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RESEARCH ARTICLE

Impact of Salinity Levels in Drinking Water during Hot Summer Season on Weight Gain, Water and Feed Intake, and Physiological Body Functions of Growing Crossbred Heifers

Alsaied Alnaimy Habeeb, Ahmed Elsayed Gad

Department of Biological Applications, Radioisotopes Applications Division, Nuclear Research Center, Atomic Energy Authority, Inshas, Cairo P.O. 13759, Egypt

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ABSTRACT

The study aimed to investigate the effects of slightly saline (3000 ppm NaCl), moderately saline water (6000 and 9000 ppm NaCl), and highly saline water (12000 and 15000 ppm NaCl) on growing bovine native heifers during hot summer season of Egypt. Total and daily gain in heifers drank slightly saline water was significantly higher than those in heifers drank River Nile water (RNW). The gain of heifers drank moderately or highly saline water decreased significantly when compared with the gain of heifers drank RNW only. Total water intake (TWI) of heifers in heifers drank slightly or moderately saline water increased significantly, while TWI of heifers drank highly saline water decreased significantly when compared with the WI of heifers drank RNW. Dry matter intake (DMI) increased significantly in heifers drank slightly saline water, while DMI of heifers drank moderately or highly saline water decreased significantly when compared with DMI of heifers drank RNW. Drinking water containing high levels of salts was accompanied by progressively significant increases in urea-N, creatinine, glucose, and cortisol concentrations. Total cholesterol and triglycerides, aldosterone concentrations as well as liver enzymes (alanine transaminase and aspartate transaminase) activities increased significantly while thyroid hormones (T4 and T3) and 17β-estradiol levels decreased significantly in heifers drinking saline water containing RNW diluted with 9000, 12000, and 15000 ppm NaCl. It can be concluded that growing heifers tolerate up to 0.6% NaCl and no advice to use highly saline water (9000, 12000, and 15000 ppm NaCl) in drinking growing heifers, especially, in hot summer season of Egypt.

Key words: Body gain, drinking water, heifers, physiological functions, salinity

INTRODUCTION

In Egypt, fresh water in the desert is very rare and represents a serious problem for expanding and developing animal farms. Animals in desert areas are usually dependent on drinking water with varying degrees of salinity. Most of the farms of animals are constructive in extending reclamation of the desert lands which is supplied for drinking by underground water which contains high level for drinking. Under these conditions, the reduction in productive and physiological performance occurs.[1] Among the problems that face animals in such an environment, exposure to heat stress during hot summer season and drinking underground water contains high levels of salts.[2] Saline water contains a significant concentration of dissolved salts, mainly, NaCl and is commonly known as salt water (salinity). Most of farm animals should drinking water contain less than 500 ppm salinity and water containing above 1000 ppm is considered salinity water.[3] Livestock water supplies contain dissolved solids <500 ppm desired range and >3000 problem range.[4] When salinity levels in water are <3000 ppm, there is little to no effect on cattle, although at first introduction mild case of diarrhea.[5] Between 3000 and 5000 ppm salinity, the effects on animal performance are variable.[6] The salinity

Address for correspondence:
Alsaied Alnaimy Habeeb,
E-mail: dr_alnaimy @yahoo.com

guidelines suggest water containing <5000 ppm may be fed to lactating cattle, but water containing >7000 ppm is unacceptable for all cattle.[7] Water salinity according to Anati[8] is fresh water (<0.05%), brackish water (0.05–3%), saline water (3–5%), and brine water (>5%). The United States Geological Survey classifies saline water in three salinity categories, salt concentration in slightly saline water is around 1000–3000 ppm (0.1–0.3%), in moderately saline water is around 3000–10000 ppm, and in highly saline water is around 10000–35000 ppm.[9]

Salinity in drinking water is a problem commonly found in Egypt and the highest permitted concentrations of salt in animal drinking water can be used with reasonable safety are not clear until now, especially, during hot summer season. This study aimed to investigate the effects of drinking water salinity (0.03–1.5% salt) on growing bovine native heifers during hot summer season of Egypt. This aim is important to the general knowledge in the field of ruminants nutrition, in view of the increase in desert areas on the globe that grows ruminants dependent on drinking well water with varying degrees of salinity.

