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RESPONSE OF CAMELS, SHEEP AND GOATS TO SALINE WATER 1. FEED INTAKE, NUTRIENT UTILIZATION AND BASIC PATTERNS OF RUMEN FERMENTATION

E.R.M. Abou Hussien, E.A. Gihad, T.M. El-Bedawy and M.H. Abdel Gawad

Department of Animal Production, Faculty of Agriculture, University of Cairo, Giza, Egypt

SUMMARY

Three drinking water salinity levels of 256 (tap water), 9472 (low salinity) and 16896 (high salinity) ppm sodium chloride were used to investigate the effect of salt stress on the nutrient utilization and rumen fermentation of camels, sheep and goats.

Three of each of sheep and goats were exposed to the three levels of salinity in 3x3 Latin square while two camels were offered tap and high salinity water in 2x2 Latin square. Berseem hay and drinking water were free choice offered.

Drinking high salinity water resulted in significant decrease in feed intake, nutrient digestibilities and nitrogen balance by sheep and goats but not by camels.

Increasing water salinity levels had no significant effect on ruminal pH, total or molar percentages of VFA's but significantly decreased ruminal ammonia-N concentrations by sheep and goats. Camels showed more tolerance to high salinity drinking water than sheep and goats in nutrient intake, digestibility, nitrogen balance and basic pattern of rumen fermentation.

Keywords: Camel, sheep, goats, water salinity, nutrient utilization, rumen fermentation

INTRODUCTION

Water availability and salinity is one of the determined factors for successful animal production in the desert since the problem of water scarcity is often complicated by the high water salinity. Animals species may differ in their tolerance to water salinity (Schmidt-Neilsen 1964). Camels were reported as better adapted animals to arid zones (Farid et al., 1979). However, Abou El-Nasr et al. (1988) concluded that salt tolerance of camels may be somewhat, higher but not much different to sheep.

The objective of the study was to compare the tolerance of camels, sheep and goats under the same experimental conditions to the increase in drinking water salinity from viewpoint of intake, digestibility, nitrogen metabolism and rumen fermentation.

MATERIALS AND METHODS

Three mature Rahmany rams of 55.3 Kg body weight and three Zaraibi bucks of 38.2 Kg body weight were arranged in two 3x3 Latin squares. Three levels of drinking water salinity were tested with sheep and goats, tap water (TW) of 256 ppm total soluble salts (TSS), low salinity (LS) of 9472 ppm TSS and high salinity (HS) of 16896 ppm TSS. However, two levels of drinking water salinity (TW and HS) were tested with two mature female camels of 450 Kg body weight in a 2x2 Latin squares. The experimental design is illustrated in Fig. 1.

Sheep

T	L	H
H	T	L
L	H	T

Goats

T	L	H
H	T	L
L	H	T

Gamels

T	H
H	T

T: Tap water (256 ppm TSS)
L: Low saline water (9472 ppp TSS)
H: High saline water (16896 ppm TSS)

Fig. 1. Experimental design.

Saline water was freshly prepared every two days considering the designed concentrations by dissolving crude salt (Rashidi salt) in tap water at level of 0.75 % for LS and 1.5% for HS. Physical and chemical properties of drinking water is presented in Table 1. Animals were watered one hour post feeding twice a day and free choice water consumption was daily recorded.

Animals were fed ad. libitum berseem hay composed of 90.61 % Dry matter, 87.31% Organic matter, 14.62% crude protein, 38.46 crude fiber and 32.23% nitrogen free extract. Daily voluntary feed intake was determined by weighing dry feed residues.

Table 1. Analysis of drinking water

Item	Tap water (TW)	Low salinity (LS)	High salinity (HS)
EC, mOsm/ml	0.40	14.80	26.40
TSS,ppm	256	9472	16896
Na, ppm	160	2479	5599
K, ppm	37	115	125
Cl, ppm	49	5680	9372

EC electric conductivity; TSS total soluble salts

Sheep and goats were individually housed in metabolic cages for 30 days for each metabolism trial, 21 days preliminary and 7 day- collection periods. However, camels were housed in individual pens. Feces and urine from sheep and goats were collected by the ordinary methods while feces was collected through a long harness fitted to the back of camels. Urine was collected through plastic tube surgically inserted in the vulva of she camels. The detailed procedure is illustrated by El-Banna (1993).

