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Effect of *Yucca schidigera* Saponin Powder on Dry Matter Intake and Nutrient Utilization of Dry Brewers' Grains Based Concentrate Mixtures by Rams on a Basal Batiki Grass Diet

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Abstract: Four rams (Fiji Fantastic sheep) pre-trial Body Weight (BW) of 42.8±1.4 kg and 2 years old on a basal diet of batiki grass (*Ischaemum aristatum* var *indicum*) were allotted to four dietary treatments in a randomized 4×4 Latin Square design, to investigate the effect of inclusion of *Yucca schidigera* Saponin Powder (YSP) in Dried Brewers' Grains (DBG) based concentrate mixtures on dry matter intake, live-weight gain Daily Protein Intake (DPI) and nutrient digestibility. YSP was added at four different levels-0 mg, 90 mg, 120 mg and 160 mg to the concentrate mixture and four dietary treatments designated as D_1-0 mg YSP (Control); D_2-90 mg YSP; D_3-120 mg YSP and D_4-160 mg YSP were fed to the rams. The inclusion of the YSP numerically improved the voluntary intake of the concentrate mixtures but not at statistical significant ($p>0.05$) level. Voluntary intake of the forage portion was higher in rams on D4, however this was not statistically significant ($p>0.05$). Total Dry Matter Intake (DMI) (concentrate +forage) followed the pattern of forage intake. DMI expressed on metabolic weight basis was 234.1, 235.2, 239.1 and 244.5 g kg^{-1} $W^{0.75}$/day for D1, D2, D3 and D4, respectively. Total DMI improved numerically with incremental levels of *Yucca schidigera* saponin powder ($p>0.05$). Daily Live Weight Gain (DLWG) was lower ($p<0.05$) in rams on D1. DLWG improved in rams on D2, D3 and D4 that had YSP included at different levels in the concentrate mixtures, however, this was not statistically significant ($p>0.05$). Feed Efficiency (FE) (g feed/g gain) was lower ($p<0.05$) in the rams on D1 than those on D2, D3 and D4. Apparent digestibility of CP improved numerically, with incremental levels of YSP in the concentrate mixtures but not at a significant level ($p>0.05$). Daily Protein Intake (DPI) was 9.8, 12.9, 13.6 and 14.2 (g kg^{-1} $W^{0.75}$/day) for rams on D1, D2, D3 and D4, respectively. The inclusion of YSP in the DBG based concentrate mixtures at the different levels improved voluntary DMI, FE, DPI, CP digestibility and subsequently DLWG. Based on the above, it is hereby suggested that levels higher than 160 mg used in this trial should be evaluated in DBG based concentrate mixtures for rams in further studies.

Key words: Fiji fantastic sheep · dry matter intake · feed efficiency · nutrient digestibility

INTRODUCTION

Brewers' grain is an important agro-industrial byproduct that results from the manufacture of beer as extracted residues of malt (generally barley). It contains the insoluble material which includes the fibre fractions, fats, proteins, together with residues of starch and dextrin. It constitutes a quality byproduct and the major use of it has been as a feed for livestock [1, 2].

After drying which is performed to allow storage and improve nutrient concentration, the product become known as dried brewers' grains [2]. It is bulky, less palatable and less laxative than wheat bran. The product however, can be fed in the wet or dry form. The drying process results in increased levels of acid detergent insoluble protein and this affects the ruminal undegraded protein content of brewers' grains. The concentration of fibre fractions and the low protein degradability means that the brewers 'grains are preferentially used for feeding ruminants. Bovolenta *et al.* [2]; Anigbogu [3] reported that dry brewers' grains could profitably be used in growing fattening diets for lambs. However, Firkins *et al.* [4] found no significant difference in the ruminal undegraded protein between wet and dried brewers' grain.

In the PICs, it is available but under utilized therefore its economic value for livestock production is not yet fully

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appreciated. The idea of incorporating dried brewers' grain into the livestock feeding system arose primarily from the desire to investigate available cheap and alternative feed resources for livestock in the Pacific Island Countries (PICs) [5-7].

Ruminant animals have a large proportion of rumen protozoa that reduce the efficiency of fermentation in the rumen. Yucca saponins are effective in suppressing rumen protozoa, by reacting with cholesterol in the protozoal cell membrane, causing them to lyse. Also *Yucca schidigera* saponin is able to decrease ruminal ammonia concentration, improve daily gain and feed efficiency in animals [8]. The beneficial effects of supplementing animal feed with *Yucca shidigera* on performance and health has been documented [8-12, 19].

