fluid is composed of the water inside the cell membrane. It creates an environment for the chemical reactions taking place in cellular metabolism. Intracellular fluid composes the largest part of the total body fluid and weighs 40% of the body. Extracellular fluid includes water outside the cells and creates an environment in which metabolic exchanges take place. Extracellular fluid can also be divided into such sections as intercellular fluid, plasma fluid and digestive tract fluid. Intercellular fluid is the fluid which totally encloses body cells and composes nearly 25% of the total body fluids. Its plasma size composes 4 - 5% of the body weight and remains stable throughout life. The amount of fluid in the digestive tract varies with environmental conditions and the nature of ration. It composes up to 30% of the body fluid in dairy cattle (2; 3; 4).

The relative water in different parts of the body varies over time. As the animal grows and matures, extracellular fluid composes a lesser part of the total body fluid, while intracellular fluid composes a larger part of the body fluid. The total body fluid, extracellular fluid and the absolute amount of the plasma increase with growth. All of the plasma and extracellular fluid serves as a reserve water depository and supplies the required water, particularly in hot summer months. A similar situation is also seen in cases of disease (diarrhea). Available water content of an adult cow varies between 56% and 81% of the live weight depending on the lactation period (3). The amounts of water in various parts of the body are shown in Figure 1 (5).

Figure 1. The water distribution in a Holstein milk cow with a live weight of 550 kilograms, producing 26 kilo grams of milk per day and consuming 16.2 kilo grams of dry matter and 65 liters of water.



Total body fluid, 362 liters

Intracellular fluid, 154 liters
Extracellular fluid, 217 liters
Digestive tract fluid, 95 liters
Plasma, 37 liters
Intercellular fluid, 85 liters

The amount of water these animals remove from their bodies is 87 liters. While the biological half-life of water in dairy cattle (when half of the total body fluid is replenished) is 7.5 days on the 21st day in prenatal period, it is down to 2.9 days on the 42nd day in postnatal period. The amount of water removed from the body during this same period increases from 42 liters to 87 liters (2).

The amount of water in the digestive tract depends on the age of the animal, its pregnancy status and its stage of lactation, constituting around 15% to 35% of its live weight. While water in the digestive tract is 15% of the live weight in cows at early lactation, it is almost 10% of the live weight in cows that are in a higher lactation period and on dry matter (2).

The Need for Water and the Prediction of Water Consumption

There are many factors that affect daily water need of dairy cattle and its consumption. The following factors are among them; physiology of the cow (pregnancy, lactation period), milk yield, the consumption of dry matter, the size of the body, whether on the pasture or in the barn, environmental factors (temperature, humidity, wind), the variety of the feeds used in the ration (for example gross feeds, fermented roughage and dry grass), the composition of the nutrients in the ration (the level of raw protein, sodium and potassium in the ration) and the quality of water source. Besides, the frequency of giving water to the cow, the temperature of the water, the social structure and relationships between the animals in the herd may also affect the consumption of water (5).

Dairy cattle meet their need for water mainly from three sources; these are potable water (free water), the water taken in in the ration and a little metabolic water which emerges as a result of the fragmentation of nutrients in cells. Nevertheless, the total water consumption of the cow consists of the water drunk and taken in with the ration.

It has been reported that 70 to 97 % of the total water consumption by dairy cattle kept in the barn is supplied with potable water, while just 38 % the total water consumption of the dairy cattle feeding on the pasture is provided with potable water (6). Also the level of dry matter in the ration is a significant factor that affects the consumption of water, and when the level of dry matter in the equation is reduced from 50% to 30% (when the moisture level of the ration is increased from 50% to 70%), the consumption of potable water diminishes by 42%. The rations that contain high amounts of salt sodium bicarbonate and protein promote water consumption (7). In Table 1, daily water requirement of dairy cattle is shown based on the size of their bodies, their milk yields and the temperature of the environment. It is clearly seen in the table that their physiological state, their level of productivity and the temperature of the environment significantly affect the daily water need of the cattle.

Different equations have been put forth to satisfy the potable water consumption of dairy cattle. Three of these equations, which have been developed by various researchers, are given below;

1. Water consumption (kg/day) = 2.53 x (milk yield, kg/day)+(% of the ration dry matter) -15.3 (8)
2. Water consumption (kg/day) = 2.15 x (dry matter consumption, kg/day)+0.73 x(milk yield, kg/day) +12,3 (9).
3. Water consumption (kg/day) = 0,90x(milk yield, kg/day)+1,58x(dry matter consumption, (kg/day)+0,05x(sodium consumption, g/day)+ 1,20x (average daily minimum temperature,˚C)+15,99 (10).

