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Digestibility and rumen fermentation of sheep as affected by drinking saline water

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ABSTRACT

Three fistulated rams were used to investigate the effect of drinking saline water on water metabolism, feed intake, digestibility, nutritive values, nitrogen metabolism, rumen microbial activities) and digesta flow rates. Three different levels of water salinity were tested using municipal town water (MTW) supplemented with either 0, 1% or 1.5% (wt/v) NaCl. The animals were offered free choice drinking water and fed clover hay (Trifolium alexandrium) ad lib. The results revealed the following:

1- *Water intake, urine water loss and insensible water were progressively increased ($P<0.05$) as the NaCl concentration increased in the drinking water.*
2- *Fecal water loss was not significantly affected upon receiving MTW + 1% NaCl (LS) but it significantly decreased upon drinking MTW supplemented with 1.5% NaCl (HS).*
3- *The digestibility of CP and EE significantly decreased with LS compared with MTW, however HS decreased the digestibility of almost all nutrients compared with LS and MTW.*
4- *Both TDN and SV did not significantly differ with adding 1% NaCl, meanwhile adding 1.5% NaCl, significantly decreased in TDN, SV and DCP.*
5- *The lowest nitrogen balance NB and digested nitrogen DN values were found with HS.*
6- *No differences in rumen pH values were noted among treatments. Values were high before feeding then started to decline after – feeding to reach the lower values at 6 h.*
7- *A significant decrease ($P<0.05$) of ammonia concentration was with HS, however the decrease was insignificant at LS compared with MTW.*
8- *All treatments had produced quite similar volatile fatty acids (VFA) up to 1 h post – feeding. Whereas from 3-6 h both LS and HS*

produced significantly lower amounts of VFA in a descending order with the increase of water salinity.

9- Molar percentages of acetate, propionate and butyrate were not appreciably affected by the salinity of drinking water.

10- Digesta passage rate of both solid and liquid phases was linearly increased as Na Cl had increased in the drinking water.

Key Words: *Water salinity, digestibility, rumen fermentation and sheep.*

INTRODUCTION

Most of farms installed and erected in new reclaimed desert areas depend mainly on under ground wells water for animal drinking. Such water usually contains different levels of salts of which the sodium chloride is a predominant constituent.

There are conflicted reports regarding the effect of salinity on animal performance. Some reports have shown remarkable improvement in weight gain, feed intake and nitrogen utilization (Ahmed *et al.*, 1985; Kandil *et al.*, 1985 and Sooud *et al.*, 1993). While others showed an opposite trend (Reffett and Boling, 1985 and Abou Hussien *et al.*, 1994a). Increases of ammonia-N concentration and slow rate of rumen outflow which is favored to growth of protozoal population have also reported (Shawket *et al.*, 1988). The work of Reffett and Boling (1985) and Abou Hussien *et al.*, 1984a), have indicated that rumen ammonia-N concentration declined by the presence of NaCl (4.4%) in food in drinking water (0.7-1.5% Rashidi Salts), respectively.

Additional studies by Shawket *et al.*, (1985) showed that drinking the saline well water decreased rumen fluids volume and increased the rate of fluid outflow. Alternation of rumen fermentation is influenced by the amount of sodium chloride supplementation (Rogers and Davis, 1982). They demonstrated that sodium chloride exerts osmotic properties in the rumen, thereby increasing rumen fluid dilution rate which leads to a decrease in rumen fermented organic matter, increases in particulate matter that moves with the flow phase and changes of production and molar proportions of volatile fatty acids. Chalupa *et al.*, (1981) indicated that sodium chloride affect nutrient breakdown in the rumen by alternations in pH or osmolarity of the rumen environment. This controversy of such review reasonably needs further investigations in this regards. The present study was designed to provide further information

concerning the possibility of using different levels of saline water in order to elucidate its effect on alteration of rumen fermentation, water and nutrients intakes, water metabolism, digestibility and nitrogen utilization in sheep.

MATERIALS AND METHODS

This experiment was carried out at the Experimental Farm, Animal Production Department, Faculty of Agriculture, Shibin El-Kom.

