

## Water Intake of Fiji Fantastic Sheep Fed a Basal Diet of Batiki Grass (*Ischaemum aristatum* Var. *indicum*) Supplemented with Dried Brewers' Grains

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**Abstract:** Water intake (WI) of the Fiji Fantastic (FF) sheep on a basal diet of Batiki grass (*Ischaemum aristatum* var. *indicum*) supplemented with dried brewers' grains (DBG) based concentrate mixtures (CM) was investigated during the dry season in Samoa. Eight (8) adult sheep (4 rams and 4 ewes); 1.5-2 years; pre-trial live-weight of 47.9±0.9 kg were randomly allotted to a double 4 x 4 Latin square design experiment and fed four concentrate mixtures compounded using dried brewers' grains (DBG), copra cake, mineral- vitamin premix and salt. DBG was included at 0, 35, 55 and 75 % levels and the concentrate mixtures were designated as Control, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> respectively. The sheep were allowed to graze on rotational basis two fenced paddocks during the day throughout the experimental period and housed in the evening. The sheep were allowed to feed on each CM for 32 d before it was changed. The first 14 d were a preliminary period designed to allow the sheep to adjust to the new feeding regime and the final 18 days for measurement of voluntary dry matter (DMI); water intake (WI), body weight change (BWC) (gain/loss) and apparent nutrient digestibility. Intake of the CM decreased (p<0.05) with incremental levels of DBG however, total voluntary DMI was compensated for through increased forage intake. WI was significantly different (p<0.05) at 772.4, 913.3, 924.9 and 927.1 (ml/head/d) for the Control, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> respectively. The level of DMI stimulated WI of the FF sheep. WI was higher in the afternoon than in the morning and evening. Sheep that had higher forage intake drank more water. BWC and daily live-weight gain (LWG) improved significantly (p<0.05) with water and forage intakes than with the intake of the concentrate mixtures. DM and organic matter (OM) digestibilities were significantly (p<0.05) lower in D<sub>2</sub> and D<sub>3</sub> compared to the control and D<sub>1</sub>. Crude protein (CP) intake was numerically higher in sheep that had higher WI. Crude fibre digestibility also improved with WI. Based on available data it could be concluded that under grazing condition the WI of adult FF sheep (45-65 kg) lie between 770 ml to 1 L. The low WI observed did not have any significant effect on the nutrition of the FF sheep during the dry season in Samoa. It is hereby suggested that more research should be carried out to determine what other factors affected the WI of the FF sheep under grazing condition supplemented with DBG based concentrate mixtures and how these differences affect water utilization and performance.

**Key words:** FF sheep · dried brewers' grains · water intake · DMI · nutrient digestibility

### INTRODUCTION

Water is an essential nutrient for all animals and total body water is the key component of living ruminants [1]. It is a major constituent of muscles and of meat and the proportion diminishes as the sheep grows and gets older. Limitations on water intake depress animal performance quicker and more drastically than any other nutrient deficiency. Water quality, as well as quantity, may affect

feed consumption and animal health since low quality water will normally result in reduced water and feed consumption. It is important for both animal welfare and business profitability that grazing ruminant livestock (goats, sheep and cattle) have an adequate supply of good quality water.

Water requirements vary with types of feed and the amount of water that may be adequate at one time for a particular diet could be insufficient for another. The

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amount of water needed by sheep varies according to the concentration of water in the feed [2] and there is a significant relationship between total water intake (TWI) and dry matter intake (DMI) [3].

Batiki grass (*Ischaemum aristatum* var. *indicum*) is the most common propagated pasture grass species for ruminant livestock in Samoa. It can tolerate heavy grazing and poor management. Dry season has effects on its nutrient content, intake and dry matter digestibility [4, 5].

The low nutritive value of Batiki grass may not sustain high levels of production of the Fiji Fantastic (FF) sheep therefore there is the need for improved nutrition through supplementation. Also, the need to match livestock production with available feed resources therefore requires the supplementation of low quality pastures with cheap concentrate mixtures which can be locally produced using available feed stuffs.

Brewer's grain is recognized as excellent protein and energy sources due to its high digestible fibre content and ruminal escape protein. The chemical composition and nutritive value have been presented by several scientists [6-8]. It constitutes a quality byproduct used as feed for livestock [6, 7] and can be fed in the wet or dry form. In the wet form it can be ensiled with other feed stuffs for use in times of feed scarcity. Its' high concentration of fibre fractions and low protein degradability [9] means that it is preferentially used for ruminant livestock.

