Review paper
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QUALITY AND REQUIREMENT OF WATER FOR DAIRY COWS

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Abstract

This study describes the importance of safety regard the water quality, as well as meeting the needs for drinking water for cows. Some of most important parameters of organoleptic, physic-chemical and microbiological properties of water are pointed in this paper. In this study the hazards and adverse consequences of presence of nitrogen compounds in water (ammonia, nitrate and nitrite) plant and animal products and food industries are described.The adverse effects are seen as symptoms of poisoning by nitrates and nitrites, so the suggestions for limited water consumption are presented, in situation of increased amount of mentioned compounds. The particularly significant focus of study was aimed to highlight the risks of water usage, that is contaminated by wastes from processing factory (slaughterhouses and tanneries) in which can be found causes of disease.In the second part of study, the formulas for calculation of drinking water amount for cows are presented, based on data about the intake dry matter, sodium and protein as well as based on the actual production of milk and temperature of air. It has been concluded that accomplishing of the needs for amount of drinking water for cows and the requirements for hygiene of water, are the main preconditions for good health of cows and higher production of milk as well for the achieving of the good quality of milk. The quality of water should be controlled by accredited institutions and laboratories.

Key words: *Cows, water* safety, *quality, contamination, requirements, consumption*.

1. Introduction

The shortage or excess of water in nature has impact on the existance and developement of the whole living world. Fresh water is substantial for agriculture, for it is indispensible for plants and animals. Dependig on the body mass, gender and age, the animal organism is composed of 55-70% water, while the water content in milk is 87.5%. That says enough about the importance of the drinking water in the diet of dairy cow. Therefore, meeting the dairy cow requirements for safe water is fundamental for reaching the production potential, animals health and milk quality. Fresh water is vital for maintenance of body fluids, electrolytic status, food digestion and absorption, metabolism, waste products elimination, thermoregulation, fetus developement and placental fluids formation. A cow that loses 10% of water will suffer appetite loss, prostration, restlessness, lowered milk yield, while losing 15-20% leads to cessation of physiological functions and death (Grubić and Adamović [1]). Epidemiologically and toxicologically speaking, the unsafe water can be a source for disease-causing bacteria, viruses, parasites and toxins (Adams and Sharpe [2], Adamović *et al*. [3]). The water is fundamental in hygiene maintenance of the animals and their habitat. Because of the above the water should be supplied from controlled water-supply facility or waterworks.

2. Quality of water for dairy cows

The principal parameters for water quality assessment are devided into: organoleptic, physico-chemical and microbiological properties. The parameters should be the same as for human use. The parameters for water quality for dairy cows according to Adams and Sarpe [2] are shown in Table 1.

2.1 Organoleptic properties

The smell and taste of water varies with the organic and inorganic particles dissolved and suspended in it. The smell of organic origin derives from feces, decayed plants and decomposed carcases or inorganic matters

(chlorine, phenol, oil). The taste can be salty from the dissolved NaCl, KCl, pungent from $CaSO_4$, bitter from $MgSO_4$, metallic from Fe, Cu. The colour of the water depends on the presence of dissolved or coloidal dispersed matters from organic or inorganic origin. It usually varies according to the presence of algae, iron or manganese, that can colour it brown, yellow, red or green.

2.2 Physico-chemical properties

The pH of the water for dairy cattle consumption shoud be 6.5-8.5, preferably neutral. pH beyond this values can disturb the ruminal activity and ruminal microflora, the dissolution, digestion and absorption of the food. Free electricity denotes the presence of electricity in the water that can affect its consumption. The symptoms for electricity in water can be seen as altered behaviour, apprehensive cows while being milked, running from or reluctance to enter the milking parlour, often defecation and urination during milking, prolonged milking, decreased water and food consumption, decreased lactation, increasing the number of somatic cells in milk and mastitis occurances. Because of this, it is necessary to control the free electricity and take precautions like: displacing defective electricity conductors, replacing defective sockets, reducing the woltage, installing electrical grounding in the stall, plumbing, watering place. Parameters of quality water intented for cows are shown in Table 1.