Rumen fluid samples before and 4 hrs post feeding were collected for two consecutive days at the end of each metabolism trial using stomach tube attached to electric suction pump from all animals. Rumen fluid pH was immediately measured using pH-meter then samples were strained on two layers of cheese clothes. Ruminal ammonia nitrogen (Conway, 1963), Total VFA's concentration (Kromann et al., 1967) and molar proportions of acetate, propionate, butyrate (Erwin et al., 1961) were determined.

Chemical composition of feed, feces, nitrogen in urine and minerals in drinking water was determined according to the A.O.A.C. (1984) methods.

Data collected were statistically analyzed using the general linear models procedures of SAS (1990). Duncan's multiple range test was used to separate means using 5% probability.

RESULTS AND DISCUSSION

Intake

Drinking LS (9472 ppm) had not affected dry matter or nutrient intake. However, drinking HS water (16896 ppm) resulted in lower ($P<0.05$) intakes (Table 2). Wilson and Dudzinski (1973) found that the increasing sodium chloride of drinking water up to 1.5 or 2% decreased voluntary feed intake by sheep. However, Sooud et al., (1993) and Kandil et al., (1985) found that feed intake increased as the salinity of drinking water increased within the tolerance levels. They suggested total salinity from 10,000 to 13,000 ppm to be the tolerance level for drinking water by sheep or camels.

Table 2. Mean effects of water salinity and animal species on dry matter and nutrient intakes ($g/KgW^{0.75}$)

Item	Water salinity			SE	Animal species			SE
	TW	LS	HS		Camels	Sheep	Goats	
DM	58.8a	59.7a	46.0b	4.0	42.8b	56.0a	62.2a	3.5
TDN	30.0a	28.9a	22.3b	1.8	25.8	25.4	29.1	2.1
SV	16.4a	15.1a	11.7b	1.2	15.9	12.5	14.7	1.3
DCP	5.0a	4.8a	3.7b	0.3	4.2	4.2	5.0	0.4

Camels consumed DM less ($P<0.05$) than sheep and goats. Goats achieved the greatest DM voluntary intake. However, no significant differences in nutrient (TDN, SV and DCP) intakes were found among the three species (Table 2) because camels were superior in nutrient utilization (Table 4). Therefore, camels may achieve a comparable nutrient intake even though their lower DM intake in comparison with sheep or goats. This result agreed with those reported by Gihad et al. (1994) that camels in comparison with sheep or goats may achieve similar TDN and DCP intake from lower DM intake.

Camels received HS water showed almost similar dry matter and nutrient intake to that by drinking tap water. However the rate of decrease in dry matter and nutrient intake due to the increase in salinity level by sheep was greater than that by goats especially when HS water was offered (Table 3). This might indicate that with the increase in drinking water salinity, camels can maintain their intakes while sheep or goats can not and goats were more tolerant than sheep to the increase in water salinity.

Table 3. Response of camels, sheep and goats to drinking water salinity in dry matter and nutrient intakes (g/Kg $W^{0.75}$)

Item	Camels		Sheep			Goats			SE
	TW	HS	TW	LS	HS	TW	LS	HS	
DM	43.1c	42.5c	69.2a	57.6ab	41.1c	69.4a	61.8ab	55.4b	4.1
TDN	26.0b	25.6b	31.4ab	28.3ab	16.5c	34.0a	29.9ab	23.7b	2.4
SV	16.0a	15.7ab	15.4ab	15.0ab	7.0c	17.9a	15.3ab	10.9bc	1.5
DCP	4.2bc	4.2bc	5.4ab	4.5bc	2.7d	5.8a	5.1ab	4.2c	0.4