Adequate intake of good-quality water is essential for sheep to excrete excess toxic substances such as oxalates, ammonia and mineral salts (phosphates that cause urinary calculi). The FF sheep is a new contribution to sheep breeds of the world and its origin has been documented by Manuelli [10]. Except for the report of Rokomatu and Aregheore [11] no other scientific investigation has been carried out on the water intake of the FF sheep outside Fiji from where it originates. The amount and quality of water required vary in response to the environment in which the sheep stock is running. It is therefore the objective of this experiment to investigate the water intake pattern of the Fiji Fantastic sheep on a basal diet of batiki grass (*Ischaemum aristatum* var. *indicum*) supplemented with dried brewers' grains based concentrate mixtures during the dry season in Samoa.

## MATERIALS AND METHODS

**Experimental site and weather condition:** The study was carried out at The University of the South Pacific,

Table 1: Percentage composition of experimental diets and proximate analysis

Ingredients, % DM	Diets: Levels of dried brewer's grains (DBG)*				Forage
	0%	35%	55%	75%	
Brewer's dried grains	0.00	35.00	55.00	75.00	
Copra cake	98.0	63.00	43.00	23.00	
Mineral - vitamin premix <sup>a</sup>	1.50	1.50	1.50	1.50	
Salt (NaCl)	0.50	0.50	0.50	0.50	
Total	100.00	100.00	100.00	100.00	
Analysis on DM basis (%)					
Dry matter	81.5	84.80	84.90	85.60	86.10
Crude protein	18.4	20.10	21.00	22.00	4.80
Crude fibre	11.7	14.10	16.50	18.90	30.90
Ether Extract	5.1	2.40	1.20	1.10	1.30
Organic matter	93.7	95.10	94.30	94.10	92.40

<sup>a</sup>Summit multi-mineral salt/vitamin: (Auckland, New Zealand): The mineral/vitamin block contain salt (NaCl), 120 g kg<sup>-1</sup> calcium, 60 g kg<sup>-1</sup> phosphorus, 60 mg kg<sup>-1</sup> manganese, 150 mg kg<sup>-1</sup> copper, 1.5 mg kg<sup>-1</sup> cobalt, 7.5 mg kg<sup>-1</sup> iodine, 600 mg kg<sup>-1</sup> manganese, 750 mg/kg iron, 600 mg kg<sup>-1</sup> zinc, 1.5 mg kg<sup>-1</sup> selenium; Vit. A, D and E.

\*Control (0 % DBG); D<sub>1</sub> = 35 % DBG; D<sub>2</sub> 55 % DBG and D<sub>3</sub> = 75 % DBG

School of Agriculture and Food Technology, Ruminant Unit, Alafua Campus, Samoa (13.5°S, 172.5°W). This investigation was carried out during the dry season (from April to September). However, the climate does not vary greatly through the year. Temperatures are seasonally uniform with the mean maximum temperature ranging from 27 to 30°C and the mean minimum temperature ranging from 20 to 23°C [12]. The relative humidity ranges between 70 to 80% and there is an average of 2,500 h of sunshine per annum.

**Animals and experimental design:** Eight (8) adult sheep (4 rams and 4 ewes) aged between 1.5-2 years with pre-trial live-weight of 47.9 ± 0.9 kg balanced for weight and sex were randomly allotted to a double 4 x 4 Latin square design experiment. There were 2 sheep (1 ram and 1 ewe) per dietary treatment during each of the four (4) phases. The sheep were individually housed in pens under a common roof, fed and watered

**Experimental diets and grazing management:** Four concentrate mixtures were compounded using dried brewers' grains, (DBG); copra cake, (CC); mineral- vitamin premix and salt. DBG was included at varying levels at 0, 35, 55 and 75% and the concentrate mixtures were designated as Control, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub> respectively. Table 1 presents the particulars of the concentrate mixtures.