The impact of different concentrations of salinity in drinking water on the growth performance, feed utilization and efficiency, water intake, physiological body functions, and blood constituents is the objectives of this study.

MATERIALS AND METHODS

Animals and feeding

The present study was conducted in bovine farm project, Biological Application Department, Nuclear Research Centre, Atomic Energy Authority, Inshas, Cairo, Egypt, during 4 weeks of hot summer season of July 2015. This work was reviewed and approved by the Animal Care and Welfare Committee of Zagazig University, Egypt (ANWD-206). These ethics contain relevant information on the endeavor to reduce animal suffering and adherence to best practices in veterinary care according to the International Council for Laboratory Animal Science guidelines. A number of 30 crossbred healthy heifers 50% (♀Brown Swiss x ♂Holstein) after weaning 6 months of age and average body weight of 150.35 kg were used in this research. The experimental heifers were offered the control diet which covers their energy and vitamin requirements according to live body weight (LBW) and daily gain.[7] Heifers fed ration consisted of concentrate feed mixture (CFM), clover hay, and rice straw. Ingredients of the CFM are un-decorticated cottonseed meal (35%), yellow maize (30%), wheat bran (30%), and soybean meal (5%). Each 100 kg CFM was supplemented with 100 g mineral mixture (each kg contains 40 g Mn, 3 g Cu, 0.3 g I, 0.1 g Si, and 30 g Fe), 100 g vitamin mixture (AD_3E), 2 kg di-calcium phosphate, and 1 kg coarse refined iodized kitchen salt. The chemical composition of the feed (on DM %) was calculated according to AOAC.[10] Crude protein, crude fiber, ether extract, nitrogen-free extract, and ash values were 17.68, 15.50, 2.87, 47.28, and 6.00% for CFM and were 14.20, 25.10, 2.60, 34.60, and 12.50% for clover hay, respectively.

Experimental design

The study aimed to investigate the effects of slightly saline (3000 ppm NaCl), moderately saline water (6000 and 9000 ppm NaCl), and highly saline water (12000 and 15000 ppm NaCl) added to River Nile water (RNW) already containing 300 ppm dissolved salts as shown in Table 1. The study was carried out on 30 healthy growing crossbred heifers and lasted 28 days after five days was taken as adjustment period during hot summer season of Egypt. Heifers were divided into six equal groups, each consisting of 5 heifers. Heifers drank RNW contain 300 ppm (0.03%), RNW diluted with 3000 ppm NaCl (slightly saline), moderately saline water (RNW diluted with 6000 ppm NaCl, 0.6%), moderately saline

Table 1: Chemical analysis of RNW

Chemical analysis of Cations and Anions*			
Cations	**Concentration, ppm**	**Anions**	**Concentration, ppm**
Na	78.61	Cl	71.19
Ca	26.80	CO_3	7.55
K	4.00	HCO_3	30.42
Mg	25.32	SO_4	55.84
Iron	0.08		
Led	0.09		
Mn	0.10		
Total	135.00		165.00
Total salinity, ppm	300		

*Chemical analysis was carried out Soil and Water Department, Radioisotopes Applications Division, Nuclear Research Center, Atomic Energy Authority, Egypt. RNW: River Nile water

water (RNW water diluted with 9000 ppm NaCl, 0.9%), highly saline water (RNW diluted with 12000 ppm NaCl, 1.2%), and highly saline water (RNW water diluted with 15000 ppm NaCl, 1.5%) in 1st, 2nd, 3rd, 4th, 5th, and 6th groups, respectively.

