Turkish Journal of Veterinary and Animal Sciences

http://journals.tubitak.gov.tr/veterinary/

Research Article

Turk J Vet Anim Sci
(2018) 42: 543-548
© TÜBİTAK
doi:10.3906/vet-1703-88

Effect of water quality on production performance of lactating Nili-Ravi buffaloes

Muhammad Asim TAUSIF[1], Faisal SHAHZAD[2,*], Jalees Ahmed BHATTI[3], Sundas QAMAR[1], Anjum KHALIQUE[4], Hifz-ul-RAHMAN[3], Hafiz Muhammad ALI[2], Azfar HUSSAIN[1]

[1]Buffalo Research Institute, Livestock Experiment Station, Kasur, Pakistan
[2]University College of Veterinary and Animal Sciences, The Islamia University of Bahawalpur, Bahawalpur, Pakistan
[3]Department of Livestock Production, University of Veterinary and Animal Sciences, Lahore, Pakistan
[4]Department of Animal Nutrition, University of Veterinary and Animal Sciences, Lahore, Pakistan

Received: 26.03.2017 • **Accepted/Published Online:** 16.09.2018 • **Final Version:** 10.12.2018

Abstract: The study was conducted to evaluate the effects of drinking water quality on the milk production performance of Nili-Ravi buffaloes. Lactating Nili-Ravi buffaloes (n = 12) of the same parity were randomly divided into three groups: A, B, and C (n = 4). Group A was offered turbine water, group B (the control) was kept on tap water, and group C was given canal water for drinking. Mean daily milk production was found significantly ($P < 0.01$) higher for group A as compared to the other groups. Dry matter intake (DMI) was lowest in group B followed by group A. Milk composition, including fat, solid not fat, and total solid percentages, was found statistically different ($P < 0.001$) among all groups. Feed efficiency was higher in the control (group B) followed by group C and group A. A significant ($P < 0.001$) difference for water intake was also observed among all groups. In conclusion, buffaloes kept on tap drinking water showed better milk production performance.

Key words: Nili-Ravi buffaloes, water quality, milk production, milk composition

1. Introduction

Buffalo is considered the best dairy animal in Pakistan and its milk constitutes about 62% of total milk production (1). The country is bestowed with the best breeds of buffalo, namely Nili, Ravi, Nili-Ravi, Kundhi, and Azi-Kheli (2). Nili-Ravi buffalo is the main dairy animal and a potential source of milk, meat, hide, and skin in Pakistan. It has more milk production potential than its current output; this potential could be better exploited by appropriate nutrition supply (3). Nutrients play a vital role in the growth of dairy cattle. Protein and energy are two important constituents of ration for dairy and beef animals and both components are quite important for efficient growth and production performance. However, sufficient amount of water must also be available to the animals to meet the bodily requirements and to properly utilize the feed components in the body.

Water is a major constituent of the body and is important for proper functioning of various physiological processes including ionic balance, digestion, absorption, metabolism, heat balance, elimination of waste products from the body, intra- and extra-cellular nutrients transport, and electrolytes balance and it also provides a fluid environment for developing fetus (4). In short, these indicate the importance of water in normal physiology and homeostasis of the body and hence the overall production of the animal (2). To meet the bodily requirements, drinking water is mainly the foremost source although food and metabolic processes also contribute (5). Feed and water intake are closely related and thus affect animal growth and production. Generally, a large amount of water is required by lactating cattle for appropriate milk production. Animals are quite sensitive to water quality and prefer to take clean water without any adulteration (6). Total dissolved solids (TDS), i.e. the sum of inorganic mater dissolved in water, is considered to be the main criterion in assessment of quality of drinking water for livestock (7). High TDS contents, mainly sodium (Na), potassium (K), copper (Cu), magnesium (Mg), iron (Fe), arsenic (As), and sulfur (S), in drinking water of dairy cows cause imbalances of some minerals in the body and thus negatively affect the milk production performance (7). The effects of drinking water with high TDS levels (above 1000 mg/L) on production of dairy cattle are not so clear. Results from experimental studies vary mainly due to variations in the specific TDS composition in the drinking water, the production level of the experimental animals used, the productive traits studied, and whether