In this respect, three adult Ossimi rams weighing on the average 50kg were fitted with rumen fistulae. Three levels of drinking water salinety were tested, using municipal town water (MTW) supplemented with 0, 1 or 1.5% NaCl (wt/v) respectively. Representative samples of MTW were analyzed and results are shown in Table (1).

Table (1): Chemical analysis of municipal town water (MTW)

PH		7.65	
Electrice conductivity	m.mhos	0.61	(indicator for salinity percent).
Sodium adsorption ratio		0.77	$= \frac{Na\ \%}{\sqrt{\frac{Ca\% + Mg\%}{2}}}$ (indicator for salinity)
Calcium	meq/L	2.90	
Magnesum	meq/L	2.40	
Sodium	meq/L	1.25	
Potastum	meq/L	0.10	
Carbonate	meq/L	0.00	
Biocarbonate	meq/L	5.95	
Chloride	meq/L	2.64	
Sulfate	meq/L	0.00	

Drinking water were available *ad lib* and daily water intake was recorded. During the experimental period, the animals were fed *ad lib.* berseem hay containing of 91% DM, 89% OM, 14% CP, 2.8% EE, 32% CF and 40.2% NFE.

Animals were placed in metabolic cages as described by Maynard *et al.*, (1979) two consecutive periods, 21 days as preliminary period followed by 11- days collecting period divided into a 7- day fecal and urine collection and a 4-day ruminal sampling period. Food and fecal

samples were collected and dried for laboratory analysis. Urine was collected daily and a 10% alquots are sampled and refrigerated till analysis for nitrogen. Analysis of food, feces and determination of total nitrogen in urine were carried out according to A.O.A.C. (1980).

During the collection period rumen samples were collected through the fistulae at 0,1,3 and 6 h post-feeding. Rumen contents were strained through four layers of cheesecloth and pH was measured immediately using pH meter with a glass electrode. Samples were preserved by the addition of 2 ml of H_2S_4O (50% v/v) to prevent ammonia losses. Samples were frozen for subsequent analysis of ammonia as described by Al-Rabbate *et al.*, (1971) and total volatile fatty acids (VFA) by Warner (1964). Individual VFAs were determined by gas liquid chromatograph (GLC). Rate of DM passage and retention time, were estimated using two external markers of polyethylene glycol (PEG, MW 4000), and chromic oxide (Cr_2O_3). A mixture of 10 g of PEG (dissolved in 250 ml of water) and 5 g of chromic oxide were dosed into the rumen via the rumen fistulae of each animal immediately before feeding. Samples of rumen content were taken at 0,1,2,3,4,5,6,7,24 and 48 h. after dosing. An aliquat of sample was centrifuged at 5000 xg for 20 min. and the supernatant was kept for analysis of PEG. The rest of samples were dried and ground (1 mm screen) for chromium analysis. Polyethelyne glycol was measured by turbidimetric method of Ulyatt (1964). Chromium concentration in rumen digesta was determined by the method of Williams *et al.*,(1962)using an atomic absorption spectrophotometer. The data were statistically analyzed according to Gill (1978).

RESULTS AND DISCUSSION

Data in Table (2) show the effect of salinity of drinking water on water intake and distribution of excreted water.

Table (2): Effect of drinking water salinity on water intake and excretion water in Ossimi sheep (ml/kg $W^{0.82}$)

Item	NaCl Supplemented to municipal town water		
	0%	1%	1.5%
Water Intake	202.4±10.2^{c}	271.3±4.5^{b}	350.0±15.0^{a}
Water Loss :			
Fecal	33.8±2.5^{a}	28.9±3.0^{a}	21.1±1.5^{b}
Urinary	110.0±8.4^{c}	182.2±6.5^{b}	238.0±5.6^{a}
Total	143.8±3.5^{c}	211.1±1.8^{b}	259.1±2.4^{a}
Insensible	58.6±1.5^{b}	60.2±1.3^{b}	90.9±2.6^{a}
Water loss as percentage of water intake			
Fecal	16.7±1.2^{a}	10.7±1.8^{ab}	6.0±1.7^{b}
Urinary	54.4±2.1^{b}	67.2±1.4^{a}	68.0±1.0^{a}
Insensible	29.0±1.8^{a}	22.2±2.3^{b}	26.0±1.6^{a}

a,b,c Means in the same row with different superscript differ significantly ($P<0.05$). MTW, municipal town water.