Digestibility

Increasing salinity level of drinking water resulted in insignificant lower nutrient digestibilities and nutritive value of the ration except for EE digestibility which significantly decreased when animals drank HS water (Table 4). The lower EE digestibility by increasing salinity level might be related to the formation of low digested insoluble soap from the insoluble salts of saline water with the dietary fat of low fat digestibility. El-Faramawi (1984) found no effect of drinking saline water on nutrient digestibility by sheep and Reffett and Boling (1985) found that increasing NaCl intake by lambs had not affected DM or CP digestibilities. Kandil et al. (1985) reported no significant reduction in nutrient digestibility by camels offered 1% NaCl in drinking water but a significant decrease when 1.5 or 2% NaCl was added to drinking water. Moreover, Squires (1973) found a slight adverse effect of drinking saline water on nutrient digestibilities by sheep. However, Sooud et al. (1993) reported that drinking saline water (10256 ppm) enhanced nutrient digestibilities by camels.

Table 4. Mean effects of water salinity and animal species on nutrient digestibilities and nutritive value, %

Item	Water salinity			SE	Animal species			SE
	TW	LS	HS		Camels	Sheep	Goats	
Digestibility,%								
DM	58.3	53.0	54.7	3.0	67.2a	49.1b	52.0b	1.1
OM	58.5	53.2	54.6	3.0	67.3a	49.5b	51.8b	1.2
CP	59.9	54.7	55.5	2.8	66.9a	50.6c	54.7b	1.4
CF	55.5	49.1	49.8	3.1	62.6a	45.4b	48.6b	1.7
EE	58.7a	53.8ab	46.9b	3.5	61.6a	48.9b	49.6b	3.3
NFE	61.8	55.7	59.8	3.4	77.0a	53.3b	54.1b	1.2
Nutritive value,%								
SV	29.3	25.2	25.7	2.7	37.0a	21.7b	23.3b	1.1
TDN	52.5	48.3	48.8	2.7	60.3a	44.8b	46.5b	1.2
DCP	8.8	8.0	8.1	0.4	9.8a	7.4c	8.0b	0.2

Camels digested all the nutrients better than sheep and goats. Sheep showed comparable digestibilities to those found for goats. However, higher ($P<0.05$) CP digestibility by goats than sheep was detected (Table 4). This result might be confirmed by the findings of Gihad et al. (1994). The higher digestibility by camels might be due to their longer retention time (Heller 1986), higher bacterial count (Ghosal (1981), the enhanced maceration and feed mixing (Vallenas and Stevens (1971).

Drinking saline water was associated with lower digestibilities and nutritive value of the ration specially with the high salinity level (TSS= 16896 ppm) by sheep and goats but not with camels. Camels showed no significant differences in nutrient digestibilities or nutritive value of the same ration by drinking TW (TSS = 256 ppm) or HS (16896 ppm TSS). Sheep and goats drinking LS water (TSS= 9472 ppm) showed almost similar nutrient digestibility and nutritive values but goats showed higher ($P<0.05$) DM and CP digestibilities at the high salinity level of 16896 ppm. (Table 5). These results might indicate that camels were more tolerant to high drinking water salinity than goats than sheep. No comparative studies with the three species under the same experimental conditions were available. In an inter- study comparison, the salinity level tolerance by camels was reported to lie between 1.0 and 1.5 percent NaCl which is similar to that by sheep as 13000 ppm.

(Kandil et al., 1985). Our results indicated that camels tolerated salinity up 16896 ppm but sheep or goats did not in regard to nutrient digestibility and nutritive value of the same ration.