* Correspondence: faisalshehzad76@yahoo.com

the cows were grazed or housed. Therefore, it is important to determine the benefits of high-quality drinking water for dairy cattle under a practical scenario. However, the available findings on the effects of water quality on productive performance of lactating Nili-Ravi buffaloes are limited and to some extent contradictory. Hence, this project was designed to evaluate the effect of different water sources (Canal: 250 mg/L of TDS, Tap: 1000 mg/L of TDS, and Turbine: 2000 mg/L of TDS) on milk production and composition of Nili-Ravi buffaloes maintained at the Livestock Experiment Station of Buffalo Research Institute, Pattoki.

2. Materials and methods

2.1. Preexperimental studies

Studies were carried out to check the quality of water from canals and underground areas. The reason behind this was to plan the research at Buffalo Research Institute in Pattoki according to drinking water quality of animals in local environmental conditions.

2.2. Water (turbine, pump, and canal)

Total dissolved solids (TDS) and pH were tested as part of the preexperimental studies.

2.3. Water sampling

Water from three different sources, i.e. turbine (with a depth of 700 feet), canal, and pump were collected separately. Five hundred mL of water from all three sources was packed in different plastic bottles with individual identification.

2.4. Analysis of water

All water samples were analyzed by Soil and Water Testing Laboratory for Research, Thokar Niaz Baig, Lahore, and the Government of the Punjab. The method used was as described by Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No.60, Washington, DC, USA. Total dissolved solids were calculated by measuring electrical conductivity in microsemens and multiplying it by 0.7 to get the TDS in ppm. pH was calculated by standard pH meter.

2.5. Experimental animals

Nili-Ravi lactating buffaloes (n = 12) of the same parity (3rd and 4th) and with similar milk production were randomly selected. The animals were divided into three groups: A, B, and C (n = 4). Group A was offered turbine water (2000 mg/L of TDS), group B (control) was kept on tap water (1000 mg/L of TDS), and group C was given canal water (250 mg/L of TDS) for drinking for 60 days. Seasonal green fodder was offered ad libitum to meet the maintenance requirements at 3:00 PM daily and was accessible till the morning milking, whereas the concentrate (Table 1) was offered twice a day at 1 kg for every 2 L of milk produced and provided at 6:00 AM and 4:00 PM before milking in the morning and in the evening. All animals were fed individually. Initially, the animals were in adjustment period for 7 days followed by 60 days for data recording and sample collection. Animals were dewormed and vaccinated well before the start of the experiment. The following parameters were studied during the experiment:

Table 1. Chemical composition of concentrate/ration for lactating Nili-Ravi buffaloes.

Ingredients	Percent
Maize	8
Cotton seed cake	22
Rape seed cake	3
Wheat bran	32
Maize gluten	20
Molasses	14
Mineral mixture	1
Crude protein	16.0
Total digestible nutrients	76.0

CP (crude protein) was calculated through wet chemistry (AOAC. 1999)

TDN (total digestible nutrient) is the tabulated value that is provided by the Division of Animal Nutrition of Buffalo Research Institute, Pakistan.

2.6. Total dissolved solids (TDS)

TDS contents of the three different water sources were tested as part of the preexperimental studies.

2.7. Animal water intake

Measurements of water trough were taken for length, width, and height with the help of a steel measuring scale. Water intake of each buffalo was determined for 24 h on daily basis. The water trough was marked inside the trough for calibration and then used for calculation of water.

2.8. Dry matter intake (DMI)

Hot air oven method was used to determine DMI on weekly basis, as described earlier (8).

2.9. Milk production

Milk was collected by hand milking practice daily at 5:30 AM and at 5:30 PM and the total milk production yield was calculated accordingly.

