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Water Quality for Dairy Cows in Transylvanian Farms

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Abstract. The aim of this study was the analysis of the quality of water consumed by dairy cows in Transylvanian farms. The water quality was determined based on indicator parameters (pH, ammonia, sulphate, iron, chlorides, organic substances, overall hardness, total number of germs, number of Coliform bacteria) and chemical parameters (nitrites, nitrates), by collecting and analysing 140 water samples (from sources and from watering devices) in 20 farms. The results were compared with the previsions of the Laws 458/2002 and 311/2004. The data was statistically processed using the SPSS version 17 software. The quality of the water from the sources and from the watering devices varied, being higher in the sources ($p<0.05$). 5% of the samples from the sources had nitrates exceeding the recommended value and 10% had nitrites. Within the indicator parameters, the following ones showed alterations: ammonia (15% from samples), iron (45% from samples), chlorides (5% from samples), overall hardness (45% from samples), organic substances (40% from samples), total number of germs (95% from samples), the number of Coliform bacteria and fecal coliforms (65% from samples). Nitrites exceeding the threshold limits were identified in three samples from the watering devices. The following indicator parameters showed divergences from the legal previsions: iron (65% from samples), chlorides (5% from samples), overall hardness (35% from samples), organic substances (70% from samples), total number of germs (95% from samples), the number of Coliform bacteria and fecal coliforms (90% from samples). In 95% of the studied farms the water consumed by dairy cows is qualitatively unsuitable, being microbiologically contaminated.

Keywords: drinking water, indicator parameters, chemical parameters, coliforms

INTRODUCTION

In conformity with the recommendations regarding the dairy cows' welfare, the animals should have permanent access to fresh drinkable water in sufficient quantity, to satisfy all metabolic processes essential for life and for performance. Cows are remarkably sensitive to the poor quality of drinking water. Cows with high productions can consume daily amounts of 100 litres of water or more (Adams and Sharpe, 1995). The quantity of water that cows consume is influenced by many factors including growth, pregnancy, lactation, activity, diet composition, feed intake and environmental temperature. The quality of water offered can also affect consumption and performance (Socha *et al.,* 2003). Water quality is often overlooked, even though research clearly shows that performance decreases when certain components of water quality reach threshold levels. Poor water quality also affects consumption, which may limit food intake and animal health (Loneragan *et al.,* 2001; Socha *et al.*, 2003). Considering all of these, the qualitative monitoring of the water consumed by farm animals is compulsory. In our country it is recognised that the water consumed by animals must be of the same quality than the water consumed by humans but in some countries special recommendations exists for the quality of the water consumed by animals. According to

our country's recommendations, the water used for animal consumption should meet the requirements of the drinking water quality standard (Law 458/2002 modified and completed with the Law 311/2004).

The aim of this study was to assess the quality of the water consumed by dairy cows in Transylvanian farms.

MATERIALS AND METHODS

A total number of 140 water samples were collected and analysed in 20 dairy farms in Transylvania (Braşov, Mureş, Bihor, Satu-Mare, Bistriţa, Alba and Cluj counties) over January – March 2010. In each farm the sampling was made from watering devices (from 20% of the watering devices) and from the water source (one sample). The samples collected from watering devices were analysed independently, by calculating then the mean values for each parameter. The sampling was made using sterilised recipients, in quantity of 2 L. The water sources were wells and main systems. The water quality was appreciated based on indicator parameters (pH, ammonia, sulphates, iron, chlorides, organic substances, overall hardness, total bacteria count, number of Coliform bacteria and fecal coliforms) and chemical parameters (nitrites, nitrates). The assays for the majority of the indicator and chemical parameters were made using a Hanna analyzer. The total number of germs was determined by inoculation on culture medium in Petri dishes and 48 hours incubation on 37 °C. In the case of the samples derived from local source (well) decimal dilutions were made previously in culture tubes. After incubation the grown colonies were calculated by a mechanical optic colony counter and the total number of germs was calculated with the help of a formula (Popescu and Borda, 2008). The number of Coliform bacteria was determined through the membrane filtration method (Popescu and Borda, 2008). The results were compared to the values set out by the Law 458/2002 modified and completed by the Law 311/2004. The results were processed using the SPSS version 17 software. The descriptive statistical indicators (mean, standard deviation, median, minimum, maximum) were calculated for the indicator and chemical parameters of the water quality in the sources and watering devices. The Mann-Whitney Test was used to compare the data.