Table 5. Response of camels, sheep and goats to drinking water salinity in nutrient digestibilities, %

Item	Camels		Sheep			Goats			SE
	TW	HS	TW	LS	HS	TW	LS	HS	
Digestibility,%									
DM	67.2a	67.3a	50.6bc	53.3b	44.7d	54.6b	53.1b	47.7c	1.2
OM	67.4a	67.3a	50.5cd	53.3bc	44.7e	54.6b	53.1bc	47.7de	1.3
CP	66.7a	67.1a	53.5bc	53.0bc	45.3d	57.3b	56.4b	50.4c	1.7
CF	63.5a	61.8a	47.5bc	48.7b	40.1c	52.9bc	49.5b	43.5c	2.4
EE	62.7a	60.6a	53.4a	56.6a	36.9b	58.8a	51.0a	38.9b	4.0
NFE	72.1a	74.0a	55.3b	55.7b	48.7c	54.7b	55.6b	51.9c	1.8
Nutritive value,%									
SV	37.1a	36.9a	22.3bc	25.8b	17.0d	25.8b	24.5b	19.6cd	1.2
TDN	60.4a	60.1a	45.4cd	48.9c	40.0e	49.1c	47.6c	42.6de	1.2
DCP	9.8a	9.8a	7.8bc	7.8bc	6.6d	8.4b	8.2b	7.4c	0.3

Nitrogen metabolism

Increasing salinity level had no significant effect on nitrogen intake or losses in feces or urine. However, nitrogen balance and protein biological value decreased ($P<0.05$) by drinking HS water (16896 ppm). Animals offered LS water (9472 ppm) showed comparable values as those offered tap water (Table 6). Kandil et al. (1985) found similar results in nitrogen metabolism by camels received tap water or water contained 1.0, 1.5 and 2.0% percent sodium chloride.

Camels showed lower nitrogen intake and losses in feces or urine and consequently higher retained nitrogen. The biological value of dietary protein calculated as a percentage of retained nitrogen from the digested nitrogen was higher by camels than sheep and goats. Meanwhile, goats consumed and lost more nitrogen than sheep but showed comparable nitrogen retention to that by sheep (Table 6). These results agreed with those found by Gihad et al. (1994) indicating the higher nitrogen utilization by camels than sheep or goats.

Table 6. Mean effects of water salinity and animal species on nitrogen metabolism (g/Kg $W^{0.75}$)

Item	Water salinity			SE	Animal species			SE
	TW	LS	HS		Camels	Sheep	Goats	
Nitrogen:								
Intake	1.34	1.38	1.11	0.09	0.98c	1.31b	1.47a	0.07
Fecal	0.54	0.62	0.50	0.06	0.32b	0.33b	0.66a	0.07
Urinary	0.59	0.67	0.65	0.04	0.53c	0.63b	0.74a	0.00
T loss	1.13	1.29	1.15	0.09	0.85c	1.26b	1.40a	0.09
Balance	0.21a	0.09a	-0.04b	0.04	0.13	0.05	0.07	0.05
BV	25.37a	11.64a	-8.74b	5.87	21.14a	1.76b	5.68b	7.30

Biological value (BV) = (retained N/ Digested N)*100

Animal species responses to salinity level of drinking water were shown in Table 7. Camels showed no significant changes in nitrogen intake, loss, retention and biological value of dietary protein by drinking HS water. Nevertheless, urinary nitrogen slightly increased by 14.3% and retained nitrogen decreased from 0.17 to 0.11 g/Kg$W^{0.75}$. Sheep showed lower nitrogen intake by drinking LS or HS water but goats received LS showed comparable nitrogen intake as that observed by drinking tap water. Fecal nitrogen was not affected significantly by salinity levels by both sheep and goats. Sheep received HS water lost more nitrogen in urine than that by drinking tap or LS water while urinary nitrogen loss by goats was unaffected by water salinity. The decrease in retained nitrogen or the biological value of dietary protein by increasing water salinity was more drastic by sheep than that by goats.