2.10. Milk composition

Collected milk samples were immediately analyzed for their composition, e.g., milk fat, solid not fat (SNF), and total solid (TS) by laboratory methods, described by the Association of Official Analytical Chemists (9).

2.11. Blood mineral profile

Blood samples (10 mL) were collected in EDTA-free tubes from each animal on fortnightly basis and analyzed for biochemical parameters including calcium (Ca), magnesium (Mg), phosphorous (P), sodium (Na), and chloride (Cl) levels. Measurement of minerals in blood serum was done through kits from Randox International Lab. Ltd, UK. Calorimetric method was used for measurement of Calcium and Magnesium and ultraviolet method was used for checking inorganic phosphorus. Randox kits catalogue no. Ca 590, Mag 570 were used for measurement of calcium and magnesium and catalogue no. PH.1016 was used for phosphorus measurements through spectrophotometer (Precisely A Analyst 200 Atomic Absorption Spectrophotometer, Perkin Elmer,Inc., Waltham, MA, USA).

2.12. Water quality

Total dissolved solids and pH level of different water samples were recorded on regular basis. All the samples were analyzed by Soil and Water Testing Laboratory for Research, Lahore (10). Total dissolved solids were calculated by measuring electrical conductivity in microsemens and multiplying it by 0.7 to get TDS in ppm.

2.13. Feed efficiency

Feed efficiency of the animals was calculated by the following formula:

Feed efficiency = milk produced/dry matter intake (L/kg)

2.14. Statistical analysis

The recorded data were statistically analyzed by using one-way ANOVA under completely randomized design (CRD). The difference of means among the treatment groups were determined by using Duncan's Multiple Range Test (11). The interpretation of the results was done by using SPSS, version 16.0 and $P < 0.05$ was accepted as statistically significant level.

The following mathematical model was applied:

$Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$,

where

Y_{ij} = each observation on jth animal due to ith treatment,

μ = overall mean,

τ_i = effect of ith treatment ($\sum\tau_i = 0$ and i = 1, 2, 3, 4),

ε_{ij} = random error associated with ith treatment with the restriction that variance $\sigma 2$ and mean are zero.

3. Results and discussion

It was observed that the animals in groups B and C consumed significantly ($P < 0.001$) higher quantity of water than those in group A (Table 2). Water intake was higher for animals receiving 10,000 mg/L of TDS in the drinking water as compared to cows that received water with 1000 and 5000 mg/L of TDS, respectively. Regarding treatments with 10,000 mg/L of TDS, it can be pointed out that diets high in salt, sodium, or protein appear to stimulate water intake (12). A study by Guadalupe et al. (13) showed that Holstein dairy cows consuming water with a low TDS level had better milk yield efficiency, lower feed intake, lower somatic cell count, and lower risk of milk fat depression than those consuming untreated water from the farm's deep well (13). Solomon et al. (14) found that daily water consumption of Israeli Holstein cows offered desalinated water was higher by 10.6 L than those in the group offered salty drinking water at the Arava Desert of Southern Israel. Contrary to these observations, brackish well water (BW) containing 3574 mg/L of TDS was compared with desalinated water containing 449 mg/L of TDS as a source of drinking water for early lactating dairy cows in the hot arid conditions of Kuwait. Dry matter and water intakes were not affected by water type ($P > 0.05$) and BW was an acceptable source of water for dairy cows (15).

Hence, high water intake could be correlated with increased milk production that was also found to be significantly higher ($P < 0.001$) for groups B and C (<1000 mg/L of TDS) than that for group A that was offered water containing 2000 mg/L of TDS (Table 2). In the same context, the results indicate that cows consuming water with a low TDS concentration had higher ($P < 0.01$) milk yield (5.8% vs 9.8%) than those offered water with high TDS level (16). Similarly, daily milk yield was relatively high in Holstein cows receiving desalinated water than in those offered salty water (5). Similarly, a significant ($P < 0.05$) increase in milk production efficiency of about

Table 2. Effects of various water types on various productive traits in Nili-Ravi buffaloes.