Table 1. Parameters of quality water for cows

Parameter	Optimum	Parameter	Optimum
Electrochem. reac., pH	6.8-7.5	Molydbenum, ppm	< 0.68
Stability index	6-7.5	Barium, ppm	< 1
Turbidity, (Jackson units)	<30	Arsenic, ppm	< 0.05
Color, PCU	<15	Cadmium, ppm	< 0.01
Dissolved solids, ppm	< 500	Chromium, ppm	< 0.05
Alkalinity,ppm	< 400	Mercury, ppm	< 0.005
CO_2, ppm	< 50	Lead, ppm	< 0.05
Chloride, ppm	<250	Aluminium, ppm	<0.5
Sulfate, ppm	<250	Boron, ppm	< 5
Fluoride, ppm	<1.2	Cobalt, ppm	< 1
Phosphate, ppm	<1	Nickel, ppm	0.25
Hardnes, ppm	<180	Selenium, ppm	0.05
Calcium, ppm	<43	Vandium, ppm	0.1
Magnesium, ppm	< 29	Ammonia, ppm	<0.05
Sodium, ppm	< 3	Nitrate, ppm	< 10
Potassium, ppm	< 20	Nitrite, ppm	< 0.1
Iron, ppm	< 0.3	Hydrogen sulfide, ppm	< 2
Manganese, ppm	<0.05	Total bacteria, 100 mL	< 200
Copper, ppm	< 0.6	Total *Coliform,* 100 mL	< 1
Silica, ppm	< 10	*Fecal Coliform*, 100 mL	< 1
Zinc, ppm	< 5	*Fecal Streptoc*, 100 mL	< 1

Water hardness represents the dissolved minerals in the water, mosltly calcium and magnesium and it is found as carbonate (temporary) and noncaarbonate (permanent) hardness. Carbonate hardness can be softened by heating that result with stone formation from precipitated $CaCO_3$ and $Mg(OH)_2$. Noncarbonate hardness, formed by the sum of sulfate, chloride, nitrate and calcium and magnesium salts, can not be eliminated by heating, does not form stones but is corosive. Depending on the concentration of dissolved salts (mg/L) the water can belong to one of four categories: soft water (0-60); moderately hard water (61-120); hard water (121-180) and very hard water (>180 mg/L). The high water hardness must be softened. Chloride in the water are found as K, Na, Mg and Ca salts. The water containing more than 250 mg/L of chloride are not recomended for animal or human use due to its toxicity. It has been stated that the high mineral content in water can have adverse effects on the milk production, and its lactose and protein concetrations (Solomon *et al.* [4], Challis *et al.* [5]).

The chloride in water originates from the wastewater from the factories, kitchens, human and animal feces and urine, which are potential sources of disease-causing microorganisms. In chlorine defficiency the water should be chlorinated to its optimal level. Excess chlorine affects the organoleptic properties of the water (smell and taste), while interacting with organic matters can result in carcinogenic compound formation. Sulfate in water can react with calcium or magnesium. When sulfates bind to magnesium the water tastes bitter, and can cause diarrhea in human and animals and other gastrointestinal disturbances, especially in young animals. Hydrogen sulfide in water derives from organic or inorganic origin. The water containing organic-derived hydrogen sulfide is not recommended. Oxygen in water is absorbed from the air or as a product of photosynthesis from the water algae. It is used for oxidation of organic matters and breathing by organisms that live in the water. The water with high organic matter content has low oxygen concentration which indicates water contamination. Assessment of the quality of contaminated water is done by determining the biological consumption of oxygen. The concentration of dissolved oxygen in water decreases with the increase of the temperature of the water (Table 2).