The sheep were allowed to graze on rotational basis in two fenced paddocks planted with batiki grass during the day and were housed in the evening. Representative herbage sample of what the sheep ate was collected at the beginning, middle and end of the experiment to determine its dry matter (DM) content. The samples were dried, processed and stored until required for chemical analysis. Estimation of voluntary herbage intake of sheep in the paddocks during each was carried out according to the procedure of Parker *et al.* [13] and intake of each sheep was determined using the following formula:

$$\text{Forage intake, kg/d} = \frac{\text{Faecal output, kg/d}}{1 - \text{herbage DM digestibility}}$$

The sheep were allowed to feed on each concentrate mixture for 32 days before it was changed. The first 14 days were a preliminary period designed to allow the sheep to adjust to the new feeding regime and the final 18 days for measurement of voluntary dry matter intake, water intake, body weight change (gain/loss) and apparent nutrient digestibility.

The concentrate mixture (1 kg) was divided into two equal halves. The first half was given to the sheep before they were let out to graze in the morning (7.30 h) and the other half was offered in the evening (18.00 h) after grazing. Also 2.5 litres of clean water was offered per sheep in individual water trough to ensure that water requirement was satisfied. Voluntary feed and water intakes were adjusted daily for increased or decreased by keeping the refusal rate at ~ 10 - 20% of the intake. Daily feed and water intakes were determined as the difference in the quantity of what was provided and the residues of the previous leftovers. Feed and water troughs were cleaned daily before new feed and water was introduced.

The sheep were weighed prior to being changed to a new concentrate mixture and records of voluntary feed intake (forage and concentrate mixtures), water consumption and body weight changes (gain/loss) were recorded. The difference between the initial and final live-weights was used to compute body weight change and subsequently daily live-weight gain of sheep in each dietary treatment

**Digestibility studies:** During each phase faeces were collected for 7 days before changing to new dietary treatment. The rams were fitted with harness bags and allowed a 2-day adjustment period before a 5-day

collection period. The ewes were housed in special pens with slatted floor covered with a very fine wire netting that allows only urine to pass through. A dustpan and brush were used to collect the faeces for 7 days.

Total daily faecal output of each sheep was weighed and a 25 % sample removed for DM determination. Faeces collected over the period, were oven dried at 70°C for 36 hours. Daily samples of faeces, concentrate mixtures and forage were bulked separately and milled with a simple laboratory mill (Christy and Norris; process Engineers, Chelmsford, UK) to pass through a 1.7-mm sieve and stored until required for chemical analysis. Apparent nutrient digestibility coefficient was calculated by difference following the procedure of Crampton [14] for mixed diets.

**Analytical and statistical procedures:** AOAC [15] methods were used to determine nutrient contents in the concentrate mixtures, forage and faecal samples. Data were analyzed using standard analysis of variance (ANOVA) with sheep, period and treatment included as the main effects using MINITAB statistical software [16]. Where significant differences occurred, the least significant difference (LSD) test was used for mean separation.

## RESULTS AND DISCUSSION

Proximate analysis of the four concentrate mixtures and the forage is presented in Table 1. The concentrate mixtures and the forage had similar dry matter (DM) content. The crude protein (CP) and crude fibre (CF) contents of the concentrate mixtures increased numerically with incremental levels of DBG. The nutrient content especially the CP of the batiki grass is consistent with values reported for batiki grass during the dry season in Samoa [4, 5].

Performance characteristics in terms of voluntary feed and water intakes and average daily live-weight gain of the sheep is presented in table 2. Concentrate intake decreased ( $p < 0.05$ ) with incremental levels of DBG however, total voluntary feed intake was compensated for through increase intake of the forage. The above observations are consistent with Aregheore and Vuilu [17]; Lechner-Doll *et al.* [18], who identified the ruminant animal as intermediate feeder with a proposed capacity of changing feed behavior, toward that of a concentrate selector or, a grazer depending on the situation. Similarly reduction in the intake of the concentrate mixture might be

Table 2: Feed intake, water consumption and average daily live-weight gains of the sheep

Parameters	Diets: Levels of dried brewer's grains (DBG)*				±SE
	0%	35%	55%	75%	
	Control	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>	
Feed intake					
Concentrate (g/head/d)	331.8b	315.6ab	290.4a	212.8a	0.05
Forage (g/head/d) (fresh)	422.8a	499.6a	536.7ab	623.2b	0.07
Total feed intake (g/head/d)	754.6a	815.2ab	827.1b	836.0b	0.03
Percentage of forage in total feed intake	56.0	61.3	64.9	74.5	6.75
Feed efficiency (feed/gain)	8.1	8.1	8.3	9.4	0.54
Water intake (ml/head/d)	772.4a	913.3b	924.9b	927.1b	64.80
Initial Live-weight (kg)	47.3	48.4	49.2	46.8	0.93
Final Live-weight (kg)	57.3	60.9	62.0	59.9	1.74
Weight gain (kg)	10.0	12.5	12.8	13.1	1.23
Average daily gain (g/head/d)	78.0a	98.0ab	100.0b	102.0b	0.39
Average daily faecal output (g)	221.3a	271.3a	351.3bc	416.3c	0.07