Environmental conditions

Air temperature (AT) °C, relative humidity (RH) (%), and temperature-humidity index (THI) were estimated weekly atat 12.00 h 4 times during the experimental period. The averages of AT, RH percentage, and THI values during experimental period were 40.0 ± 0.84°C, 72.4 ± 0.75%, and 96.9 ± 1.14, respectively. These climatic conditions reaffirmed that heifers were suffering from very severe heat stress according to Kendall and Webster[11] who reported that THI = (1.8*AT+32)−[(0.55−0.0055*RH)×(1.8*AT−26)], where AT = air temperature (°C) and RH = relative humidity (%), and then classified as follows: <70 = normal or absence of heat stress, 70–80 = Alert or moderate heat stress, 79–82 = danger or severe heat stress, and >82 = emergency or very severe heat stress.

Measurements

Initial and final LBW of each heifer was weighted to estimate total gain (kg) after 28 days and daily body weight gain (DBG) (g). Food consumption for each group was measured weakly by subtracting the residuals of feed from that offered for heifers in the previous day and calculated as dry matter intake (DMI). The DM concentration of the feed was determined from the weight difference before and after oven drying at 105°C for 24 h. The daily DMI of each group was calculated by multiplying the daily fresh feed intake with the DM concentration. Water intake was measured weakly for each group by subtracting the residuals of water from that offered for heifers in the previous day. Feed/gain ratio and water intake/gain ratio were calculated.

Blood sampling and analysis

One blood sample was collected at the day 28 from the jugular vein of each heifer before morning meal without anticoagulant in vacutainers tubes and then placed on ice water immediately following collection. Total protein, albumin, urea, creatinine, total cholesterol, triglycerides, and glucose concentrations as well as alanine transaminase and aspartate transaminase enzymes activities were estimated by the colorimetric method using commercial kits (Diamond Diagnostic, Egypt). Globulin was estimated by subtraction of albumin from total proteins. T_3, T_4, aldosterone, and 17β-estradiol hormones were estimated using radioimmunoassay technique by the coated tubes kits (Diagnostic Systems Laboratories, Inc., Webster, Texas, USA) and the radioactivity of iodine-125 (^{125}I) is determined in gamma counter.

Statistical analysis

Data were statistically analyzed by one-way analysis of variance using the computer program of SAS.[12] The statistical model was as follows: $y_i = \mu + T_i + e_{ij}$, where y_j = the observation, μ = overall mean, T_i = the fixed effects of salinity treatment (RNW, 0.03, 0.3, 0.6, 0.9, 1.2, and 1.5%), and e_{ij} = random error. The significant differences between group's means were tested at a level of $P < 0.05$ using new multiple range test.[13] The percentage change due to salinity in each item was calculated as follows: {(RNW-S) × 100}/RNW, where RNW= River Nile water and S= salinity level.

RESULTS

Effects of different salt levels in drinking water on body weight gain

Total gain in 28 days and average DBG in heifers drank slightly saline water increased significantly by 27.27% over heifers drank RNW. The gain in heifers drank RNW diluted with 6000 and 9000 ppm NaCl decreased significantly by 21.21 and 44.95, respectively, when compared with heifers RNW. The gain of heifers drank RNW diluted with 12000 and 15000 ppm NaCl decreased significantly by 73.74 and 74.24%, respectively, when compared with heifers drank RNW only. Drinking water containing moderately saline water has a negative effect on the growth of heifers, and the negative effect increases with increasing concentration of salts (highly saline water) [Table 2].

Effects of different salt levels in drinking water on water intake

TWI of heifers drank slightly saline water in

28 days increased significantly by 59.59% over to TWI of heifers drank RNW. TWI of heifers drank RNW diluted with 6000 and 9000 ppm NaCl increased significantly by 84.94 and 44.12%, respectively, when compared with the WI of heifers drank RNW. The TWI of heifers drank RNW diluted with 12000 and 15000 ppm NaCl decreased significantly by 16.44 and 24.9%, respectively, when compared with WI of heifers drank RNW only [Table 2].

Water intake in heifers was directly proportional to the salt concentration of their drinking water which indicates an intimate relationship between salt intake and water intake in slightly saline and moderately saline water. However, as the level of salts in the water increases in highly saline water, the TWI and daily water consumption decreases when compared with the WI of heifers drank RNW only Drinking water containing slightly, moderately and highly saline water was accompanied by progressively significant increases in water/gain ratio [Table 2].