RESULTS AND DISCUSSIONS

The results obtained following the analysis of the samples collected from 20 dairy farms from Transylvania are shown in tables 1 and 2. Table 1 presents the indicator and chemical parameters for the samples collected from the sources and table 2 shows the results for the samples from watering devices. It can be seen that among the indicator parameters the pH values and the sulphates are below the maximum admissible values for all of the samples, regardless of their provenience (source, watering device). The ammonia was identified in 30% of the samples collected from the water sources and in 65% of the samples from watering devices. Its concentration varied between 0.02 and 3.78 mg/l in the water from the sources and between 0.02 and 4.92 mg/l in the watering devices. The iron was found in concentrations of 0.01-1.66 mg/l in the samples from the sources and of 0.03-2.20 mg/l in the samples collected from the watering devices. The chloride had values between 17-267 mg/l in the water from the sources and between 34-289 mg/l in the watering devices, only one sample exceeding the threshold value (sample 2). The overall hardness was too low in 9 samples collected from the sources and in 7 samples from the watering devices.

Tab. 1

Indicator and chemical parameters of the water quality in the sources

Sample	Indicator parameters										Chemical parameters	
	pH	Ammonia (mg/l)	Sulphate (mg/l)	Iron (mg/l)	Chloride (mg/l)	Hardness (°dH)	mg O_2/l	NTG cfu/ml	Coliforms cfu/100ml	Fecal coliforms cfu/100ml	Nitrate (mg/l)	Nitrite (mg/l)
*	6.5-9.5	0.50	250	0.2	250	>5	5	0	0	0	50	0.50
1	6.96	0.00	1-10	0.01	49.00	15	1.19	9	0	0	43	0.53
2	8.84	1.33	1-10	0.21	267.00	2.2	3.03	3	8	2	5	0.54
3	6.91	0.87	10-100	0.22	202.60	32.5	14.63	70	167	17	79	0.74
4	7.15	3.78	10-100	1.66	177.00	27.2	6.95	44	5	5	26	0.36
5	7.24	0.04	1-10	1.35	93.00	17.6	136.05	109	17	2	0.5	0.7
6	7.8	0.00	1-10	0.02	57.00	16.7	46.52	875	34	9	1.9	0.5
7	7.79	0.02	1-10	0.98	64.00	15.8	123	1257	174	34	1.5	0.10
8	7.77	0.00	1-10	0.44	58.00	17.5	146.2	7839	273	172	3.7	0.5
9	7.78	0.00	1-10	0.88	68.00	17.8	16.43	84	6	2	0.3	0.52
10	7.44	0.00	1-10	0.34	43.00	9.7	34.09	956	34	0	1.8	0.15
11	6.63	0.00	1-10	0.34	64.00	1.8	2.63	2	0	0	2.71	0
12	7.95	0.00	1-10	0.04	63.00	1.3	2.55	10	0	0	0.8	0.09
13	7.17	0.00	1-10	0.00	69	26	2.15	275	22	9	23	0.15
14	6.54	0.05	1-10	0.72	45	2.9	4.34	767	22	9	2.64	0.02
15	6.90	0.00	1-10	0.73	34	1.5	17.87	2456	141	70	3.04	0.15
16	7.40	0.00	1-10	0.00	35	2.7	1.36	9	0	0	0	0
17	7.00	0.00	1-100	0.05	29	3.6	2.3	689	130	46	5.8	0
18	7.20	0.00	1-100	0.00	108	2.1	1.06	23	0	0	0	0
19	7.17	0.00	1-10	0.02	17	5.1	2.4	0	0	0	0	0
20	7.00	0.00	1-10	0.00	31	4.5	2.9	528	22	2	0	0