Animal groups*	Water intake (L)	Dry matter intake (kg)	Feed efficiency (ratio)	Milk production(L)
A	53.0 ± 0.54^{b}	16.17 ± 0.10^{b}	0.37 ± 0.06^{b}	5.91 ± 0.05^{b}
B	56.3 ± 0.62^{a}	16.02 ± 0.18^{b}	0.48 ± 0.10^{a}	7.94 ± 0.08^{a}
C	57.5 ± 0.48^{a}	17.36 ± 0.15^{a}	0.46 ± 0.08^{a}	7.70 ± 0.06^{a}
P value	<0.001	<0.001	<0.001	<0.001

*Animal groups: (A) turbine water, (B) tap water, (C) canal water.

17% was observed by Guadalupe et al. (13) in cows that consumed reverse osmotic desalinated drinking water. Contrary to these observations, milk production was found not to be affected in multiparous lactating Holstein cows offered water with various salinity levels (10,000 mg/L, 5000 mg/L, or 1000 mg/L of TDS (12). Similarly, other authors could not find any differences either in daily milk yield between water types with various TDS levels (5,13,17). These studies might have been conducted in the areas where animals were fed on saline water for a long time and their body systems were adjusted with the salinity. Thus, it could be concluded that the provision of adequate clean and palatable water to dairy animals is of prime importance for good production.

Daily DMI was recorded in buffaloes allocated to water with various salinity levels, and the values were found significantly higher ($P < 0.05$) in buffaloes offered canal water compared to those in the other two groups (Table 2). Similar to our results, cows offered reverse osmotic desalinated water had less dry matter intake and higher milk yield efficiency than those in the nondesalinated water group (13). In the present study, the lower DMI in high-TDS group could be due to high levels of sulfates that adversely affect rumen microorganisms, reducing their number and activity (18). Usually, low-TDS drinking water is helpful to improve the welfare status of animals; that is why milk yield was found higher in the present study in tap water (low-salt water) compared to that in turbine water. We found that mean SNF (%) of buffaloes on canal water was significantly ($P < 0.001$) higher compared to that of the buffaloes offered tap water (Table 3). Mean fat (%) and TS (%) of group A were significantly higher ($P < 0.001$) than those of the other two groups (Table 3). Similarly, Solomon et al. (15) observed an increased fat percentage and daily fat production (1.02 vs 0.96 kg/cow/day) in milk of animals receiving desalinated water than in milk of those drinking salty water. Moreover, Revelli et al. (17) observed that the fat percentage in milk was high in animals that drank water with low salt concentrations. Composition of milk was not affected among lactating Holstein cows offered water with increasing quantities (10,000 mg/L, 5000 mg/L, or 1000 mg/L) of TDS (12) or nondesalinated (>1809 mg/L TDS) or reverse osmosis desalinated (<554 mg/L TDS) drinking water (13). Moreover, Arjomandfar et al. (5) also found no effects of water with various TDS levels on fat concentration. The indifference on the milk yield in these experiments may reflect the indifferences in water consumption or the indifference in mineral concentration in milk yield. Thus, the cows that drank water with a high TDS content had a risk of producing milk fat depression 3.3 times higher ($P < 0.01$) than those that drank water with a low TDS concentration (13). Beede (19) mentioned that content of minerals in the diet and availability and quality of drinking water could affect the dilution ratio of feed in the rumen, decreasing fiber fermentation and some metabolite precursors of fat synthesis in milk. Milk fat depression syndrome is an increasing problem in Mexican dairy cattle herds and has caused economic losses since this type of milk does not receive economic compensation from the national dairy processing industry.

