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Full Length Research Article

Nitrogen Retention and Water Balance in Animals Fed Medium Protein Diet amidst Limited Water Supply

Ajibola .A

Department of Physiology
Obafemi Awolowo College of Health Sciences
Olabisi Onabanjo University
P.M.B 2005 Ikenne Ogun State

ABSTRACT

Nitrogen metabolism of animals fed a medium protein diet (10.5% cp) ad libitum with restricted water consumption was studied. During the 8-day digestibility trial, 3 groups of five animals each were subjected to 30%, 50% and 100% water supply, with concomitant jugular blood samples taken daily to monitor their hydration status. Water loss via the urine reflects the animals water intake, thus control animals voided more urine ($P < 0.05$) than 50% and 30% groups. Treatment groups retain high amount of nitrogen, in contrast to control animals that lost 2.4% nitrogen via the faeces. Inadequate drinking caused decreased excretion of urea. The improved nitrogen retention coupled with high rates of urea recycling enhances nutrients digestion and consequently the animals' absorptive capabilities.
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Keywords: *nitrogen, water restriction, digestion, urea, absorption, animals*

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INTRODUCTION

Animals in many parts of the world, especially Africa, where water is scarce are faced with irregular, infrequent and inadequate water supply. Desert breeds of sheep and goats are known for their adaptability to little water consumption, whereas their domestic counterparts depend on adequate and regular water supply for their metabolic activities. Several works have been done on nitrogen metabolism and limited water supply by desert breeds (Singh, More & Sahni, 1976; Brosh, Shkolnik & Choshniak, 1987; Silanikove, 1984) and little done on domestic ruminants (Silanikove, 1984; van der Walt *et. al.*, 1999). Hence, knowledge of the digestive functions of domestic goats and their ability to retain nitrogen when exposed to limited water supply is essential.

MATERIALS AND METHODS

Fifteen mature male goats obtained from the Department of Physiology, Faculty of Veterinary Science, University of Pretoria, South Africa formed the research flock. The animals with initial body weight of 16 to 42 kg (average 29 kg) were adapted to the feed for at least 10 days prior to the study. They were fed *ad libitum* with a medium quality diet containing 10.5% crude protein and 17.5 Mj/kg gross energy level and housed individually in metabolic cages. Each goat was served 5 litres of clean drinking water daily during adaptation. Blood samples were taken from the jugular veins of the animals to determine the haematocrit, total plasma protein (TPP) and plasma osmolality. These and other physiological parameters were used to monitor the hydration status of the animals.

They were randomly divided into three groups (A, B, C) of 5 goats each. Group A animals received 30% *ad libitum* of their regular water intake; group B goats were served 50% *ad libitum* water intake; while group C which served as control had no reduction in their water supply (100% *ad libitum*). Feed supply to the animals was *ad libitum* throughout the study, which lasted for a period of 8 days.

Daily feed intake and water consumption by each goat were measured and recorded. The faeces and urine produced were collected and measured daily, and samples stored at -20°C. The faeces was thawed and analyzed for moisture (AOAC, 1984) and protein using an FP – 428 Nitrogen and Protein Determinator designed by Leco Inc., USA.

The data were recorded as means ± SEM and the Student t – test was used for comparison. Less than 5% statistical level ($P<0.05$) was accepted as being significant for any observation.

RESULTS

As presented in table 1, water consumption (L kg $^{-1}$ feed consumed) increases as water intake by the animals increases. Water loss via the urine is significantly ($P<0.05$) higher in control animals (100% water *ad libitum*) than treatment groups (table 2), a reflection of higher water intake by these animals. Free access to water also produces higher loss of water due to metabolism, respiration and insensible loss (table 2). The water efficiency was calculated in ml/kg $BW^{0.75}$/day and presented in table 3. The treatment groups are shown to be more efficient in the use of water. Table 4 shows that the treatment groups retain higher quantity of nitrogen while the control animals' loss 2.4% nitrogen consumed rather than being retained. Similarly a significant amount of urea is lost by animals having unhindered access to water (table 5) unlike the treatment groups.

Table 1:
Water intake, feed intake and water consumption by animals differing in water supply

	Group A	Group B	Group C
Water intake (Ld^{-1})	0.33 ± 0.00^a	0.65 ± 0.09^b	1.43 ± 0.37^c
Feed intake (Kgd^{-1})	0.54 ± 0.08^a	0.64 ± 0.09^a	0.76 ± 0.16^b
Water consumed (LKg^{-1} feed intake)	0.61 ± 0.10^a	1.02 ± 0.17^b	1.88 ± 0.33^c

Superscripts that differ on the horizontal line are significantly different (P<0.05).

Table 2:
Water balance by experimental animals (Means±SEM).