In all the three equations, milk yield, dry matter consumption and the level of dry matter in the ration are emphasized as important elements in the prediction of potable water consumption.

The cattle on dry matter are those that are pregnant and that give no milk. Potable water consumption of these cows can be predicted by means of the following equation; daily potable water consumption (kg/day)=2.212x(dry matter consumption. kg/day) + 0.2296x(the America dry matter%) + 0.03944 (the America raw protein %) - 10.34.

Table 1. Daily water requirement of dairy cattle, liter/day(11)

Live Weight(kg)	Milk yield (kg/day)	Environmental temperature ºC		
		4 and below	16	27
Heifers				
91		8.8	11.0	14.5
181		16.3	20.3	26.9
363		27.8	34.8	46.7
544		38.3	47.6	63.9
The cows on dry matter*				
635		42.7	52.9	71.4
726		45.8	56.4	76.2
The cows in lactation**				
635	9	52.9	63.9	78.9
635	27	96.9	115.0	135.2
635	36	118.9	140.5	170.5
635	45	141.0	166.1	201.3

*For life share and pregnancy. **for life share and milk yield.

Other environmental factors that are not included in the equations could affect the consumption of water. The calculated water consumption of the cattle in different yield groups in farming conditions may differ from the calculated-predicted values by around 15 to 20% (5).

Effect of Water Quality on Productivity

The characteristics that are examined in determining water quality are usually taste and odor, physical and chemical properties, the presence of toxic compounds, the level of mineral elements and the level of microbial contamination. These factors may directly affect the tastefulness and drinkability of potable water or disturb the digestive physiological functions of the animal.

The major compounds in drinking water that adversely affect the milk yield of dairy cattle are total solid compounds dissolved in water (total inorganic substances), sulfur, sulfate, chlorine, nitrates, iron and fluoride (1). There are always regions where mineral elements, microorganisms or other toxic compounds may be higher than the normal even if they are in the same region, and this may be hazardous to the cattle. However, it could be difficult to determine such instances and eliminate the reasons that adversely affect the source (5).

Table 2. The acceptable limits of the compounds in the potable water of dairy cattle and the problems caused by high levels of these compounds (11).

The property measured	Acceptable limits	Problems likely to appear
pH	6-9	It may reduce water consumption.
Total dissolved inorganic substances(total dissolved solid compounds)	0-1000 mg/liter	The levels above 3000 mg/liter may cause temporary diarrhea. Higher levels cause permanent diarrhea and refusal of water.
Hardness	0-120 mg/ liter	It usually poses no problem.
Iron	0-3000 mg/ liter	It leads to a reduction in water consumption due to bad taste.
Nitrate nitrogen	0-100 mg/ liter	It leads to reproductive problems.
Nitrite nitrogen	0-10 mg/ liter	It may cause toxicity.
Sulfate	0-500 mg/ liter	It leads to a reduction in water consumption and diarrhea.
Total bacteria count	0-1000 /ml	It leads to general health problems and diseases.
Coli form bacteria count	0-50/100ml	It leads to general health problems and diseases.

The relationship between the pH and quality of water is quite low and the pH of nearly all water sources is between acceptable values, which is between 6.5 and 8.5 (1). However, the pH of the water affects its tastefulness, its corrosive effects and some other qualities. The potable water with a pH below 6 may promote acidosis in ruminants (13).

The hardness of water refers particularly to the concentrations of calcium and magnesium elements in water. Soft waters are those that contain 0-60 mg calcium + magnesium/liter, while hard waters are those that contain more than 181 mg of calcium and magnesium (13). It was reported that, in comparison with soft waters, very hard waters (290 mg calcium+ magnesium/liter) don't significantly affect the milk yield, the increase in live weight, water consumption and the ratio of water consumption to milk production (13). Hardness and saltiness of water are different concepts and they may not be related to each other. It's possible that saltwater may have low levels of calcium and magnesium.

The Total Solid Matter Dissolved in Water

The total solid matter dissolved in water or salts dissolved in water are another quality of water used in determining the quality of water. Important minerals or ions dissolved in water are carbonate, chloride, sulfates, silisium, iron, nitrates, sodium, potassium, calcium magnesium and fluoride. The presence of high levels of these substances shows that the drinkability qualities of the water are poor. The total solid matter or compounds dissolved in water are the total of inorganic substances dissolved in the water. However, the level of the total substances dissolved in water may be quite different from each other as regards the true mineral composition of the same waters. The solid matters dissolved in water at the same time show the level of the salinity in the water. The data regarding the effects of the water containing inorganic matter dissolved in water in various degrees on dairy cattle are presented in Table 3.