Table 7. Response of camels, sheep and goats to drinking water salinity in nitrogen metabolism (g/Kg$W^{0.75}$)

Item	camels		Sheep			Goats			SE
	TW	HS	TW	LS	HS	TW	LS	HS	
NI	0.97c	0.99c	1.58a	1.20bc	1.14bc	1.59a	1.53a	1.25b	0.08
FN	0.31c	0.32c	0.71a	0.57b	0.63ab	0.68a	0.68a	0.62ab	0.09
UN	0.49d	0.56cd	0.59bcd	0.58cd	0.70abc	0.73ab	0.76a	0.73ab	0.05
TNL	0.80c	0.88c	1.30ab	1.15b	1.33ab	1.41a	1.44a	1.35ab	0.07
NB	0.17ab	0.11b	0.28a	0.06b	-0.18c	0.18ab	0.10b	-0.10c	0.04
BV	25.39ab	6.90abc	31.07a	9.76c	-35.55e	19.64abc	13.51bc	-16.10d	4.77

NI nitrogen intake; FN fecal nitrogen; UN urinary nitrogen; TNL total nitrogen loss; NB nitrogen balance
Biological value (BV) = (retained N/ Digested N)*100

Basic pattern of rumen fermentation

Increasing water salinity had no significant effect on basic pattern of rumen fermentation except ruminal ammonia nitrogen which decreased (P0.05) from about 21.28 mg/100 ml for tap water and 20.78 for LS water to 16.63 mg/100 ml for HS water (Table 8). Chalupa et al. (1981) found that NaCl (300 g/day, 4.4 % diet) increased rumen turnover rate but decreased ruminal pH and ammonia N and total VFA's concentrations whereas the molar percentages of VFA were not changed.

Camels showed higher ($P<0.05$) ruminal pH and ammonia-N than sheep or goats (Table 8). Ghosal et al. (1981) suggested that the alkali secretions of glandular compartments in the rumen wall of camels might be the reason of high ruminal pH than sheep or goats. The higher ruminal ammonia-N by camels than sheep or goats was attributed to that the mechanism by which camels are known to be very efficient at conserving body nitrogen by limiting urea excretion would result in higher rumen nitrogen and more active fermentation than would otherwise be possible (Williams,1963). The three species showed comparable values of basic pattern of rumen fermentation. Williams (1963) also found that the proportions of volatile fatty acids by camels were similar to those produced in the rumen of sheep or cattle.

Table 8. Mean effects of water salinity and animal species on basic pattern of rumen fermentation

Item	Water salinity			SE	Animal species			SE
	TW	LS	HS		Camels	Sheep	Goats	
pH	6.81	6.81	6.55	0.12	7.21a	6.60b	6.50b	0.09
VFA	31.93	35.49	31.64	2.28	34.26	30.76	35.00	2.28
NH3-N	21.28a	20.78a	16.63b	1.25	24.09a	18.76b	17.88b	1.15
Molar proportion of VFA								
Acetate	56.85	60.71	59.04	1.85	59.38	58.41	58.88	1.90
Prop.	25.18	24.93	27.92	1.30	24.20	26.96	25.65	1.30
Butyrate	12.84	8.84	9.23	2.40	7.93	12.98	10.21	2.39
Others	5.13	5.52	3.81	3.03	8.49	1.66	5.26	2.96
AP	2.27	2.61	2.15	0.14	2.47	2.32	2.46	0.14

Prop. propionate; AP acetic:propionic ratio

The response of animal species to water salinity was only significant in ammonia-N concentrations. Ammonia-N had not changed before feeding or increased after feeding by camels consumed HS water. However, increasing water salinity was associated with a decrease in ammonia-N by sheep or goats either before or 4 hr after feeding. No significant differences in the response of the three animal species to water salinity was found for the other rumen parameters indicating the comparable response of camels, sheep and goats to drinking water salinity in basic pattern of rumen fermentation (Table 9).

Table 9. Response of camels, sheep and goats to drinking water salinity in basic pattern of rumen fermentation