Results indicated that drinking saline water induced a significant increase in water intake which consequently increased water excreted as urine and insensible water, mean while fecal water decreased ($P<0.05$) in response to HS but not LS as compared with MTW.

Sheep lost their water in urine more than in feces with drinking saline water (Abou El-Nasr *et al.*, 1988). Findings of Wilson and Dudzinki (1973) indicated that urine volume excreted was related to sodium to be excreted while water losses in feces was related to fecal dry matter and of the diet.

Data in Table (2) show that excreted water as percent of water intake was altered by drinking saline water. The increasing of water intake in both groups LS and HS may be due to the amount of Na Cl ingested. Similar conclusion was also documented by (Wilson, 1966). Results obtained in the presents study are in good agreement with those reported by Reffett and Boling (1985), Abou El-Nasr *et al.*, (1988), Khamis *et al.*, (1989) and Abou Hussien *et al.*, (1994 b).

Dry matter (DM) and nutrients intake as affected by treatments are presented in Table (3).

Table (3): Effect of drinking water salinity on dry matter intake and nutrient intake (g/kg $W^{0.75}$)

Item	NaCl Supplemented to municipal town water		
	0%	1%	1.5%
Dry matter intake (DMI)	69.0±2.9^a	63.0±3.2^a	42.6±5.2^b
Total digestible nutrient (TDN)	3.53±1.5^a	3.16±1.8^a	2.12±2.8^b
Starch value (SV)	2.42±1.6^a	2.22±2.1^a	1.5±1.2^b
Digestible crude protein (DCP)	0.62±1.0^a	0.57±0.8^a	0.38±0.4^b

a,b,c Means in the same row with different superscript differ significantly (P<0.05)

Values of DM, TDN, SV and DCP were significantly decreased (P<0.05) in HS group but not in LS group as compared with MTW group. This may indicate that animals could not maintain their intake upon increasing salinity of drinking water at level of 1.5% Na Cl. Decreased cellulose degradation as a result of increased osmotic pressure of rumen fluid may have been responsible for the reduced DM intake (Rogers *et al.*, 1979). Drinking saline water decreased feed intake in heifers (Saul and Flinn, 1984) and in rams (Shawkat *et al.*, 1988). On the opposite, Kandil *et al.*, (1985) and Sooud *et al.*, (1993) indicated that feed intake of sheep increased as the salinity water increased with tolerance levels ranged from 10.000 to 13.000 ppm. Recently (Abou Hussien *et al.*, 1994 a,b) found that this level to be 9472 ppm.

Data in Table (4) showed that drinking LS insignificantly decreased the digestibility of DM, OM, CF and NFE. However, CP and EE digestibility significantly (P<0.05) decreased in response to (LS).

Table (4): Digestion coefficient and nutritive values as affected by drinking saline water.

Item	NaCl Supplemented to municipal town water		
	0%	1%	1.5%
Dry matter (DM)	67.0±1.2^a	64.56±1.4^a	55.1±0.92^b
Organic matter (OM)	66.9±0.9^a	65.0±1.0^a	55.8±1.4^b
Crude protein (CP)	61.0±1.1^a	57.3±2.2^b	41.4±2.5^c
Crude fiber (CF)	68.4±0.86^a	66.8±0.8^a	58.2±1.2^b
Ether extract (EE)	52.4±2.4^a	45.4±1.6^b	34.68±1.4^c
Nitrogen free extract (NFE	55.7±0.94^a	54.1±1.2^a	44.0±1.8^b
Nutritive value, %			
SV	35.03±0.9^a	32.2±1.2^a	24.0±1.5^b
TDN	55.74±1.0^a	53.57±0.92^a	43.85±1.8^b
DCP	8.54±0.95^a	7.95±0.90^b	5.8±1.4^c