Effects of different salt levels in drinking water on DMI

DMI increased significantly by 33.3% in heifers drank slightly saline water over DMI of heifers drank RNW. DMI of heifers drank RNW diluted with 6000 was not affected significantly when compared with the DMI of heifers drank RNW only. However, DMI of heifers drank RNW diluted with 9000 ppm NaCl decreased significantly by 11.81% when compared with the DMI of heifers drank RNW. DMI of heifers drank RNW diluted with 12000 and 15000 ppm NaCl decreased significantly by 33.33 and 54.67%, respectively, when compared with the DMI of heifers drank RNW only Drinking water containing moderately and highly saline water was accompanied by progressively significant increases in feed/gain ratio [Table 2].

Effects of different salt levels in drinking water on blood biochemical components

Immunity function

Drinking water containing different levels of salinity during hot summer season was not affected significantly on total protein, albumin, and globulin concentrations. The same trend was observed in total cholesterol and triglycerides concentrations in heifers drank water containinig 3000 and 6000 ppm NaCl. However, total cholesterol and triglycerides concentrations in heifers are changed by drinking saline water RNW with 9000, 12000, and 15000 ppm NaCl. These levels have a negative effect on lipid fractions which caused significant increases in total cholesterol and triglycerides concentrations when compared to these levels in heifers drank RNW [Table 3].

Table 2: Effect of different levels of salinity on total gain and daily body gain (DBG, g), TWI, L, and DMI, kg in heifers exposed to hot summer conditions

Parameters	Drinking water salinity level, ppm					
	RNW	Slightly saline	Moderately saline water		Highly saline water	
	300	3000	6000	9000	12000	15000
Initial LBW	150.0±0.6	150.1±0.5	150.0±0.4	151.0±0.5	150.4±0.5	150.6±0.5
Final LBW	169.8^{b}±1	175.3^{a}±1.1	165.6^{c}±1.3	161.9^{d}±0.9	155.6^{e}±0.5	155.7^{e}±0.8
Total gain, kg	19.8^{b}±2	25.2^{a}±1.4	15.6^{c}±0.8	10.9^{d}±0.6	5.2^{e}±0.2	5.1^{e}±0.2
DBG, g	707^{b}±23	900^{a}±35	557^{c}±26	389^{d}±21	186^{e}±15	182^{e}±16
Change %		(+27.27)*	(−21.21)*	(−44.95)**	(−73.74)**	(−74.24)**
TWI, L/28 day	746^{c}±22	119^{b}±35	1379^{a}±36	1075^{b}±32	623^{d}±18	560^{d}±16
DWI, L	26.6^{c}±1.5	42.5^{b}±1.6	49.3^{a}±1.8	38.4^{b}±1.3	22.3^{d}±0.9	20.0^{d}±0.5
Change %		(+59.59)**	(+84.9)**	(+44.12)**	(−16.44)*	(−24.90)*
Total DMI, kg/28 day	147^{b}±0.5	196^{a}±0.5	161^{b}±0.7	130^{c}±0.6	98^{d}±0.2	66.5^{e}±0.1
Daily DMI, kg	5.3^{b}±0.10	7.0^{a}±0.12	5.8^{b}±0.15	4.6^{c}±.15	3.5^{d}±0.10	2.38^{e}±0.05
Change %		(+33.33)**	(+9.52) ^{NS}	(−11.81)*	(−33.33)**	(−54.67)**
Feed/ gain ratio (FC)	7.42	7.77	10.32	11.93	18.85	13.04
Change %		+4.72^{NS}	+39.08**	+60.78**	+154.04**	+75.74**
Water intake/gain ratio	37.68	47.22	88.51	98.71	119.89	109.89
Change %		+25.32**	+134.90**	+161.97**	+218.18**	+191.64**