Table 3. The consumption of the water containing dissolved solid compounds inorganic matter by dairy cattle and the results[1] (13)

The level of total compounds dissolved in water	Possible effects
Less than 1000 mg/L (fresh water)	It poses no serious risks.
1000-2999 mg/L (slightly salty water)	It doesn't affect the health and performance but may cause temporary diarrhea.
3000-4999 mg/L (moderately salty water)	Although it is generally accepted as satisfactory water, it causes diarrhea when it is consumed for the first time.
5000-6999 mg/L (salty water)	Although it may be used for adult cows, it shouldn't be given to pregnant cows and calves on milk.
7000-10000 mg/L (very salty water)	It shouldn't be given if possible. It shouldn't be given to pregnant animals, dairy cattle and to the animals that are exposed to stress. It negatively affects the performance in young animals.
More than 10000 mg/L (overly salty water)	It should never be given to animals at all.

[1] Solid compounds or mineral substances dissolved in water are usually expressed as synonymous with saltiness.

Different results have been obtained from the studies conducted to determine the effect of the level of saltiness in water on water consumption of by dairy cattle, their consumption of feed and their milk yield. For instance (14), the authors of a study reported that the milk yield dropped when they added 2500 milligram/liter salt (NaCl) to tap water with a total inorganic matter of 196 mg/l dissolved in the water. In another study carried out in dry conditions to determine the effect of saltiness of water on water consumption by dairy cattle (15), it was found that the water consumption of the cows given desalinated water had 10.6 liter more water consumption than that of the cows given salt water. Besides, the daily milk yield of the cows consuming salt-free water was 3.6 kilogram more than that of the cows consuming salty water. In other words, the saltiness of water negatively affects the milk yield. A similar result was observed in hot conditions in the cows which were given water containing 4300 milligram/liter dry matter dissolved in water (16). However, it was reported (17) that the water with a content of 3500 milligram/liter inorganic matter dissolved in water didn't affect the milk yield of the cows. Nevertheless, the effects of particularly sulfates, which pose more problems than the total solid compounds dissolved in water, on dairy cattle weren't examined in these studies.

American National Resource Council (18) has reported that the water with the total dissolvable dry matter content of less than 5000 milligram/liter could be given to dairy cattle but that the water containing more than 7000 milligram/liter total dissolved dry matter is not convenient for all cattle and thus shouldn't be given to them. However, it was reported that the water containing 3500 milligram per liter matter dissolved in water did not affect the milk yield in cows.

Sulfur and Sulfates

It is recommended that the sulfate concentration of the potable water shouldn't exceed 1000 milligram per liter for mature cows and 500 milligram per liter for calves (19). Sulfates are present in water in the form of calcium, sodium, magnesium, iron and hydrogen sulfate. The one with the highest toxicity among these compounds is hydrogen sulfate; even if it is present in water in very little quantities (0.1 mg/L), it leads to a decrease in water consumption. In other

words, hydrogen sulfate is a form of sulfate that causes the greatest decrease in water consumption (12). Sulfur and sulfate are separately given in water analysis reports. Sulfur is present in water in the form of hydrogen sulfate; it causes water to smell like a rotten egg, and it's believed to affect water consumption. It is seen that the initial water consumption could rise with water that doesn't smell like a rotten egg but contains hydrogen sulfur. However, it isn't known what the level of hydrogen sulfate is or what the degree of the smell that reduces the consumption of water is. It isn't also known how much the cattle can drink when they have adapted to the smell of the water and when the only source of water is the water with hydrogen sulfate (5).

Even though sulfates, particularly in the form of sodium sulfate, play a role in causing diarrhea when they are present in potable water in high levels, cattle get used to this water in a short-term and diarrhea doesn't last long. Nevertheless, the adverse effect of sulfates on the milk yield of dairy cattle depends on the sulfate concentration of potable water and on the form of sulfate in water (19). A high concentration of sulfate in potable water also increases the need for selenium, vitamin A and copper (20). The greatest problem in well water is the high level of sulfate (5).

Although it is known that a high level of sulfate concentration in potable water could lead to a decrease in water consumption and in milk yield among dairy cattle, there is no agreement among researchers as to the maximum quantity of sulfate that can be tolerated in water.
It was reported that consumption of 3493 milligram per liter of sulfate in water in the form of sodium sulfate leads to a decrease in water consumption, live weight, the rate of increase in live weight and dry matter consumption in heifers (21) and that they can tolerate the waters containing 1462 milligram per liter of sulfate (22). The observations made in the field show that the water with a high level of sulfate (for example 1200 milligram per liter) leads to a decrease in feed consumption and milk yield particularly in cows that have just given birth and causes an increase in the cases of abomasum slips as well as in the rate of the attachment of infant placentas to the body (23).