A,b,c Means in the same row with different superscript differ significantly (P<0.05)

Increasing drinking water at high level (HS) resulted in significant decrease ($P<0.05$) in the nutrients digestibility compared with MTW and LS. Organic matter was significantly reduced in wether ingested NaCl in the ration at 1.7, 2.5 and 3.1% (Moseley and Jones, 1974). The lower CP digestibility was mainly due to low food intake, while the lower of EE digestibility could be due to the formation of low digested insoluble soap from the insoluble salts of saline water with the dietary fat of low fat digestibility. The finding of Reffett and Boling (1985) indicated that increasing NaCl intake by lambs had not affected nutrient digestibilities. However, increasing salinity of drinking water induced slight effect (Squires, 1974) or significant decrease of nutrient digestibilities (Abou Hussien *et al.*, 1994 a). The lower digestibilities assocaited with drinking saline water led to lower nutritive values expressed as TDN, SV and DCP. Drinking LS decreased DCP values ($P<0.05$) and insignificantly the values of TDN and SV as compared to MTW.

The lowest TDN, SV and DCP values were found for HS followed by LS and MTW. Differences were statistically significant ($P<0.05$). Nutrient utilization was altered differently, decreased in lambs ingested high level of Na (Reffett and Boling, 1985; Abou Hussien *et al.*, 1994 a).

Results of nitrogen balance (NB) are presented in Table (5).

Table (5): Nitrogen balance as affected by drinking saline water.

Item	NaCl Supplemented to municipal town water		
	0%	**1%**	**1.5%**
Nitrogen intake (NI)	29.12±1.02	26.7±0.8	17.92±0.6
Fecal nitrogen	11.6±0.7	11.4±0.95	10.5±0.8
Digested nitrogen (DN)	17.52±1.4	15.3±1.5	7.42±1.2
Urinary nitrogen	11.0±1.5	11.5±1.8	11.8±1.0
Nitrogen balance (NB)	6.52 ± 1.8^{Aa}	3.8 ± 1.2^{Ab}	-4.4 ± 1.0^{Bc}
NB/NI, %	22.4 ± 1.76^{Aa}	14.23 ± 2.2^{Aa}	-24.6 ± 1.7^{Bb}

a,b,c and A.B Means in the same row with different superscript differ significantly ($P<0.05$) and ($P<0.01$)

Drinking saline water progressively decreased DMI Table (3) and consequently nitrogen intake (NI) was reduced Table (5). Differences were significant ($P<0.05$). However, MTW and LS groups had positive NB and excreted similar amounts of N in urine and feces meanwhile HS

group had negative NB due to more N excreted in urine comparing with the other two groups. Nitrogen balance followed the same pattern of NI. Differences were significant among the different groups. There are inconsistent reports regarding the effect of salinity on N utilization. Some reports have shown remarkable improvement (Ahmed *et al.*, 1985), while others showed an opposite trend (Reffett and Boling, 1985).

Rumen pH values over 6 h post dosing are presented in Table (6).

Table (6): Rumen activity as affected by drinking saline water.

Item	Time	NaCl Supplemented to municipal town water		
		0%	1%	1.5%
pH	0	6.94	6.80	6.76
	1	6.52	6.30	6.20
	3	6.02	5.88	5.80
	6	5.81	5.77	5.74
Ammonia – N (mg/dl)	0	20.8±1.2	20.5±2.6	21.4±1.07
	1	26.6±4.8^{a}	25.6±2.5^{a}	18.6±5.0^{b}
	3	30.2±5.8^{a}	23.4±1.7^{a}	17.2±10.6^{b}
	6	24.0±12.0^{a}	21.5±2.8^{a}	14.5±10.6^{b}
Total VFA (m mol/dl)	0	11.6±5.8	11.0±7.5	12.0±3.0
	1	14.2±8.3^{a}	12.8±7.6^{a}	10.6±4.6^{b}
	3	16.6±6.8^{a}	11.8±1.0^{b}	9.8±3.8^{c}
	6	13.5±2.2^{a}	9.2±6.4^{b}	7.1±6.8^{c}

a,b,c Means in the same row with different superscript differ significantly ($P<0.05$)