Change % due to salinity= (saline water value - tab water value) ×100/tab water value. $^{a, b}$Means within raw in each item with different superscript are significantly differ. **Significant at P< 0.01 and ***significant at P< 0.001. DBG: Daily body weight gain, TWI: Total water intake, DMI: Dry matter intake, LBW: Live body weight

Table 3: Effect of different levels of salinity on physiological body functions in heifers exposed to hot summer conditions

Physiological functions	Drinking water salinity level, ppm					
	RNW	Slightly saline	Moderately saline water		Highly saline water	
	300	3000	6000	9000	12000	15000
Immunity function						
Total protein, g/dl	7.15±0.24	7.20±0.19	7.10±0.14	7.30±0.04	7.27±0.02	7.07±0.15
Albumin, g/dl	3.87±0.04	3.96±0.09	3.93±0.16	4.00±0.15	4.10±0.08	3.94±0.02
Globulin, g/dl	3.28±0.02	3.24±0.04	3.17±0.01	3.30±0.05	3.17±0.04	3.13±0.02
Cholesterol, mg/dl	96.3^b±2.1	99.33^b±3.1	99.67^b±2.8	129.53^a±2.1	129.66^a±4.1	130.67^a±2.0
Triglycerides, mg/dl	79.0^b±3.3	82.67^b±2.9	86.00^b±2.9	115.00^a±2.3	117.33^a±5.1	119.00^a±3.3
Kidney function						
Urea, mg/dl	40.0^d±2	42.1^d±2	58.0^c±3	68.0^b±5	80.0^a±3	81.33^a±3
Urea change %		+5.18^{NS}	+45.00**	+70.00**	+100.00***	+103.33***
Ceatinine, mg/dl	1.08^d±0.1	1.10^d±0.02	1.43^c±0.08	1.47^c±0.02	1.80^b±0.04	2.07^a±0.06
Creatinine change %		+1.85^{NS}	+32.41**	+36.11**	+66.67***	+91.67***
Liver function						
ALT, IU/L	14^b±0.4	15.7^b±0.9	14.3^b±0.8	25.3^a±1.0	26.3^a±0.9	28.7^a±0.6
AST, IU/L	17.0^b±2	17.0^b±2.9	18.0^b±1.9	27.7^a±1.6	29.0^a±1.0	31.3^a±1.6
Glucose levels						
Glucose, mg/dl	100^c±3.7	104^c±2.8	136^b±4.5	139^b±6.1	167.5^a±8.7	174.7^a±4.5
Glucose change %		+4.00^{NS}	+36.30**	+39.00**	+67.50***	+74.67***

Change % due to salinity = (Saline water value - tab water value) ×100/tab water valuea, ^{b}means within raw in each item with different superscript are significantly differ. **Significant at $P < 0.01$ and ***significant at $P < 0.001$

Kidney function

Urea-N and creatinine concentrations were not affected significantly in heifers due to drinking water containining 3000 ppm NaCl. However, heifers drinking water containing high levels of salt at the rate of 6000, 9000, 12000, and 15000 ppm NaCl was accompanied by progressively significant increases in urea-N and creatinine concentrations [Table 3].

Liver function

No significant difference was found in liver enzymes activities of heifers that drank water containing 3000, and 6000 ppm NaCl as compared to heifers that drank River Nile water.. Liver enzyme activities increased significantly by drinking saline water containing 9000, 12000, and 15000 ppm which indicate a negative effect on liver function [Table 3].

Glucose level

Glucose concentration was not affected significantly in heifers drank water containing 3000 ppm NaCl. However, drinking water containing high levels of salt at the rate of 6000, 9000, 12000, and 15000 ppm NaCl was accompanied by progressively significant increases in glucose concentration [Table 3].