Sulfates and chlorine are basically active anions or negative loaded ions. If the quality of inorganic compound matter dissolved in water is more than 500 milligram per liter, it is generally because of the high content of sulfate and chlorine. When the sulfate plus chlorine concentration in water is high, it could adversely affect the digestion of nutrients, the electrolyte balance of the body and the milk production. Therefore, it is absolutely necessary to pursue and assess the water on the farm where the concentration of these two ions are more than 1,000 milligram per liter and whether they negatively affect the water consumption of cows, their health and milk production.

Nitrates

Nitrates are not toxic for dairy cattle, but nitrates that arrive in the rumen with the water taken in are converted by rumen bacteria into nitrites, and nitrites are toxic for ruminants (12). Nitrites show their toxic effects by converting hemoglobin into methemoglobin that has far less capacity to carry oxygen, in which case the capacity of blood to carry oxygen drops, and the symptoms of oxygen deficiency emerge in the animal.

It was reported that high levels of nitrate in potable water could lead to reproductive problems in dairy cattle. In a long-term study (35 months) (24) conducted to determine the effects of nitrates on the reproduction and milk production of dairy cattle, dairy cattle were given tap water that contained 19 milligram per liter nitrate and water that contained high levels of nitrate into which nitrate was added in the form of potassium nitrate (374 mg/L). In the first 20 months of the study, the nitrate level of the potable water didn't have a significant effect on the reproduction and milk production of the cows, but in the remaining 15 months of the study, the

water with a high nitrate content led to an increase in the number of insemination per pregnancy, a decrease in the rate of pregnancy in the first insemination and a lapse in the duration between pregnancies. The following table shows the recommended levels of nitrate in the potable water for farm animals.

Table 4. The Levels of Nitrate in Potable Water for Farm Animals and Their Effects

The level of Nitrat (NO_3), mg/L	The level of Nitrat-Nitrojen (NO_3-N), mg/L	Its effect
0-44	0-10	It can be consumed safely.
45-132	10-20	It can be consumed safely together with balanced rations that have a low level of nitrate.
133-220	20-40	It could be dangerous if consumed for long.
221-660	40-100	It is risky for health and could lead to death.
More than 661	More than 101	It is not convenient as potable water and likely to increase loss of animals resulting from deaths.

(13)

In a study conducted on 127 cattle farms in different parts of the state of Iowa in the United States, in which the effects of the nitrate level of water (varying from 1 to 300 mg/L and averaging between 25 and 30 mg/L) used from wells on the reproductive capacities of the dairy cattle were studied (25), it was found that the reproductive performance dropped in the herds which consumed water that had high levels of nitrate-nitrogen, in a similar way to the result of the aforementioned study and the lapse between pregnancies was extended. Waters with a nitrate level of less than 44 milligram per liter or with a nitrate-nitrogen level of less than 10 milligram per liter are considered safe as potable water (18).

Iron

Iron is an element essential for the growth of cells, utilization of oxygen in the body and the normal functioning of the immune system as well as for the activities of many enzymes. The iron concentration of potable water is usually high, and therefore it is an element which causes the greatest problems after sulfates on farms and which reduces the quality of water. The maximum tolerable iron quantity in potable water is reported to be 0.3 milligram per liter. The waters that contain more iron are risky and may cause the deterioration of health both in humans and in dairy cows besides bringing about a decrease in water consumption since it spoils the taste of the water. Because the iron content of feeds is high enough, iron deficiency can rarely be seen in mature cows. Consuming high quantities of iron in drinking water and feeds could negatively affect the appetite center in the brain, leading to a decrease in feed consumption (26).

A great part of the iron in the water is in a ferrous form (Fe+2), easily dissoluble and thus absorbable faster and in higher quantities. The iron in such a form is converted into a form of iron with +3 value (ferrous form, Fe+3) , which is less dissoluble in water or oxidized when the water is pumped out from wells and gets in contact with oxygen, copper pipes or heating units or when the pH of the water is above 7.5. This leads to the formation of a reddish color, characteristic of iron, in the drinking water. Even iron as low as 0.3 milligram per liter in drinking water leads to the appearance of brown spots on clothes, the proliferation of iron bacteria, which block the flow of water in water pipes and which have an unpleasant odor, and to the formation of dark red-brownish sediment (27).

On the other hand, the iron in feed stuff or rations is in a ferric form. Because ferric iron is poorly dissolvable, the absorption of the iron in the ration through the digestive tract is around

10%. Even though the absorption of ferric iron is low, it is high enough for cows to meet the daily need for absorbable iron. The need for absorbable iron for a cow that yields 45 kilo grams of milk daily is 35 milligrams, and it is usually met safely with rations (18). However, the iron consumption of a cow which consumes water containing 0.3 milligram per liter of iron is twice, compared with the cows given water from which iron is removed. The consumption of total absorbable iron will be three times as much as the daily need with the water containing 0.6 milligram per liter. For this reason, waters with high levels of iron are too risky for the health of animals and for their productivity.