Table 2. Amount of oxygen in water depending to temperature

Water temperature / ^{0}C	Dissolved oxygen, mg/L
0	14.56
5	13.06
10	11.25
15	10.06
20	9.09
25	8.26
30	7.52

The presence of carbon dioxide in water derives from the degradation of organic matters and its mineralization. It can react with the water and give carbonic acid which is corosive, can cause water pipes abrasion, especially the lead pipes that can contaminate the water and cause lead toxicity in human and animals. CO_2 concentration above 10 mg/L in the water indicates organic matter contamination. Nitrogen compounds (ammonia, nitrates, nitrites) in water indicate organic matter contamination from animal or plant. Defficiency in oxygen and some microorganisms activity can cause nitrates and nitrites transformatin, especially nitrites into ammonia. Higher concentration of nitrates can cause nitrogen toxicity. Nitrites can bind to oxygen and prevents the formation of oxyhemoglobin in animals and human. Symptoms of nitrate and nitrite intoxication are suffocation, rapid breathing, hypersalivation, cramps, blue muzzle, bluish colour of the eyes and brown colour of the blood. Higher nitrate concetration can lead to slow growth, reproduction problems, abortion and vitamin A defficiency.

The water can contain the following inorganic elements: iron, manganese, copper, zinc, lead, arsenic, flourine and others. The iron can be from inorganic (ferric form) or organic origin (ferrous form). The prsence of iron is usually associated with the presence of manganese. The water containing higher concetration of iron favours the developement of Crenotrix algae that form colonies that can narrow the water pipes.

The lead, copper and zinc derrive from the wasted pipes. They give metalic taste to the water and can disturb the digestion in the gastrointestinal system. Arsenic comes from industrial waste or pesticides and insecticides. It is a potent toxin giving nervous and gastrointestinal signs. Fluorine in water is found in the form of sodium fluoride. Higher concentration of fluorine in water can cause tooth disease (fluorosis), while its defficiency can cause dental caries. In this case it should be added to the water to the level of 1 mg/L. Radioisotopes in water derrive from the soil that is contaminated with water containing radioisotopes, or waste water from facilities that utilize it. Pesticides are found in streams and ponds after rain has washed them from the field that has been treated.

2.3 Microbiological properties

Microorganisms (bacteria, viruses, aslgae) in water come from the surface water, atmospheric, underground and waste water that contain organic matter from plant and animal origin. The water must not contain fecal coliform bacteria. They also indicate presence of other bacteria dengerous to the animal's health. Contaminated wastewater from industrial plants (leather manufacturing) can contain some disease causing agents (anthrax, foot and mouth disease, glanders, cholera, avian influenza, swine fever).

The water can harbour some viruses (*hepatitis*), *coccidia, nematodes, cestodes, trematode cercaria,* that makes it epidemiologically very relevant. The water containing blue-green bacteria (*Cyanobacteria*) should not be consumed by the cattle. They grow during the night in hot and dry weather in the swamps, standing water and water pools. They can produce toxins (*neurotoxins* and *hepatotoxins*) that can cause intoxications and sometimes even death of the animals.

2.4 Water requirements for dairy cows

The water makes the largest part of the meal. About 83% of the water is from the consumed water from the water feeding place (Dado *et al*. [6], Dahlborn *et al* [7]). Cows with high milk production (40-60 L/day), 600-700 kg body weight, consuming more than 20 kg dry matter, have much greater need for water compared to those with low milk production. The need for water is higher in hot weather and dry diet. According to ARC (Čobić and Antov [8]), the needs for water for dairy cows on ambient temperature of -17 to +27 ^{0}C is 3.5-5.5 L per kg of dry matter consumed. The needs for water for cows weighing 600 kg, depending on the temperature and milk production are shown in Table 3 (Wattiaux, [9]).

Table 3. Requirements of cows depending the amount of milk and temperature in L

Ambient temperature ^{0}C	Milk production, kg				
	0	10	20	30	40
0	37	47	63	77	91
15	46	65	81	95	109
30	62	83	99	113	127

Optimal moisture content in the forage for dairy cattle should be 48-50% which equals 10-15 L, not including the water that is consumed from the water-feeding place. It should be noted that the need for water is also higher in very low temperatures, probably due

to the increased metabolism, such as physiological thermoregulation. Increase in ambient temperature from 0 to 25 ^{0}C increases the need for water consumption for 25% or 1% for every single ^{0}C (Muller [10]. Consuming water 15-20% less than needed is considered as a problem. Needs for water depend on the body mass, age, stage of production, quantity and quality of milk production, ambient temperature and relative humidity, digestibility of the meal, its protein content and ingested sodium. The needs for volunteerely consumed water (Murphy *et al*. [11]) can be calculated through this equation:

Water, kg/cow/day=35.2 + 1.58 x DMC + 0.90 x M + 0.11 x Na + 2.64 x T

(DMC = dry matter consumed, kg/cow/day; Na = consumed sodium in g/cow/day; T = average air temperature during 7 days in ^{0}C).