Effects of different salt levels in drinking water on hormonal levels

Levels of salinity in drinking water 6000 ppm NaCl do not have any side effect on thyroid hormones (T4 and T3), aldosterone, and 17β-estradiol hormonal levels. However, drinking water containing salinity at a rate of 9000, 12000, and 15000 ppm NaCl was accompanied by progressively significant decrease in T4, T3, and 17β-estradiol levels and significant increase in aldosterone level [Table 4]. Cortisol hormone level seems to be more sensitivity to salinity in drinking water by heifers than other hormones. Cortisol level starts to increase in heifers drank 6000 pm NaCl and progressively significant increase in heifers drinking water containing salinity at a rate of 9000, 12000, and 15000 ppm NaCl [Table 4]. These hormones directly influence neuronal organization in the brain through the activation of the neuropeptide angiotensin II which is a powerful stimulus for thirst and sodium appetite and immediate increase in water intake followed by a slower increase in sodium intake.[14] Aldosterone is the main hormone that controls sodium balance by changing the kidney's reabsorption of sodium and thus the amount excreted in the urine.[2] Levels of salinity in drinking water 6000 ppm NaCl were not affected significantly on aldosterone hormonal level during hot summer season.

Table 4: Effect of different levels of salinity on glands function in heifers exposed to hot summer conditions

Gland functions	Drinking water salinity level, ppm					
	RNW	Slightly saline	Moderately saline water		Highly saline water	
	300	3000	6000	9000	12000	15000
Thyroid gland function						
T_4, nmol/l	100.40^a±2.3	97.60^a±2.4	96.80^a±1.2	65.70^b±3.8	64.10^b±2.1	67.70^b±2.1
T_4 change %		−2.79^{NS}	−3.59^{NS}	−34.56**	−36.16**	−32.57**
T_3, nmol/l	4.15^a±0.2	4.10^a±0.1	3.99^a±0.1	2.88^b±0.1	2.67^b±0.1	2.57^b±0.1
T_3 change %		−1.20^{NS}	−3.86^{NS}	−30.60**	−35.66**	−38.07**
Adrenal gland function						
Aldosterone, ng/ml	7.8^d±0.14	8.0^d±0.24	8.2^d ± 0.22	10.5^c±0.22	12.5^b±0.29	14.8^a±0.30
Aldosterone change %		+2.56^{NS}	+5.13^{NS}	+34.62**	60.26**	+89.74**
Cortisol, (ng/dl)	12.1^d±0.7	12.3^d±0.6	16.4^c±0.4	20.6^b±0.5	24.0^a±0.7	24.6^a±0.8
Cortisol change %		+1.65^{NS}	+35.54**	+70.25**	+89.35**	+103.31**
Ovary function						
17β−estradiol, pmol/l	206.17^a±5.8	198.00^a±3.1	199.89^a±4.3	158.54^b±3.3	145.55^{bc}±4.3	139.67^c±2.9
17β-estradiol change %		−3.96^{NS}	−3.05^{NS}	−23.10**	−29.40**	−32.25**

Change % due to salinity= (Saline water value - tab water value) ×100/tab water value. $^{a, b}$Means within raw in each item with different superscript are significantly differ. NS: Not significant and **significant at $P < 0.01$

DISCUSSION

Effects of different salt levels in drinking water on body weight gain

The reductions in body weight gain in heifers may be due to the negative effect of high level of salts in drinking water on appetite which decreases food consumption as well as reduction in food efficiency and efficiency of utilization of organic matter. Drinking water containing high levels of salts resulted in depression in digestibility and utilization of the different nutrients may contribute to the decrease of growth performance.[15] In addition, salt additions in drinking water can change the rumen fermentation pattern and also reduced rumen digestion and concentration of protozoa, selenomonas, and total microbial population.[1] Physiologically, the deterioration of growth performance of heifers drinking water high in saline may be mediated through a resultant increase in the osmotic pressure of body fluids which accompanied by a decrease in thyroid hormone concentration and reduce the hepatic synthesis of RNA which reduces the incorporation of amino acids into protein.[2]

Effects of different salt levels in drinking water on water intake

The high consumption of water in heifers is expected to assist the elimination of excess salt during slightly and moderately saline water.The high consumption of water containing excess of Na causes an increase in feeling of thirst that leads to heifers drinking more water. The extra amount of water consumed by animal during the warmer months of the year was needed to replenish the increasing evaporative water losses associated with the dissipation of heat during these months.[2] The decrease of water consumption in heifers drinking water containing highly saline water may be due to that animals became suffered from acute salinity.