Because the waters with a high level of iron are absorbed rapidly through the digestive tract, they could lead to problems. The iron existing in a ferrous form in water is dull and spoils the taste of the water, leading to a decrease in water consumption. This decrease is accompanied by a decrease in food consumption and milk production (28). Besides, iron has a strong oxidative capacity, and because of this, it causes harmful molecules which distort the cellular membranes and disrupt the activities of cells to emerge in animals that consume waters with a high level of iron (oxidative stress), which in turn leads to diarrhea, a decrease in feed consumption, growth and milk production, causing the immune system to be adversely affected (29). The cows that have just given birth are affected greatly by surplus iron, and because the immune system cannot function properly, there is an increase in such cases as the failure of infant placentas to become attached to the body as well as in the incidence of such bacterial diseases as mastitis and metritis (23). Consumption of more iron than the body needs at the same time blocks the absorption of copper and zinc through the digestive tract, leading to a deficiency in these elements. The pH of the potable water and its sulfate concentration affect the dissolubility of the iron in the water and its form. The iron in the water in which sulfate concentration is over 200 milligram per liter forms compounds with sulfate ions rather than iron hydroxide (Fe(OH)), creating iron sulfate, and this leads to further deterioration in the taste of the water. Low pH of water increases the dissolvable capacity of ferric iron.

The studies conducted in the field have shown that the addition of hydrogen peroxide by 35% to the waters with a high level of iron (0.25 L to 4 tones) helps remove the iron bacteria in pipes and water bowls. Just after hydrogen peroxide is added to the water, it may be required to remove the filters in the system, to open the valves, or even to detach the pipes at the seams in order to clean the sediment in them. If required, this process can be repeated (23).

In order to eliminate the adverse effects of iron mentioned above, it is necessary to add such antioxidant compounds as vitamin A and zinc to rations (30). If the water used on dairy cattle farms contains iron equal to or more than 0.3 milligram/liter of iron, alternative water sources should be found, or iron should be removed from the water with a proper method.

The Other Elements in Water

A high level of calcium in drinking water doesn't usually pose a problem for farm animals (13). However, the waters that contain a high level of calcium could lead to a lack of phosphorus by negatively affecting the absorption of phosphorus through the small intestine if enough phosphorus is lacking in the ration. Therefore, it is necessary to pay attention to the ratio of calcium to phosphorus in the ration, and efforts should be made to keep this ratio at the desired level (2/1) (27). When the chlorine-ion concentration in drinking water is 250 to 500 milligram per liter, it causes the water to have a salty and bitter taste. However, the chlorine concentration of the drinking water is generally far below 250 milligram per liter. In a study in which the balance of sodium potassium chlorine and water was studied in highly productive cattle in recent years, it was reported that the milk production significantly increased depending on the increase in the quantity of chlorine and potassium retained in the body. These two elements are the major ions in sweat; it was also reported that the loss of ions through perspiration in hot weather could lead to a restriction on the milk production capacity of dairy cattle (31). Dairy

cattle and other ruminant animals can tolerate high quantities of manganese in the ration. This is because the absorption of manganese through intestines is very low, at a rate of 1% or 8% (19). Manganese exists in well waters more in the form of manganese oxide, and waters with high levels of manganese could adversely affect the performance of farm animals.

The Other Factors That Affect the Consumption of Water

Temperature of the Environment

The environment in which dairy cattle live has a significant effect on the quantity of water they consume. The consumption of water by dairy cattle is positively correlated with the temperature of the environment, and the consumption of water rises during summer months. It is seen that the consumption of water by cattle in an environment at 32 degrees Celsius is twice to four times as much as by the cows kept in an environment at a temperature of 2 - 10 degrees Celsius. When cattle lose water from their bodies through perspiration, respiration, excretion and milk during hot summer months, they increase their consumption of water in order to replace it (32;7). It is reported that the water consumption of the Holstein cows increases by 1.1 - 1.2 liters in reaction to an increase of 1 degree Celsius in environmental temperatures between 7 and 19 degrees Celsius, in the temperature of barns or in weather temperatures (10;33). Besides, the consumption of dry matter by Holstein and Jersey cows increases (accordingly the milk production) along with the increasing water consumption at environmental temperatures of -16 to 27 degrees Celsius. However, it is reported that the consumption of water increases substantially at temperatures of 27 degrees Centigrade, whether the level of dry matter in the ration is low or high (34). Providing shade for dairy cattle in the roaming yard during hot summer months helps decrease loss of water from the body as it would prevent the body from being overheated and keep the animals cooler, thus reducing the consumption of water by animals. For this reason, it is important to provide enough shadowing cover for dairy cattle particularly in open or free stalled barns in that it lowers the adverse effects of high environmental temperature. If given the choice to stay in the shade or to walk a source of water which is under the sun, the cattle were seen to choose to stay in the shade. Consequently, providing water under a shadowing extension for dairy cattle would promote the consumption of water (35).