\*Control (0 % DBG); D<sub>1</sub> = 35 % DBG; D<sub>2</sub> 55 %DBG and D<sub>3</sub> = 75 %DBG  
a, b, c - means within each treatment for each variable with different letter differ significantly

due to palatability problem. Ensminger *et al.* [19] reported that dried brewer's grains have low palatability. However, the total voluntary feed intake is within values reported for sheep (ewes and rams) that weighs between 50 to 60 kg [20].

In contrast the rate of passage of concentrate mixture in the rumen was faster than that of the forage or any roughages. An increase in dry matter intake results in a faster rate of passage of feed in ruminant livestock; moreover it seems the amount of concentrate mixture consumed led to increase in mean retention time.

However, voluntary intake of the concentrate mixtures by the sheep supports the reports of Bovolenta *et al.* [7] in Italy and Anigbogu [21] in Nigeria who fed increasing levels of DBG to growing lambs, respectively and reported that dry brewer's grains could profitably be used in growing fattening diets for lambs.

Water intake (WI) is the sum of water consumed voluntarily by drinking and water contained in the feed. Except for the daily grazing, the concentrate portion was offered dry. Voluntary water intake was significantly different ( $p < 0.05$ ) at 772.4, 913.3, 924.9 and 927.1 (ml/head/d) for sheep on the Control, D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>, respectively. The level of voluntary DM intake stimulated the water intake of the FF sheep; and water intake was higher in the afternoon than in the morning and evening (personal observation).

Voluntary water intake (Table 2) was high for sheep that had higher levels of DBG in the concentrate mixtures. When WI was expressed in relation to dry matter intake the values were lower than those obtained by Gihad *et al.* [22] for sheep. There was increase in the WI of the sheep in relation to total feed intake. This observation is in agreement with Forbes, [3] who reported significant relationship between total water intake (TWI) and dry matter intake (DMI).

Water intake may be affected by several factors, including changes in levels of some nutrients. The nutrient profile of the concentrate mixtures was similar except for crude protein (CP), crude fibre (CF) and ether extract (EE) (Table 1). Sheep on the DBG based concentrate mixtures compared to the control had more WI due to the high CP intake, which necessitated more water requirements to clean the kidneys of nitrogenous waste [23]. Studies have pointed out the dependency of WI on feed intake. Giger-Reverdin and Gihad [24] demonstrated that WI is strongly influenced by the water content of the feed; and DMI and WI are highly correlated. The sheep on D3 had a higher water intake than the other groups and the increase in WI with respect to increase in the total forage intake is consistent with Reynolds and Lindahl [25] who reported that WI increase as the level of forage increased.

Frequency of watering, consumption of feed, plane of nutrition and composition of feed, age, pasture and watering have effects on WI, however not much data are available on the exact WI of the sheep [20] especially under tropical conditions. However, it has been reported that season [2] as well as pasture type and time of grazing have effects on water intake [8]. Charry *et al.* [2] reported that WI of the sheep is significantly higher in the dry season than in the wet season. In this study it was observed that the time of grazing during the day has effects on WI of the FF sheep. Aregheore and Rokomatu, [8] reported that the WI of FF lambs in the dry season was twice the intake during the wet season. The average WI of the FF sheep in Samoa is comparatively low (mean 884 ml) compared to 1.3 litres reported for the FF lambs in Fiji during the dry season period [8] and 1.5 to 2.5 l/day reported for adult sheep in a tropical environment [2]. Age of sheep, environmental temperature and relative humidity may be implicated for the differences observed in WI.