* = maximum admissible values

Tab.2

Indicator and chemical parameters of the water quality in the watering devices

Sample	Indicator parameters										Chemical parameters	
	pH	Ammonia (mg/l)	Sulphate (mg/l)	Iron (mg/l)	Chloride (mg/l)	Hardness (°dH)	mg O_2/l	NTG cfu/ml	Coliforms cfu/100ml	Fecal coliforms cfu/100ml	Nitrate (mg/l)	Nitrite (mg/l)
*	6.5-9.5	0.50	250	0.2	250	>5	5	0	0	0	50	0.50
1	6.85	0.02	1-10	0.03	53.00	17.2	6.55	530	34	14	45	0.44
2	8.78	4.92	1-10	0.17	289.00	3.4	4.07	5015	22	22	10	0.4
3	6.85	1.12	10-100	0.29	239.00	33.6	14.87	1250	23	13	41	0.53
4	6.89	4.63	10-100	2.20	183.00	28.2	7.35	824	1694	174	17	0.24
5	7.13	0.22	1-10	1.60	84.00	18.2	600.4	32450	2608	1548	10.8	1.12
6	7.62	0.03	1-10	0.49	66.00	18.4	171.90	3296	109	22	3.3	0.74
7	7.73	0.06	1-10	1.23	89.00	16.3	309	5205	221	130	2.9	0.38
8	7.58	0.10	1-10	0.74	71.00	17.8	181.38	18650	1600	1584	4.4	0.71
9	7.82	0.00	1-10	1.04	74.00	18.7	44.87	4285	9	0	2.2	0.3
10	7.75	0.00	1-10	0.73	78.00	21.6	70.78	6262	189	22	3.00	0.4
11	6.83	2.03	1-10	1.09	56.00	9.8	21.74	25650	2159	2067	3.08	0.08
12	6.75	0.5	1-10	0.88	63.00	5.4	118.32	38800	1811	9	4.17	1.8
13	6.74	0.07	1-10	0.94	65	12	78.74	4307	34	33	2.97	0.09
14	7.10	0.27	1-10	0.79	52	4.6	6.08	3723	278	17	4	0.02
15	6.98	0.05	1-10	0.76	71	2.8	29.90	6387	1704	345	6	0.2
16	7.50	0.00	1-10	0.00	61	4,3	2.5	19	0	0	0	0
17	7.20	0.00	1-100	0.20	167	4.5	4.4	2380	467	130	22.15	0.01
18	7.20	0.00	1-100	0.00	123	4.8	2	63	7	2	0	0
19	7.40	0.00	1-10	0.10	34	5	3.8	0	0	0	0	0
20	7.10	0.00	1-10	0.00	48	4.3	5	1965	275	9	0	0.01

* = maximum admissible values

Tab.3

Descriptive statistic analysis for the indicator and chemical parameters of the water quality from the sources and watering devices in 20 dairy farms

Parameters	Mean		Standard deviation		Median		Maximum		Minimum	
	S	WD	S	WD	S	WD	S	WD	S	WD
pH	7.33	7.29	0.53	0.49	6.54	6.74	8.84	8.78	7.18	7.16
Ammonia (mg/l)	0.30	0.70*	0.88	1.47	0.00	0.00	3.78	4.92	0.00	0.05
Sulphate (mg/l)	28	28	36.93	36.93	10	10	100	100	10	10
Iron (mg/l)	0.40	0.66	0.49	0.59	0.00	0.00	1.66	2.20	0.21	0.73
Chloride (mg/l)	78.68	98.30	64.51	68.39	17	34	267	289	60.50	71
Hardness (mg/l)	11.17	11.99	9.85	9.41	1.30	1.20	32.5	33.6	7.40	7.60
mg O_2/l	28.38	84.18*	47.65	146.13	1.06	2.00	146.20	600.40	3.68	18.30
NTG (cfu/ml)	$8x10^2$	$8.05x10^{3*}$	$1.7x10^3$	$1,14x10^4$	0.00	0.00	$7.83\ x10^3$	$3.88\ x10^4$	96.5	$4x10^3$
Coliforms (cfu/100ml)	52.75	$6.62x10^{2*}$	78.80	$8.81\ x10^2$	0.00	0.00	$2.73\ x10^2$	$2.60x10^3$	19.5	$2.05\ x10^2$
Fecal coliforms (cfu/100ml)	18.95	$3.07x10^{2*}$	40.48	$6.27\ x10^2$	0.00	0.00	$1.72\ x10^2$	$2.06x10^3$	2	22
Nitrate (mg/l)	10.03	9.09	19.71	12.95	0.00	0.00	79.00	45.00	2.27	3.65
Nitrite (mg/l)	0.25	0.37	0.26	0.45	0.00	0.00	0.74	1.80	0.15	0.27

n=20; S = water sampled from sources; WD = water sampled from watering devices;

*= $p<0.05$, considered significant between S and WD

The values of the organic substances were between 1.06 and 289 mg/l, exceeding the admissible values in 8 samples from the sources and in 14 samples from the watering devices. The total number of germs (TNG) had great variations among the farms but also among the sources and the watering devices, having values between 2 and 3.88 x 10^4 cfu/ml, showing obviously greater values in the watering devices (Table 2). In 65% of the samples collected from the sources and in 90% of those from the watering devices total and fecal coliforms were detected, in very high numbers in some farms (Tables 1-2). Among the analysed water samples 80% had nitrates, their concentrations being between 0.5 and 79 mg/l. The nitrites were detected in 70% of the analysed water samples, having values between 0.01 and 1.8 mg/l.

Table 3 shows the descriptive statistical parameters for the water samples collected from the water sources and the watering devices in 20 dairy farms. There are significant differences (Mann-Whitney Test, $p<0.05$) between the water from the sources and the water from the watering devices in the ammonia, organic substances, total number of germs and the numbers of total and fecal coliforms.