The Temperature of Potable Water

Various studies have been conducted on dairy cattle to determine the effects of the temperature of water on the temperature of the tripe, rumination, the digestion of nutrients, feed consumption, milk production, the temperature of the body and similar traits. A great majority of these studies aimed at determining the effect of cool potable water on the aforementioned traits in hot environmental conditions, and thus there is little information as regards the consumption of water by dairy cattle in cold weather conditions (5). In a study conducted on the cows which were kept in a barn at an average temperature of 15 degrees Celsius and which had been milked for 12 to 15 weeks and which had a daily 4% fatty milk yield of around 26 kilogram per day, the cows were given water with temperatures of 3, 10, 17 end 23 degrees Centigrade. Daily water consumption of the cattle to which water with a temperature of 23 degrees Celsius was 75.1 liter, which was lower than those of the other groups, whereas the daily water consumption rates of the cows to which water with a temperature of 3, 10 and 17 degrees Celsius were given were similar to each other, averaging 80 liters. However, the average milk yield of the cows which were given potable water with a temperature of 17 and 23 degrees Celsius was found to be higher than that of the cows to which water with a temperature of 3 degrees Celsius was given. In this study, no significant effect of the temperature of the potable water was observed on the consumption of dry matter, the consumption of salt given in different cribs, the duration of rumination and on the increase or decrease in live weight. The author of the study stated that it could be beneficial to supply dairy cattle with lukewarm water in cold

environmental conditions. The temperature of potable water and the quantity drunk affect the temperature of the tripe fluid; it was reported that the temperature of the tripe fluid returned to its former state in 70 to 120 minutes after cold water was drunk. The temperature of potable water didn't affect the consumption of dry matter, energy and the digestion of raw proteins in the cows on dry matter which were kept in an environment at -3 to 12 degrees Celsius and were given water with a temperature of 1, 14, 18 and 39 degrees Celsius (5). Although it's possible to lower body temperature by giving cold potable water to dairy cattle which are given potable water at temperatures varying between 10 and 30 degrees Celsius at high environmental temperatures, it is established that this effect is temporary and that the body temperature rises again 2.2 hours later at the most. Nevertheless, it was reported that the dry matter consumption of the dairy cattle given water with a low temperature or cold water and their milk yield increased or weren't significantly affected (37; 38; 39; 40). In a study conducted by Wilkes at al. (1990), cows that were in lactation were given potable water with a temperature of 10 or 30 degrees Celsius in bowls placed side by side. All the 24 cows in the study preferred the water which was at a temperature of 30 degrees Celsius. This result shows that dairy cattle preferred the potable water closer to their body temperature if they are given the right to choose. The studies conducted revealed that the most convenient temperature of potable water for dairy cattle was between 17 and 28 degrees Centigrade. Dairy cattle prefer lukewarm water both at high environmental temperatures and in dry environmental conditions if given the right to choose between them.

The Dampness Level of the Ration

Dairy cattle meet part of their need for water with the ration they consume. The dampness level of the ration or the level of dry matter which is the sum of the nutrients of the ration other than water affects the amount of water a cow will consume by drinking. As the dampness level of the ration diminishes, in other words, as the level of dry matter increases, the consumption of potable water increases too (10; 9). Even though the need for potable water in dairy cattle decreases with the rations that contain more than 50% dampness, so does the consumption of dry matter. This is undesirable. Dry matter consumption of cows increases by 6 to 9% with the rations containing more dry matter. The most convenient level of dry matter in dairy cattle rations is between 55 and 75% (41).

The Presence of Sufficient Water

The water consumption of dairy cattle depends on supplying a sufficient amount of water, and it has an enormous effect both on the behavior of cows and on their productivity. Milk yield and water consumption are positively correlated; as the milk yield increases, so does the consumption of potable water and dry matter. Accordingly, since water consumption of cows has an effect on their milk yield, they will yield less milk when their consumption is restricted or sufficient water cannot be supplied (7; 10).