Feed efficiency of the buffaloes in groups B and C was significantly ($P < 0.001$) higher than those in group A in our results (Table 2). The results of the present study show a positive correlation between water intake and feed intake. Our findings were supported by Ali et al. (20) who reported that dry matter intake increased significantly with increase of water intake. It would be due to low TDS value of water that had a positive effect on dry matter intake. The differences among treatments for calcium, phosphorous, and magnesium in blood were statistically insignificant ($P > 0.05$) in buffaloes treated with various water salinity levels. However, sodium was found to be statistically significant among various treatments ($P > 0.05$). Interestingly, various TDS levels of water affected the sodium concentration of blood (Table 4). It seems that, among others, sodium was the only element which was affected by water elements. This confirms the different metabolism of various elements in dairy cows and may

Table 3. Effects of various water types on milk composition (%) in Nili-Ravi buffaloes.

Animal groups*	SNF	Fat	TS
A	9.72 ± 0.04[a]	7.06 ± 0.03[a]	16.78 ± 0.04[a]
B	9.50 ± 0.04[b]	6.81 ± 0.06[b]	16.40 ± 0.06[b]
C	9.80 ± 0.05[a]	6.86 ± 0.02[b]	16.38 ± 0.07[b]
P value	<0.001	<0.001	<0.001

*Animal groups: (A) turbine water, (B) tap water, (C) canal water; SNF: solid not fat, TS: total solid.

Table 4. Effects of various water types on blood minerals profile (ppm) in Nili-Ravi buffaloes.

Animal groups*	Calcium	Phosphorous	Magnesium	Natrium	Chloride
A	10.0 ± 0.40[a]	4.7 ± 0.15[a]	2.42 ± 0.07[a]	323.3 ± 5.5[a]	106.5 ± 0.96[a]
B	8.93 ± 0.28[a]	4.4 ± 0.18[a]	2.15 ± 0.18[a]	303.7 ± 4.7[b]	104 ± 0.44[a]
C	9.58 ± 0.55[a]	5.5 ± 0.11[a]	2.36 ± 0.14[a]	139.7 ± 4.1[c]	100 ± 0.77[b]
P value	0.224	0.058	0.360	<0.001	0.266

*Animal groups: (A) turbine water, (B) tap water, (C) canal water.

be because of different levels of these elements in water consumed in these experiments. However, Arjomandfar et al. (5) did not find any effect of water quality on Na^+, Ca^{2+}, and Mg^{2+} in serum by desalinating water to the TDS level of 570 mg per L but K^+ concentration was significantly higher in cows consuming saline water ($P > 0.05$).

Bahman et al. (15) indicated a tendency for higher levels of all these ions in the plasma of the cows on saline water, which could be due to a higher level of TDS than that in our experiment. Homeostatic mechanisms control the level of minerals in bodily fluids; therefore, the concentrations of minerals tend to stabilize after a period of saline water intake (9). The mineral levels in blood may remain slightly higher than normal physiological values when TDS levels are higher, as in the study of Arjomandfar et al. (5).

According to the recommendation of the National Research Council (9), water containing more than 5000 mg/L of TDS is considered satisfactory for lactating animals while levels greater than 7000 mg/L should be avoided. Water has little or no effect on milk production of cattle when its TDS level is less than 3000 ppm while high TDS concentration decreases milk production in hot season than in winter (15). We also observed that buffaloes provided with turbine water (high TDS) showed no signs of illness but milk production was significantly reduced compared to animals provided with tap or canal water. Similarly, beef cattle when subjected to water containing 6000 mg/L of TDS showed lower daily weight gain compared to animals consuming water with 1300 mg/L of TDS (5). The results of our study also depict that buffaloes showed better feed efficiency when subjected to water with 1000 mg/L of TDS or less.

The results of the experiment were helpful to determine the appropriate water quality (1000 and 250 mg/L of TDS) to significantly increase the buffalo milk production in central Punjab. The results of this study have also provided useful guidelines for safe use of drinking water in problem areas as turbine water negatively affects the milk production performance of buffaloes. It is concluded that in the study, the Nili-Ravi buffaloes that drank tap water with a low concentration of total dissolved solids had better milk yield efficiency and better feed efficiency than those that drank turbine water from the farm's deep well, and showed better milk performance when subjected to water with 1000 mg/L of TDS or less.