The pH values progressively declined post-feeding reaching its lowest values after 6 h in all groups. Increasing salinity caused a slight decrease of rumen pH among groups. Chalupa *et al.*, (1981) showed that Na Cl (4.4% of the diet) decreased rumen pH. The present finding are in accordance with those of Abou Hussien *et al.*, (1994a) when they tested 3 levels of water salinity, tap water, 0.75 and 1.5% Rashidi salt.

Pattern of change in rumen ammonia concentration differed among the experimental groups. The maximum value was 30.2 mg/dl at 3h post feeding for MTW group, 25.6 mg/dl at 1 h for LS and progressively decreased with the time in HS group. In general, sheep within HS group had significantly ($P<0.05$) lower ammonia concentration compared with other groups. These findings are in agreement with those reported by Reffett and Boling (1985) and Abou Hussien *et al.*, (1994a). They found

that rumen ammonia concentration was reduced by the presence of Na Cl (4.4%) in food or water (0.7-1.5% Rashidi salts), respectively. While others showed that ammonia concentration increased in rams fed roughage diet and drunk saline well water (Shawkat *et al.*, 1988).

Drinking saline water decreased total VFA concentration in rumen. Pattern of response of total VFA to drinking water of various grades of salinity was quite similar to that of rumen ammonia-N Table (6).

However drinking saline water had no effect on molar proportions of acetate, propionate and butyrate as presented in Table (7).

Table (7): Molar proportions of VFA's as affected by drinking saline water (Mol/100 mol)

Item	Time	NaCl Supplemented to municipal town water		
		0%	**1%**	**1.5%**
Acetate %				
Before feeding	0	52.3	52.0	50.9
	1	55.0	54.0	52.0
Post - feeding	3	52.0	51.0	48.0
	6	50.0	52.0	47.0
Propionate %				
Before feeding	0	23.0	19	21.3
	1	24.0	21	22.0
Post – feeding	3	25.0	21	20.0
	6	23.5	20	21.0
Butyrate %				
Before feeding	0	22.0	28	25.5
	1	19.0	23.5	23.0
Post - feeding	3	20.0	21.0	19.0
	6	21.0	19.5	22.0

This confirms reports undertaken by Rogers and Davis (1982) and Abou Hussien *et al.*, (1994a). Unappreciated effect of salinity on molars proportions of rumen VFA's may be due to increasing outflow of nutrients and decreasing substrate availability for VFA production (Hemsley, 1975). The present finding disagree with those reported by (Shawket *et al.*, 1988) who found that total VFA was not affected, however molar proportion of propionic acid was increased when sheep

drank the saline weter. Others found that the concentration of total VFA in rumen fluids was reduced in sheep given Na Cl (Rogars *et al.*, 1979).

Retention time for both solid and liquid phases in rumen significantly decreased with the increase of water salinity Table (8). Consequently, rate of outflow followed an opposite trend.

Table (8): Flow rate and retention time in rumen as affected by drinking water salinity.

Item	NaCl Supplemented to municipal town water		
	0%	1%	1.5%
Solid			
Retention time	16.6±2.4[a]	14.4±5.40[b]	8.5±2.4[c]
Flow rate (%h)	6.0±1.6[c]	6.97±3.20[b]	11.8±1.3[a]
Liquid			
Retention time	4.67±5.2[a]	3.33±2.8[b]	2.5±1.8[C]
Flow rate (%h)	21.4±8.4[c]	30.3±6.2[b]	40.0±4.6[a]

a,b,c Means in the same row with different superscript differ significantly ($P<0.05$)