Yucca is used in ruminant diets to promote digestion and improve production performance. It increases organic matter digestion and with mixed roughage diets it increases plant fibre digestion [13]. Makkar *et al.* [14] reported that the incorporation of saponins into ruminant diets in particular roughage-based diets might be advantageous as it would lead to higher microbial yield and lower emission of environment polluting gases, (CO_2 and CH_4). This experiment therefore intend to investigate the effect of *Yucca schidigera* saponin (YSP) powder on dry matter intake and nutrient utilization of brewers' dried grains based concentrate mixtures fed to rams (Fiji Fantastic sheep) on a basal diet of batiki grass (*Ischaemum aristatum* var. *indicum*).

MATERIALS AND METHODS

***Yucca schidigera* powder:** This is a 100% natural powder made entirely from the stem of *Yucca schidigera* plant specie exclusively found in the Mexican state of Baja, California and in the Southwestern deserts of the USA (DK Sarsaponin 30, Desert King International, Chula Vista, Ca. USA).

Animals, experimental design, diets and management: Four rams (Fiji Fantastic sheep) with pre-trial body weight (BW) of 42.8±1.4 and 2 years of age were allotted to four dietary treatments in a randomized 4×4 Latin Square design. A concentrate mixture was prepared using dried brewers' grains, copra meal, mineral/vitamin premix and salt. *Yucca schidigera* saponin powder was added at four different dosage levels (0 mg, 90 mg, 120 mg and 160 mg) and the dietary treatments were designated as: -D_1-0 mg YSP (Control); D_2-90 mg YSP; D_3-120 mg YSP and D_4-160 mg YSP. Table 1 presents the particulars of the concentrate mixture to which Yucca was added at different dosage levels.

Table 1: Percentage composition of the concentrate mixtures with different levels of *Yucca schidigera* saponin powder

	Diets*			
Ingredients (%)	D_1	D_2	D_3	D_4
Dried brewers' grains	68.0	67.1	66.8	68.4
Copra meal	29.0	29.0	29.0	29.0
Mineral vitamin supplement**	2.0	2.0	2.0	2.0
Salt	1.0	1.0	1.0	1.0
Yucca schidigera saponin powder (YP)	0.0	0.9	1.2	1.6
Total	100.0	100.0	100.0	100.0

*D_1-0 mg YSP (Control); D_2-90 mg YSP; D_3-120 mg YSP and D_4-160 mg YSP, **Summit multi mineral salt block (Lake Grassmere, New Zealand) contained Sodium Chloride (NaCl), 89.2%; Sodium (Na), 34.8%; Calcium (Ca), 2.79%, Copper (CU), 1250 mg kg^{-1}; Zinc (Zn), 580 mg kg^{-1}; Iodine (I), 94 mg kg^{-1}; Iron (Fe), 89 mg kg^{-1}; Cobalt (Co), 65 mg kg^{-1}, Selenium (Se), 3 mg kg^{-1}

The rams were fed on each dietary treatment for 21 days period before the treatment was changed. The first 10 days being for adaptation and adjustment and the final 11 days for data collection (voluntary feed intake measurement and faecal collection).

For each period, a ram was offered both the concentrate mixture and fresh batiki grass (*Ischaemum aristatum* var *indicum*) that was harvested on a daily basis and chopped with a bush knife into pieces of 6-8 cm before being fed to the rams. Both concentrate (600 g) and grass (2.0 kg) were offered in two equal portions at 8.00 h in the morning and 1600 hr in the evening. Feed offered was adjusted daily for increased or decreased intake by keeping refusal rate at 10-20% of the intake. Sample of batiki grass was collected on a weekly basis for dry matter determination. Feeds offered and refused were recorded on daily basis to estimate voluntary feed intake. Body weights change of the rams were recorded at the beginning and end of each period and these were used to calculate the amount of the feed mixtures to be given during the next period. The difference between the initial and final weights was used to compute daily live weight gains for each diet and period.

Digestibility study: At the end of each period, rams on each concentrate mixture were used to measure digestibility. Apparent digestibility was calculated over a 5 d faecal collection period and a daily 25% aliquot was collected for processing. Faeces were dried in a forced air oven at 70°C for 36 h. Daily samples of faeces and diets in

each dietary treatment were bulked separately and milled with a simple laboratory mill to pass a 1.7 mm sieve. These were stored in air-tight bottles until required for analyses.

Analytical methods: Dry Matter (DM) content of feedstuffs (dried brewers' grains and copra meal), concentrate mixtures (*Yucca schidigera* saponin powder was added at four different dosage levels) and faeces were dried to constant weight at 70°C for 36 h in a forced air oven, ash by incineration at 600°C for 2 h. Crude Protein (CP) by a micro-Kjeldahl procedure [15]. All analyses were completed in triplicate.