In a study carried out with Holstein cows (9), a group of cows were given water in free quantities, while another group were deprived of water for 3 days. On the 1st day, the milk yield of the cows that drank water without restriction was 22 kg/day, while the milk yield in the group deprived of water dropped by 7% and was 20.3 kilogram per day. Deprivation of water had a greater effect on cows on the second and third days; the milk yield of the cows in the latter group was 11.2 kg/day on the second day and 6.1 kg/day on the third day. Compared with the cows that were given water in free quantities, the milk yield of the cows that were denied water was found to be 49% and 79% lower on the second and third days respectively. The milk yield of the cows that weren't given any water for 3 days returned to normal only after 12 days passed. Like other ruminant animals, dairy cattle lose an important quantity of nutrients in periods when water is insufficient, and replacement of these nutrients takes a few weeks (42). The studies conducted have revealed that dairy cattle prefer a steady supply of potable water and

that the water consumption of the cattle that were given water every two or three days was lower than usual (43). An adequate supply of water to dairy cattle is important in preventing competition for water between the cattle. It is shown that the cows with a soft temperament in a herd or group consume less water, compared with more brave, aggressive cows (5). It shouldn't be ignored that such a case could result in a low milk yield from the herd. It is necessary for the water bowl to be refilled as fast as possible after animals drink water from a water bowl. Otherwise, there will be competition between animals for water. The inadequate number of water bowls will promote competition among crowded herds. If a sudden and unexpected drop in the milk yield of a group or a herd is observed, it should be definitely checked whether there are enough water bowls and whether the water bowls work properly. In order to enable the animals to drink in a relatively short time following the milking or feeding on a farm, there should be enough water bowls or enough distance should be kept between the water bowls for each cow. Although it may change depending on the milk yield of the cattle and the dry matter level in the ration, a pipe of 160 centimeters long, from both sides of which water can be drunk, would be sufficient for 30 to 60 cows (5). Because dairy cattle consume 50% to 60% of their need for water immediately after milking, placement of water bowls on the way to the barn will encourage the water consumption of the cows leaving the milking unit. It has been reported that the gutter-type feeders should be 80 or 90 centimeters high from the ground and the depth of the water in the water bowl should be at least eight centimeters for the animal to dip its nose for at least three to five centimeters. Also the depth of water in the water bowl should be no more than 15 to 30 centimeters for the water not to become stale (19). The depth of the water should be between 15 and 30 centimeters, and the water bowl shouldn't be filled up. In this way, the cows can find the opportunity to reach fresh water all the time, the water will not get stale, cleaning will be done more easily, and less water will be wasted. The cattle in a section or in the barn should be able to reach the water source easily, and they shouldn't be obliged to walk more than 150 meters to find a water source. Another desirable point is that water bowls should be close to feeders. There should be an extension on the water bowls to protect them from the sun. The vicinity of the water bowls should be large enough for the cattle to move freely. In the connected stalled barns, one bowl should be allocated to each cow. It is not desirable to allocate a single bowl to two cows kept in adjacent stalls in such barns because either of the cows may be offensive and aggressive and therefore may prevent the submissive cow from drinking water, in which case the milk yield of the latter will drop. This has practical implications because it will cause the productivity of the herd to drop. Besides, the flow speed of water into bowls can affect the consumption of water; it can be said that dairy cattle prefer the water flowing fast and filling up the bowl quickly. In a study conducted in this regard, when the flow speed of water into the bowl was 2, 7 and 12 liters per minute, the daily water consumption of the cows were found to be 77, 83 and 88 liters respectively (44). In order to remove any restrictions on water consumption, it is important that the water bowl or water tank should be emptied and cleaned at least twice or three times a week, if possible, every day (35).

The Microorganism in Water

It is not desirable for water sources to be contaminated with microorganisms. The level of coli form bacteria in potable water is at least as important for cattle as for humans. Total number of coli form bacteria should be less than 15 in 100 ml. of water for dairy cattle. If the total number of bacteria exceeds 500 in 100 ml of water, it could signal a problem with the water quality. The total number of bacteria should be less than 1 million. The waters that have a high number of total bacteria shouldn't be given to dairy cattle as well as to other farm animals (45). The high level of bacteria in potable water also leads to a decrease in water consumption and in milk yield.

If there are plenty of nutrients in water, blue-green mosses can rapidly grow in stagnant waters, in pools, in lakes, streams and rivers where the flow is slow. They can cause poisoning due to the toxins (poisonous compounds) they produce in addition to reducing water consumption. For

this reason, the waters in which blue-green mosses have developed shouldn't be given to animals. Loss of appetite, loss of weight, a lack of coordination in movements, a lack of response to such acts as intimidation, feeding and scaring can be observed in cattle consuming such water. If consumed too much, such water can cause damage to the liver, hardening in muscles and sudden deaths (46; 45).