Effects of different salt levels in drinking water on DMI

These results indicated that DMI of heifers drank slightly saline water was useful for animal feeding and DMI improved significantly compared with DMI of heifers drank RNW. However, heifers drank RNW diluted with 9000, 12000, and 15000 ppm NaCl have a negative effect on DMI which decreased progressively when compared to DMI of heifers drank RNW. Decrease in feed consumption of heifers may be due to that excessive chloride levels in drinking water of heifers increase the osmotic pressure in the rumen, and this causes a decrease in total microbial population in the rumen, metabolic activity, digestion of organic matter and protein, and reducing an animal's food intake in ruminants.[16] The increase in consumption of salts caused a depression in digestibility coefficients and in the utilization of nutrients and decreasing nitrogen retention.[17]

Effects of different salt levels in drinking water on blood biochemical components

The increase in water intake containing high levels of NaCl causes an apparent increase in the blood electrolyte concentrations and consequently may result in stressing kidney function to excrete the excess of salts, urea-N, and creatinine from blood through urine. These results indicated that heifers drank water containing 9000, 12000, and 15000 ppm NaCl have a negative effect on kidney function and may be suffering from kidneys failure.[1] Kidney function is limited by the osmotic ceiling, and the volume capacity which determines the volume of water that could be saved with solute and the amount of salt which an animal can tolerate is related primarily to its ability to maintain the osmolarity, distribution, and volume of body fluids by means of homeostatic mechanisms.[18] Heifers drank water containing moderately and high levels of salinity may be exposed to salinity stress which increased cortisol hormone and consequently increased the gluconeogenesis process in liver, resulting the increase in liver enzymes activities.[17] It seems that these levels of salinity in drinking water caused side effect on glucose metabolism as indicated by increasing glucose level to 36.30 and 39.00% in heifers drank moderately saline water at the rate of 6000 and 9000 ppm NaCl and more in heifers drank highly saline water at the rate of 12000 and 15000 ppm NaCl to reach 67.50 and 74.67%, respectively, when compared to glucose level in heifers drank RNW. Heifers drank water containing moderately and high levels of salinity may be exposed to salinity stress which increased cortisol hormone and consequently increased the process in liver, resulting the increase in glucose level.[1]

Effects of different salt levels in drinking water on hormonal levels

Excess intake of Na has been found to be accompanied by a reduction in serum thyroid hormones (T4 and T3) levels in rabbits with a greater decline in T_4 than in T_3.[15] Cortisol secretion from the adrenal gland through increase in ACTH secretion by the anterior pituitary gland often increases greatly in stressful situations.[2] Animals respond to stress by releasing ACTH from the anterior pituitary gland which causes the adrenal cortex to release aldosterone and corticosterone. Therefore, these hormones increased in heifers drinking highly saline water [Table 4]. These results may be due to that heat stress increases the sodium requirement above in a thermal neutral environment.[19] Not only does the sodium requirement, as a percentage of the diet, increase due to sweating and decreased feed intake but prolonged heat stress also reduces blood aldosterone concentration, resulting an increased loss of sodium in the urine. In non-lactating Holstein cows, aldosterone concentration had decreased over 40% during heat stress compared with thermal neutral environment.[20]

Pathological effects

It notices that heifers drank highly saline water seemed to be suffering from dysfunction in most of physiological body function and animals become emaciated, lethargic, and weak. Occasional diarrhea and severe anorexia are also noticed. Some symptoms include appear unwell, lack of appetite and reluctant to drink, increased urination initially followed by small amounts of concentrated urine, nasal discharge, lying down, and nervous signs. Therefore, used highly saline water in drinking animals should be avoided for growing heifers.

It can be concluded that drinking highly saline water could not tolerate by heifers subjected to heat stress conditions as indicated by negative effects on growth and blood constituents. We recommended that the highest permitted concentrations of salt should be 0.6% for growing heifers under heat stress conditions. Such concentrations of highly saline water could be maintained in salty waters either by dilution with fresh water, if it is available, or by elimination of salts from the drinking water.