It was observed that the sheep that had higher forage intake drank more water. Relatively, the amount of water needed is inversely related to the amount of water in feeds (dry matter content of feed). It could be adduced that the

Table 3: Apparent Nutrient digestibility Coefficients

Nutrients (%)	Diets: Levels of dried brewer's grains (DBG)*				Forage	±SE
	0%	35%	55%	75%		
	Control	D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>		
Dry matter	64.8a	62.8a	56.6ab	55.7b	48.7c	5.70
Crude protein	72.1a	73.7a	74.4a	75.6b	37.6b	14.58
Crude fibre	40.3a	44.6a	48.5ab	51.8b	68.9c	9.82
Organic matter	67.6a	66.9ab	59.6b	58.8b	52.6	5.57
Daily protein (N x 6.25) intake (g kg <sup>-1</sup> W <sup>0.75</sup> /day)	13.3	14.8	15.6	16.6	-	1.21
Metabolic water intake (ml kg <sup>-1</sup> W <sup>0.82</sup> /day)	115.9a	133.2b	134.6b	134.8b	-	7.95

a,b, c - means within each treatment for each variable with different letter differ significantly

increased forage intake might have occurred due to increased saliva flow which resulted in greater WI since fluids travel faster than particles [26] in the digestive system.

The amount of WI to total feed intake (concentrate + forage) increased with the forage portion for sheep on the control and those on varying levels of DBG (D<sub>1</sub>, D<sub>2</sub> and D<sub>3</sub>).

Body weight change (BWC) and average daily live-weight gain (ADG) improved significantly (P<0.05) with increase in water and forage intakes. Interactions due to level and proportion of intake of feed type (concentrate versus forage) had effect on WI and BWC. Daily live weight gain (ADG) of the sheep is consistent with Saipaia [27] who fed varying levels of dried brewers' grains based concentrate mixtures to the FF sheep in Samoa. The ADG observed in all sheep is an indication that the feeding was in excess of maintenance requirements and this is consistent with Osuhor *et al.* [28]. The level of water and feed intakes may be implicated for the higher live-weight gains obtained in the sheep on D<sub>2</sub> and D<sub>3</sub> dietary treatments.

Body weight changes and subsequently ADG of sheep in each of the treatments may reflect changes in rumen fill as much as changes occurring in body tissues and therefore should be treated with caution. The sheep were on each concentrate mixture for a short duration and may not exactly reflect the level of performance the concentrate mixtures might support if fed for a long time and this observation is in agreement with Undi *et al.* [29]. Total faecal output increased with higher WI (Table 2).

Dry matter (DM) and organic matter (OM) digestibilities were significantly (p<0.05) lower in D<sub>2</sub> and D<sub>3</sub> compared to the Control and D<sub>1</sub> (Table 3). Reasons for the observed decrease in DM and OM digestibilities are difficult to explain. It was expected however, that the sheep on the Control and D<sub>1</sub> that had higher OM digestibility would have higher body weight gain, but this was not the situation in this trial.

The low total voluntary feed intake in the control group seems to have contributed to low gut content and consequently, improved DM and OM digestibility even with less water intake. A reduction in DM and OM digestibilities (p<0.05) with increased WI was observed in D<sub>2</sub> and D<sub>3</sub> compared to the control and D<sub>1</sub>. However, the practical significance of these seems questionable.

Crude protein (CP) digestibility tended to be numerically higher in sheep that had higher water intake. Also, CF digestibility improved with WI an indication that there was no DM accumulation in the digestive tract (probably the rumen) to slow down the rate of passage of feed residues. The intake of the forage and concentrate mixtures; and apparent nutrients digestibility differ between treatments. It was also observed that although batiki grass has low CP content the digestibility of its CF was higher than that of the concentrate mixtures (Table 3) and this was probably a reflection of the quality of the fiber in the batiki grass compared with the concentrate mixtures. Of interest however, are the numerical differences in the apparent nutrients digestibility between the sheep in the different concentrate mixtures and the level of forage intake (Table 3).

There was significant difference (p<0.05) between treatments in metabolic water intake. Although numerical differences were observed in the daily crude protein intake of the sheep, these were not statistically significant. A reduction in WI may have a deleterious effect on feed utilization and metabolic water intake when sheep are grazed on low quality forage in the dry season period. However, based on available data it could be concluded that under grazing condition the WI of the adult FF sheep that weighs between 45-60 kg lies between 770 ml to 1L. Compared to the reports of Charry *et al.* [2]; and Aregheore and Rokomatu [8], the low WI of the FF sheep did not have any significant effect on their nutrition during the dry season in Samoa. It is hereby suggested that more research should be carried out to determine what other factors affected the WI of the FF sheep under grazing condition supplemented with concentrate mixtures based on DBG and how these differences affect water utilization and performance.

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