Sampling time (hr)	Camels		Sheep			Goats			SE
	TW	HS	TW	LS	HS	TW	LS	HS	
					pH				
0	7.36	7.48	6.76	6.95	6.79	6.69	6.79	6.93	0.20
4	7.08	6.94	6.49	6.39	6.23	6.19	6.15	6.24	0.27
				VFA's (meq./l)					
0	31.1	28.5	39.8	34.1	48.3	41.2	33.0	36.5	3.4
4	35.4	42.1	51.0	43.8	28.8	43.7	49.4	38.3	5.4
				Ammonia-N (mg/100 ml)					
0	18.1	18.7	20.3	17.7	15.4	20.9	16.9	15.7	1.6
4	27.2	32.3	22.0	19.2	17.9	18.3	16.9	18.9	2.1
				Acetate,%					
0	53.9	58.8	45.4	52.7	58.9	53.6	46.9	52.3	4.9
4	61.0	63.8	43.9	66.1	62.1	61.5	62.8	62.9	1.3
				Propionate,%					
0	25.4	25.6	27.6	34.0	26.6	27.9	17.8	30.9	3.7
4	23.5	23.3	24.3	26.1	26.4	26.1	23.8	27.3	1.4
				Butyrate,%					
0	8.2	7.8	9.6	8.6	7.9	13.9	10.3	8.5	3.0
4	8.4	7.3	9.2	7.5	8.7	8.5	11.8	8.2	2.7
				Acetate:propionate ratio					
0	2.12	2.41	1.85	1.73	2.23	1.96	3.64	1.73	0.28
4	2.60	2.75	2.69	2.55	2.36	2.36	2.77	2.31	0.18

It could be concluded that camels are more tolerant to high salinity of drinking water up to 16896 ppm total soluble salt (TSS) but sheep and goats were not. However, goats showed somewhat more tolerance than sheep to such high level of salinity. The tolerance level of drinking water salinity might exceed 16896 ppm by camels and 9472 ppm by sheep. However, it lies between 9472 and 16896 ppm TSS by goats in viewpoint of intake, digestibility, nitrogen balance and basic pattern of rumen fermentation.

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إستجابة الإبل والأغنام والماعز لماء الشرب المالح.١- كمية المأكول، الإستفادة الغذائية والمقاييس الأساسية لتخمرات الكرش.

السيد رفعت أبوحسين - السيد أحمد جهاد - طه محمد البداوى - محمد حسن عبد الجواد

قسم الإنتاج الحيوانى، كلية الزراعة، جامعة القاهرة، الجيزة، مصر

حضر ماء الشرب بحيث يحتوى على ثلاثة مستويات من الملوحة هى ملوحة ماء الصنبورروملوحة متوسطة ٠,٧٥٪ ملح خام وملوحة عالية ١,٥٪ ملح خام وقدرت تركيزات ملوحة ماء الشرب كجزء فى المليون من الأملاح الذائبة الكلية فكانت منخفضة (٢٥٦ جزء فىالمليون) ومتوسطه (٩٤٧٢جزء فىالمليون) و عالية (١٦٨٩٦جزء فىالمليون) . درس تأثير هذه المستويات من الملوحة على الإستفادة من الغذاء ومقاييس تخمرات الكرش فى الإبل و الأغنام و الماعز فى مربع لاتينى ناقص بأستخدام ثلاثة كباش وثلاثة جداء عرضت لمستويات الملوحة الثلاثة و ناقتين عرضت للمستوى المنخفض و العالى فقط. غذيت الحيوانات للشبع على دريس البرسيم فقط وكان ماء الشرب متاحا كل الوقت.

أظهرت النتائج أن شرب الماء ذو مستوى الملوحة العالى أدى الى إنخفاض معنوى فى كمية المأكول ومعاملات هضم المركبات الغذائية وميزان النيتروجين فى الأغنام والماعز بينما لم يكن هذا التأثير معنويا مع الإبل. كما أدت زياده ملوحة ماء الشرب الى إنخفاض فى تركيز أمونيا الكرش ولم تؤثر معنويا على درجه حموضة سائل الكرش و تركيز الأحماض الدهنية الطيارة المنفردة أو الكلية

وقد أظهرت النتائج أيضا أن الإبل أكثر إحتمالا للمستوى العالى من ملوحة ماء الشرب من الأغنام والماعزمن ناحية التأثير على كمية المأكول من المركبات الغذائية ومعاملات هضمها و ميزان النيتروجين و المقاييس الأساسية لتخمرات الكرش.