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REFERENCES

1. Marai IF, Habeeb AA. Effects of Salinity of Drinking Water on Farm Animals. In: Dewi IA, Axford RF, Marai IF, Omed H. Pollution in Livestock Production

Systems. Wallingford, UK: Commonwealth Agricultural Perau International; 1994. p. 119-35.
2. Habeeb AA, Marai IF, Kamal TH. Heat Stress. In: Philips C, Piggins D, editors. Farm Animals and the Environment. Ch. 2. United Kingdom: Commonwealth Agriculture Bureau International; 1992. p. 27-47.
3. Department of Health Education and Welfare, USA 1962. Drinking Water Standards Review. Washington, DC: PHS Publication No. 956. US Government Printing Office.
4. Pfost DL, Fulhage CD. Water Quality for Livestock Drinking. University of Missouri Extension, Agricultural Engineering Extension, EQ381; 2001.
5. Sanchez WK, McGuire MA, Beede DK. Macromineral nutrition by heat stress interactions in dairy cattle: Review and original research. J Dairy Sci 1994;77:2051-79.
6. Solomon R, Miron J, Ben-Ghedalia D. Performance of high producing dairy cows offered drinking water of high and low salinity in the Arava desert. J Dairy Sci 1995;78:620-4.
7. National Research Council. Nutrient Requirements of Dairy Cattle. 7th Rev. ed. Washington, D.C: National Academy of Sciences Press; 2001.
8. Anati DA. The salinity of hypersaline brines: Concepts and misconceptions. Int J Salt Lake Res 1999;8:55-70.
9. U.S. Environmental Protection Agency. Drinking Water Treatment. Washington, DC, U.S. EPA, Office of Water 2004. Available from: http://water.epa.gov/lawsregs/guidance/sdwa/upload/2009_08_28_sdwa_fs_30ann_treatment_web.pdf.
10. AOAC. Association of Official Analysis Chemists, Official Methods of Analysis. 5th ed. Washington, DC, USA: AOAC; 1990.
11. Kendall PE, Webster JR. Season and physiological status affects the circadian body temperature rhythm of dairy cows. Livest Sci 2009;125L:155-60.
12. SAS. Statistical Analysis System. SAS/STAT Procedures Guide for Personal Computer. Version 8th ed. Cary, NC, U.S.A: SAS Institute Inc.; 2004.
13. Duncan DB. Multiple range and multiple F-test. Biometrics 1955;11:1-42.
14. Fitzsimons JT. Angiotensin, thirst, and sodium appetite. Physiol Rev 1998;78:583.
15. Marai IF, Habeeb AA, Gad AE. Tolerance of imported rabbits grown as meat animals to hot climate and saline drinking water in the subtropical environment of Egypt part 1. Anim Sci (Britain) 2005;81:115-24.
16. Curran G. Water for Livestock: Interpreting Water Quality Tests. Prime fact 533, second edition, NSW Government, Department of Primary Industries, 2014. Available from: http://www.dpi.nsw.gov.au.
17. Marai IF, Habeeb AA, Kamal TH. Response of livestock to excess sodium intake. Ch. 11. In: Phillips CJ, Chiy PC. Sodium In Agriculture. Ch. 11. Kent, UK: Chalcombe Publications; 1995. p. 173-80.
18. Assad F, El-Sherif MM. Effect of drinking saline water and feed shortage on adaptive responses of sheep and camels. Small Rumin Res 2002;45:279-90.
19. Schneider PL, Beede DK, Wilcox CJ. Responses of lactating cows to dietary sodium source and quantity and potassium quantity during heat stress. J Dairy Sci 1986;69:99.
20. El-Nouty FD, Elbanna IM, Davis TP, Johnson HD. Aldosterone and ADH response to heat and dehydration in cattle. J Appl Physiol Respir Environ Exercise Physiol 1980;48:249.