Our results are in accordance with those obtained in other studies, proving that the drinking water provided for the animals is often of a poor quality (Ensley, 2000; Socha *et al.*, 2001; Wagner *et al.*, 2001; Popescu *et al.*, 2005). The modified concentrations of some indicator and chemical parameters (Tabel 1) compared to the legal previsions indicate the improper quality of the water consumed by the dairy cows in the assessed farms. The threshold for ammonia (0.5 mg/l) was exceeded in the water offered to cows in three of the farms. Ammonia results from degradation of organic matter and of anorganic azotate fertilizers in waters, its presence indicating a recent fecal pollution, increasing also the concentrations of the organic matter and of chlorides; this fact was also evident in our study (Table 2). The maximum admissible concentration of the iron was exceeded in 65% of the samples collected from the watering devices and in 45% of the samples from the water sources. The iron in the drinking water does not endanger the health of the dairy cows. Yet its high concentration leads to the alteration of the water's taste and colour and its accumulation on the inner surface of the pipes reduces the water's flow (Adams and Sharpe, 1995). Another parameter which presented alterations in comparison to the legal previsions was the hardness of the water. This parameter does not represent a risk-factor for the health and production of the animals. Only a few studies were made about the impact of the water hardness on animals and these indicate that this parameter has no effect on animal health or voluntary water consumption (Looper and Waldner, 2002). The presence of the organic substances in much higher concentrations than the admitted values indicate also the existence of water pollution factors both at the sources level and in the watering devices.

Only one sample from the water sources showed the nitrates exceeding the maximum admissible limit. Nitrites with concentrations above 0.5 mg/l were found in two samples from wells and in three samples collected from watering devices. According to the researches of Grant (1996), the nitrate concentrations exceeding 100-150 mg/l of drinking water can cause reproductive disturbances in mature cows and replacement heifers, which will show lower growing rates, but usually there are no significant milk production alterations at moderately raised nitrate levels in the drinking water. Concentrations of nitrite exceeding 30 mg/l may be hazardous to animal health. Both nitrate and nitrite can cause toxicity to animals, with nitrite being far more toxic than nitrate (ANZECC, 2000). According to Adams and Sharpe (1995), nitrate levels over 100 ppm as NO_3 may adversely affect cattle. Levels of 500-1000 ppm NO_3 may cause moderate symptoms of toxicity in cattle while those over 1000 ppm may result in

acute symptoms and death. These guidelines for cattle assume normal levels of nitrate in the diet.

However, the great numbers of germs in the water consumed by the dairy cows are concerning (Table 2). The presence of the coliforms, especially of the fecal coliforms, in the majority of the water samples collected from the watering devices indicate also a high risk of waterborne diseases. In this case our results are again in accordance with other studies.

A large US study of livestock drinking water (LeJeune *et al.*, 2001) investigated 473 water troughs on 98 dairy farms. The authors concluded that troughs are a major source of exposure of cattle to enteric bacteria, including a number of food-borne pathogens, and the degree of bacterial contamination appeared to be associated with potentially controllable factors. The results of the study indicated that drinking water offered to cattle is often of poor microbiological quality with total coliforms and *E. coli* counts of around 10^5 and 10^4 cfu per litre respectively. *E. coli* O157 was isolated from 1.3% and *Salmonella spp.* from 0.8% of troughs. Interestingly, metal troughs had significantly lower coliform and *E. coli* counts compared to other construction materials respectively concrete, plastic and other materials. The group also found that bacterial contamination was higher in troughs that were closest to the feed-trough. Proximity of the troughs to the feed-trough may have permitted a greater amount of food to enter the trough, thus increasing the level of contamination, as well as providing a nutrient-rich substrate for bacterial growth at the bottom of the trough. LeJeune et al. (2001) also noted the association between the quality of the water and the ecological parameters measured, suggesting that many of the same factors that influence the survival and proliferation of bacteria in natural aquatic ecosystems have parallels in water trough environments. In our study the quality of the water from the sources was better than that from the watering devices (Table 3), which indicates that water gets polluted either at the level of the watering devices or before reaching the drinking facility. Bacterial contaminants in troughs may arise from multiple sources (e.g. cud or faecal material and extraneous matter including dust or feed). In some instances, depending on the source, water may be heavily contaminated before it enters the trough. Overland and sub-surface flow of faeces into waterways is also likely to play a part in bacterial dissemination as *E. coli* can survive in bovine faeces for several weeks (Wang *et al*., 1996). Sediments within a trough may have much higher levels of microbial contamination.

CONCLUSIONS

In 95% of the studied farms the water consumed by the cows is qualitatively improper due to its microbial contamination. Even if the water is better in the majority of the sources, major alterations of its quality are produced at the level of the watering devices where the water becomes undrinkable and dangerous for the consumers.

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