References

1. Economic Survey of Pakistan. Economic Advisor Wing, Ministry of Finance, Government of Pakistan, Islamabad. 2012
2. Khan MS, Ahmad N, Khan MA. Genetic resources and diversity in dairy buffaloes of Pakistan. Pak Vet J 2007: 27: 201-207
3. Jabbar MA, Fiaz M, Iqbal T, Abdullah M, Marghazani IB. Effect of different dietary energy levels on milk production in lactating Nili-Ravi buffaloes. J Anim Plant Sci 2013; 23: 13-16.
4. Reece WO. Functional Anatomy and Physiology of Farm Animals. 3rd ed. Philadelphia, PA, USA: Lippincott Williams & Wilkins; 2005.
5. Arjomandfar M, Zamiri MJ, Rowghani E, Khorvash M, Ghorbani G. Effects of water desalination on milk production and several blood constituents of Holstein cows in a hot arid climate. Iran J Vet Res 2010; 11: 233-238.
6. Schutz K. Effects of providing clean water on the health and productivity of cattle. Report for NRC 2012; 400: 346.
7. NRC. Nutrient Requirement of Dairy Cattle. 7th rev. ed. National Academy Press, Washington, DC, USA; 2001.
8. Malkeet SP, Cassandro VT, do-Amaranteb, Garciac RM, Slaughterd DC, Mitcham EJ. Methods to analyze physico-chemical changes during mango ripening: a multivariate approach. Postharvest Biol Tec 2011; 62: 267-274.

9. AOAC. Official Methods of Analysis. 18th edition, Association of Analytical Chemists, Washington, DC, USA.

10. Richards LA. Diagnosis and improvement of saline and alkaline soils united states salinity laboratory staff, Agriculture Handbook No. 60 United States; Department of Agriculture, 160; 1954.

11. Steel RGD, Torrie JH, Dickey DA. Principles and Procedures of Statistics. 3rd ed. New York, NY, USA: McGraw-Hill, Book Co Inc,; 1997.

12. Valtorta SE, Gallardo MR, Sbodio OA, Revelli GR, Arakaki C, Leva PE, Gaggiotti M, Tercero EJ. Water salinity effects on performance and rumen parameters of lactating grazing Holstein cows. Int J Biometeorol 2008; 52: 239-247.

13. Guadalupe, Jose GM, Herrera-Monsalvo CD, Lara-Bueno A, Lopez-Ordaz R, Jaimes JJ, Ramírez-Valverde R. Effects of drinking water desalination on several traits of dairy cows in a Mexican semiarid environment. Life Sci J 2015; 12: 83-97.

14. Solomon R, Miron J, Ben-Ghedalia D, Zomberg Z. Performance of high producing dairy cows offered drinking water of high and low salinity in the Arava desert. J Dairy Sci 1995; 78: 620-624.

15. Bahman AM, Rooket JA, Topps JH. The performance of dairy cows offered drinking water of low or high salinity in a hot arid climate. Anim Prod 1993; 57: 23-28.

16. Jaster EH, Schuh JD, Wegner TN. Physiological effects of saline drinking water on high production dairy cows. J Dairy Sci 1978; 61: 66-71.

17. Revelli GR, Sbodio OA, Gallardo MR, Valtorta SE, Tercero EJ. Performance of dairy cows of low production in pastoral conditions with salt or desalinated drinking water supply. Mag FAVE Sec Sci Vet 2005; 4: 77-88.

18. Umar S, Munir MT, Azeem T, Ali S, Umar W, Rehman A, Shah MA. Effects of water quality on productivity and performance of livestock: a mini review. Vet 2014; 2: 11-15.

19. Beede DK. Evaluation of water quality and nutrition for dairy cattle. In: Proceedings of High Plains Dairy Conference. Albuquerque, NM, USA; 2006. pp. 1-24.

20. Ali A, Mustafa MI, Bilal MQ, Muhammad G, Lateef M, Ullah S. Effect of watering frequency on feed intake, milk production and composition in Sahiwal cattle during summer. J Anim Plant Sci 2015; 25: 19-22.