Differences were significant at ($P<0.05$). The increase in water intake (Table 2) accounted for, at least in part, the increase in outflow of rumen fluid and short retention time of digesta. Varge and Prigge (1982) reported that liquid dilution rate is dependent on solid retention time. The shorter retention time and higher outflow associated with drinking saline water could be a good explanation for lower digestibility of nutrients. As a result of increased the flow rate, increases of ruminal passage of nutrients and particulate matter that move with fluid phase (Rogers and Davis, 1982), and it is not favored for increase of the total protozal population (Shawket *et al.*, 1988). Also, increase in rumen outflow had a decrease in rumen fermentation; VFA production may be reduced because of a decrease in substrate availability (Bennink *et al.*, 1978; Shawket *et al.*, 1988). The longest retention time of Cr_2O_3 in MTW group is probably a reflection of increasing feed intake (Table 3) compared with those drank saline water. It could be concluded that, drinking saline water containing 1–1.5% NaCl resulted in greate response in water intake and excretion and decreases in most of nutrient digestibility. Differential influences were observed in rumen fermentation, decrease in ammonia concentration, at HS not at LS, decrease in total VFA production and

increase in digesta flow rate of rumen. However, proportional VFA did not differ in response to changes in water salinity.

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القيمة الهضمية وتخمرات الكرش فى الأغنام ومدى تأثرها بملوحة ماء الشرب

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هدفت هذه الدراسة الى توضيح تأثير إضافة ملح الطعام بمعدات صفر ، ١ ، ١,٥ % الى مـــاء الشرب للأغنام المغذاة على دريس برسيم للشبع على تمثيل الماء – معدلات هضم المركبات الغذائيـــة المختلفة وميزان الازوت ، الاستفادة من الغذاء ، دراسة بعض بيانات النشاط التمثيلى فى الكرش عـــن طريق تقدير كل من الحموضة وتركيز الامونيا والأحماض الدهنية الطيارة، وتم تقدير زمـــن مكـــوث الكتلة الغذائية ومدى تدفقها من الكرش. وقد استخدم هى هذه الدراسة ثلاث ذكور خراف أوسيمى ذات فستيولا مستديمة بالكرش.

أوضحت النتائج :

١- ازدادت كمية ماء الشرب ، والماء المفرز فى البول ، بزيادة درجات الملوحة .

٢- قلت نسبة افراز الرطوبة فى الروث معنويا مع المستوى العالى من الملوحة.

٣- انخفض معنويا معامل هضم كل من البروتين الخام والدهن مع شرب الماء المنخفض الملوحة ، بينما أدى شرب الماء المرتفع الملوحة الى انخفاض فى معاملات هضـــم المركبـــات الغذائيـــة المختلفة.

٤- لم يتأثر معنويا كلا من قيم معادل النشا أو مجموع المواد الغذائية المهضومة بشرب المـــاء ذات الملوحة المنخفضة ولكن شرب الماء ذات الملوحة العالية أدى الى انخفاض معنوى فى هذه القيم.

٥- قل ميزان الازوت مع شرب المياه المنخفضة الملوحة وكان الميزان سالب عند شرب المياه عالية الملوحة .

٦- قيم الحموضة لم تتغير معنويا بين المعاملات ، كانت القيم مرتفعة قبل التغذية ثم بـــدأت تنحـــدر مع مرور الوقت .

٧- انخفض تركيز الأمونيا انخفاض غير معنوى مع شرب الماء منخفض الملوحة مع مرور الوقـــت من الاكل ومعنوى مع شرب الماء عالى الملوحة.

٨- تقارب تركيز الاحماض الدهنية الطيارة الكلية فى الكرش للمعاملات المختلفة قبل الاكل ولكـــن لوحظ انخفاض غير معنوى عند شرب المياه منخفضة الملوحة ومعنوى عند شرب الماء عاليـــة الملوحة مع مرور الوقت .

٩- لم يحدث تغيير كبير فى نسب المولارتية لحمض الخليك والبروبيونيك والبيوتريك .

١٠-لوحظ انخفاض فى فترة مكوث المادة الصلبة فى الكرش مع زيادة نسبة الملح فى ماء الشـــرب وعلى العكس زاد معدل مرور السوائل فى الكرش .