The formulation for water requirements for dry cows, which includes the consumed proteins, was given by Holter and Urban [12].

Water, kg/cow/day = -10.34 + 0.2296 x DM% in ration + 2.212 x DMC kg/day + 0.03944 x (TP, %DM)^2

(DM% = dry matter, %; DMC = dry matter consumed, kg/cow/day; TP, %DM = percentage of total protein in the dry matter in a ration).

It is accepted as a landmark that for every litter of milk, depending on the ambient temperature and feed moisture, 3-4 L of water is needed.

The best ways of providing water are the ones that enable drinking water ad lib or/and multiple times during the day. The cows that were provided semi-automatic water devices and ad lib drinking, drank 18% more water and produced 3.5% more milk with 10.7% more milk fats than cows that were water fed twice a day. The cows that are kept in the sun drink 18% more water than the ones in the shade (Muller *et al*. [11]).The cows that increase their body mass and pregnant cows in the last trimester drink more water.

3. Conclusions

- Meeting the requirements for good quality and hygienically safe water are basic prerequisites for achieving high production performance, good animal health and high quality products. That's why it should receive the same amount of attention as food.
- The control of water safety should include analysis of its organoleptic, physico-chemical and microbiological properties, and should take place at least once in 6 months. The control should be performed by specialized and accredited laboratories.

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4. References

[1] Grubić G., Adamović M. (2003). *Ishrana visokoproizvodnih krava*. Monografija, Izdavač Institut PKB Agroekonomik, Beograd.

[2] Adams R.S., Sharpe E.W. (1995). *Water intake and quality for dairy cattle*. Dairy&Animal Science, DAS 95-8, pp 1-7.

[3] Adamović M., Branković A., Kovačević D., Mandić-Miladinović M., Ristanović-Ponjavić I., Ristić G., Milisavljević D. (2008). *Kvalitet i potrebe vode za krave - kvalitet vode na farmama u regionu Beograda*. Biotehnologija u stočarstvu, Vol. 24, pp 63-71.

[4] Solomon R., Miron J., Ben-Ghedalia D. (1995). *Performance of high prodicing cows offered drinking water of high and low salinity in the arava desert.* J. dairy sci., 78, pp. 620-624.

[5] Challis D.J., Zeinstra J.S., Anderson M.J. (1987). *Some effects of water quality on the performance of high yilding dairy cows in an arid climate.* Vet. rec., 120, pp 12-15.

[6] Dado R.G., Allen M.S. (1994). *Variation in and relationships among feeding, chewing, and drinking variables for lactating cows*. J. dairy sci., 77, pp 132-144.

[7] Dahlborn K., Akerlind M., Gustafson G. (1998). *Water intake by dairy cows selected for high or low milk fat percentage when fed two forage to concentrate ratios with hay or silage*. Swedish j. agric. res., 28, pp 167-176.

[8] Čobić T., Antov Đ. (1996). *Govedarstvo. Proizvodnja mleka*. Novi Sad.

[9] Waittiaux M.A. (1994). *Tehnical Dairy Guide: Nutrition and Feeding.* Univ. of Wisc., Madison.

[10] Muller C.J.C., Botha J.A., Smith W.A. (1994). *Effect of shade on various parameters of frisien cows in a mediterrianen climate in South Africa. I feed and water intake, milk production and milk composition.* Afr. jour. anim. sci., 24, (2), 49-55.

[11] Murphy W.R., Davis C.L., Mc Coy G.C. (1983). *Factor affecting water consumption by holstein cows in early lactation.* J. dairy sci., 66., pp. 35.

[12] Holter J.B., Urban J.R.W.E. (1992). *Water partitioning and intake in dray and lactacting holstein cows.* J.dairy sci., 75, pp 1472 -1479.