	Group A	Group B	Group C
Intake			
Free water (Ld^{-1})	$0.33{\pm}0.00^a$	$0.65{\pm}0.09^b$	$1.43{\pm}0.37^c$
% of total intake	89.2	92.9	96.0
Feed water (Ld^{-1})	$0.04{\pm}0.008^a$	$0.05{\pm}0.008^b$	$0.06{\pm}0.13^b$
% of total intake	10.8	7.1	4.0
Total water intake (Ld^{-1})	$0.37{\pm}0.02^a$	$0.70{\pm}0.10^b$	$1.49{\pm}0.43^c$
Output			
Urine (Ld^{-1})	$0.22{\pm}0.008^a$	$0.21{\pm}0.09^a$	$0.36{\pm}0.36^b$
% of total intake	59.5	30.0	24.2
Faecal water (Ld^{-1})	$0.11{\pm}0.03^a$	$0.24{\pm}0.09^b$	$0.27{\pm}0.09^b$
% of total intake	29.7	34.3	18.1
Unmeasured water (Ld^{-1})	$0.04{\pm}0.09^a$	$0.26{\pm}0.16^b$	$0.86{\pm}0.11^c$
% of total intake	10.8	35.7	57.8
Total water loss (Ld^{-1})	$0.37{\pm}0.02^a$	$0.71{\pm}0.10^b$	$1.49{\pm}0.43^c$

Superscripts that differ on the horizontal line are significantly different ($P<0.05$).

Table 3:
Water efficiency of animals on different water regimens (Means±SEM).

	Group A	**Group B**	**Group C**
Body weight (Kg)	29.7±11.0	28.8±8.3	30.6±8.3
Water intake (Ld^{-1})	$033{\pm}0.00^a$	$0.65{\pm}0.09^b$	$1.43{\pm}0.37^c$
Water efficiency ($mlkg^{-0.75}BWd^{-1}$)	$28.1{\pm}10.3^a$	$55.5{\pm}15.8^b$	$112.0{\pm}31.0^c$

Superscripts that differ on the horizontal line are significantly different ($P<0.05$).

Table 4:
Nitrogen consumption, excretion and retention by animals on water restriction (Means±SEM).

	Group A	Group B	Group C
Intake			
N consumed (gd^{-1})	$9.00{\pm}1.65^a$	$10.79{\pm}1.71^a$	$12.75{\pm}3.15^b$
Excretion			
Faecal N (gd^{-1})	$4.40{\pm}1.10^a$	$6.97{\pm}1.62^b$	$7.83{\pm}2.04^b$
% of N consumed	48.9	64.6	61.4
Urine N (gd^{-1})	$1.73{\pm}0.78^a$	$1.74{\pm}0.72^a$	$5.23{\pm}8.29^b$
% of N consumed	19.2	16.1	41.0
Retention			
Intake – excretion (gd^{-1})	$2.87{\pm}0.80^a$	$2.08{\pm}1.52^a$	$-0.31{\pm}7.28^b$
% of N consumed	31.9	19.3	-2.4

Superscripts that differ on the horizontal line are significantly different ($P<0.05$).

Table 5:
Urine output, urea output and urea concentration of experimental animals

	Group A	**Group B**	**Group C**
Urine volume (Ld^{-1})	$0.22{\pm}0.008^a$	$0.21{\pm}0.09^a$	$0.36{\pm}0.36^b$
Urea output ($mmold^{-1}$)	$82.6{\pm}37.8^a$	$82.9{\pm}34.2^a$	$249.0{\pm}349.7^b$
Urea conc. ($mmolL^{-1}$)	365.90±45.6	404.04±72.8	524.28±281.7

Superscripts that differ on the horizontal line are significantly different ($P<0.05$).

DISCUSSION

The amount of water consumed by the experimental goats on 100% water *ad libitum* was more than that of the water-restricted animals. It has been previously demonstrated that goats drink small volumes of water (Devendra, 1980; More and Sahni, 1981). It was of interest to note that the goats used for this study differ significantly ($P<0.05$) in the use of water to meet various metabolic needs. Contrary to expectation the experimental animals have different unmeasured water values despite being of the same species with the same physiological demands, housed and fed under the same environmental conditions. However the treatment groups were superior with regard to water utilization and management than those given water free choice.

The reduced voluntary feed intake accompanying inadequate drinking led to decreased nitrogen consumption by the treatment groups, since the main source of nitrogen intake by the goats is feed. Correspondingly, the total amount of nitrogen excreted decreased as the water supply to the animals reduces. When the nitrogen loss was expressed as a percentage of N-intake (table 4), high losses were recorded through the faeces. This was a reflection of feed consumption and faecal output, thus a high feed intake produced a high faecal loss of nitrogen. The low nitrogen excretion by the water-restricted groups facilitated increased nitrogen retention. This was in contrast to the control group with a negative nitrogen balance while the treatment groups retained a significant percentage of the nitrogen consumed. These observations aligned with earlier reports from Brosh *et al* (1987) and van der Walt *et al* (1999) that infrequent and inadequate drinking lead to decreased nitrogen excretion and improved nitrogen retention. According to Kimambo *et al* (1999), this might be associated with low ammonia production in the rumen, due to low rate of degradation, thereby allowing most of the protein to escape ruminal digestion. This may be digested in the abomasum and small intestine. The elevated nitrogen uptake from the small intestine may lead to increased metabolism in the liver and could result in enhanced nitrogen recycling into the rumen.

Van der Walt, Boomker, Meintjes and Schultheiss (1999) reported that limited water intake by ruminants probably leads to a smaller amount of urea loss via the kidneys, which in turn increases the amount of urea recycled to the rumen. The significantly low quantity of urea (table 5) lost by the goats given small quantity of water to drink might facilitate their ability to recycle urea. The urea recycled to the rumen coupled with the favourable nitrogen balance by the treatment groups would elevate ammonia production by ruminal microbes. Earlier workers show that the improved conditions in the rumen enhance the digestion of nutrients by these animals (Kimambo *et al* 1999). The present study corroborated these findings as well as high rates of nutrients absorption.

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