The Characteristics of Drinking Water in Dairy Cattle

Dairy cattle consume a greater part of their daily need for water, up to 50 to 60%, in the first hour following the milking. Maximum water consumption takes place in the first to the third hours following the milking in the evening. The remaining part of the daily water consumption is taken in after each feeding (47, 45). If possible, cattle tend to consume feeds and water in succession or alternately. The duration of drinking water for dairy cattle shows great variations in terms of the amount of water they consume per minute and the number of visits to the water bowls in order to drink water. For example, Dodo and Allen (1994) reported that cattle spent 18.5 minutes everyday drinking water, drank 4.3 liters of water every minute, visited the water bowls 14 times a day to drink water and drank around 6.4 liters of water each time. It was reported in another study (47) that the duration of drinking water everyday was between 2 and 8 minutes and the amount of water drunk every minute varied between 4.5 and 14.9 liters. Another author (48) reported that cattle drank water for 12 to 16 minutes everyday and drank 4.5 to 5 liters of water per minute, drank from gutter-tank type water equipment 24 times a day and consumed 5.7 liters of water each time. The results of the research have also shown that the more offensive and dominant of the animals that use the same water bowl utilize water bowl more frequently, compared with the submissive ones (33, 49). However, the dominant animals in the herd may not necessarily be the most productive animals. After all, the feed consumption and the milk production of more submissive animals would be lower. Therefore, it may be importance to pay attention to such kind of relations in order to improve productivity in the herd.

The Effect of Potable Water on the Need for Minerals

Because it is an excellent solvent, water contains lots of minerals to varying extents. The quantity of the daily mineral consumption of cattle which they meet through drinking water can be calculated by making use of the level of productivity in a group or herd, their need for minerals, the level of dry matter and water consumption and the mineral values determined by an analysis of potable water.

If the usability of the minerals in water is accepted as 100 percent, the potable water can supply a great quantity of the required minerals; it can even provide more than the required amount as with iron, magnesium and copper (19). Osborne (2001) reported that the dairy cattle take in 16 - 40 grams of bicarbonate with the water they drink each day. It should be noted that the mineral level of potable water may vary greatly with its source, the geographical region and even with countries.

It is of great importance to pay attention to this source of minerals, which is usually ignored, and it shouldn't be forgotten that this may be the cause of several metabolic disorders commonly seen particularly in dairy cattle with high productivity or may provoke these disorders.

The Effects of Poor and Extreme Consumption of Water

The symptoms of insufficient water consumption show themselves in the following ways; the manure much harder than it usually is, a decrease in the amount of urine excreted, abnormality

in the behavior of drinking water, a decrease in the consumption of feeds (dry matter) or in milk production, the tendency to drink the urine or other fluids accumulating in puddles (may be a result of a lack of salt), an increase in the loss of water from the body, loss of weight, loss of live weight, an increase in the amount of blood erythrocytes depending on weakening, an increase in the value of blood hematocrit, an increase in osmolarity (50). On the other hand, if too much water is consumed, the amount of urine rises greatly, the manure is wet and it splashes around when it falls to the ground. However, such irregularities can be seen in case of acidosis or when such minerals as sodium and potassium are consumed.

There is a marked increase in the amount of urine along with the milk production just as the production of urine rises in cows feeding on such roughage with a high content of water as corn silage or grass on the pasture.

Results and Suggestions

The most essential nutrient for dairy cattle is water. Providing sufficient amounts of water for dairy cattle and facilitating them to reach this water freely play an important role in the productivity of dairy cattle farms. It is possible to experience great trouble in terms of the health and productivity of the cows on the farms or in the plants where these conditions cannot be ensured. For this reason, every effort should be made to supply dairy cattle with clean and sanitary water. The average daily consumption of water by cows should be calculated by attaching a water meter to the beginning of the water system in order to determine the actual water consumption of the cattle. As water consumption increases among dairy cattle, so do the consumption of dry matter by dairy cattle and their milk production. There is a positive correlation between these three items. The most important minerals that lead to a decrease in the water quality of potable water and adversely affect the productivity and health of the cows are iron (it should be less than 0.3 milligram per liter), sulfate and chlorine (the total of these two shouldn't exceed 1000 milligram per liter). If there is sufficient water in the plant, its quality should be determined by having laboratory analyses conducted. It is important to have these analyses conducted regularly and by reliable laboratories.

The most common problem in meeting water need of dairy cattle on many farms is the insufficient number of water bowls that would make it possible for the animals to consume water without getting in trouble and the narrow distance between the water bowls allocated to each animal. Whether in a connected stalled or in a free stalled barn, this results from the fact that the number of water bowls is not increased in accordance with the increasing number of animals in the herd. The water bowls which are sufficient at the beginning remain inadequate in number as the herd grows in number; accordingly, the competition for water consumption rises among cattle, and dramatic decreases are observed in milk production.

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