Statistical analysis: Data on voluntary dry matter intake (DMI), daily live-weight gain (DLWG); Daily Crude Protein Intake (DCPI) and apparent nutrient digestibility coefficients were analyzed according to standard analysis of variance (ANOVA) using individual ram as replicate with MINITAB statistical software [16]. Where significant differences occurred, the Least Significant Difference (LSD) test was used for mean separation.

RESULTS

Table 2 presents the proximate chemical composition of the experimental diets and the forage fed to the rams during the different phases. The batiki grass had low crude protein content, but had high crude fibre and more nitrogen free extract than the concentrate mixtures.

Table 2: Proximate chemical composition of batiki grass and the concentrate mixtures

		Diets*			
Nutrients (%)	Batiki grass	D_1	D_2	D_3	D_4
Dry matter	82.5	84.2	89.8	90.2	90.7
Crude protein	4.1	16.4	16.9	17.8	18.1
Crude fibre	31.7	18.1	17.0	16.6	16.7
Ether extract	0.9	1.2	1.3	1.8	2.0
Ash	4.9	8.3	8.7	8.7	10.1
Organic matter	95.1	91.7	91.3	91.3	89.9
Nitrogen free extract	58.4	57.1	56.1	55.1	53.0

*D_1-0 mg YSP (Control); D_2-90 mg YSP; D_3-120 mg YSP and D_4-160 mg YSP

Table 3 presents performance characteristics of rams of the Fiji Fantastic sheep on the different levels of *Yucca schidigera* saponin powder in dried brewers' grains based concentrate mixtures.

Voluntary intake of the concentrate mixtures was 333.4, 341.9, 374.5 and 380.0 g d^{-1} for the rams on D1 and D2; D3 and D4, respectively, however there was no significant difference ($p>0.05$) in intake of the concentrate mixtures among the rams in the four dietary treatments. Voluntary dry matter intake (DMI) of the forage portion was high in all dietary treatments, however, the rams on D4 had higher forage intake, while those on D1, D2 and D3 had similar level of forage intake. Total dry matter intake (DMI) (concentrate+forage) followed the pattern of

Table 3: Voluntary feed intake, daily live-weight gain; feed efficiency and apparent nutrient digestibility coefficients of rams

	Diets*			
Parameters	D_1	D_2	D_3	D_4
Initial live weight (kg)	44.7	43.5	41.5	41.5
Final live weight (kg)	54.0	60.0	58.0	59.0
Live weight gain (kg)	9.3	16.5	17.0	17.5
Daily gain (g d^{-1})	111.0a	196.0b	202.0b	203.0b
Feed Intake				
Concentrate intake (DM g d^{-1})	333.4	341.9	374.5	380.0
Forage intake (DM g d^{-1})	1109.6	1109.6	1109.6	1149.2
Total dry matter intake (concentrate + forage (g d^{-1})	1443.0	1451.5	1484.1	1529.2
Total dry matter intake (g kg^{-1} $W^{0.75}$/DM)	234.1	235.2	239.1	244.5
Feed efficiency (feed/gain)	13.6a	7.4b	7.3b	7.5b
Apparent nutrient digestibility coefficients (%)				
Dry matter	63.4	65.4	67.0	66.5
Crude protein	70.6	76.9	76.3	78.4
Crude fibre	50.3	52.9	56.9	59.8
Daily protein (N×6.25) intake (g kg^{-1} $^{0.75}$/day	9.8	12.9	13.6	14.2

*D_1-0 mg YSP (Control); D_2-90 mg YSP; D_3-120 mg YSP and D_4-160 mg YSP; a, b Means in the same row followed by different letters are significantly different ($p<0.05$)

forage intake. DMI expressed on metabolic weight basis was 234.1, 235.2, 239.1 and 244.5 g kg^{-1} $W^{0.75}$/day for D1, D2, D3 and D4, respectively. Total DMI improved numerically with incremental levels of *Yucca schidigera* saponin powder ($p>0.05$). Daily Live Weight Gain (DLWG) was lower ($p<0.05$) in rams on D1. Live-weight gains of rams on D2, D3 and D4 that had *Yucca schidigera* saponin powder in their concentrate mixtures (Table 3) numerically improved.

Feed efficiency (g feed/g gain) was 13.6; 7.4; 7.3 and 7.5 for D1, D2, D3 and D4, respectively. The rams on D1 had the lowest feed efficiency while the rams on D2, D3 and D4 had similar feed efficiency (FE). This indicates that the rams on D1 will require more feed per gram of live weight gain.

Apparent nutrient digestibility coefficients-dry matter (DM), Crude Protein (CP) and Crude Fibre (CF) (Table 3) shows that CP and CF digestibility improved numerically but not at a significant level ($p>0.05$) with incremental levels of *Yucca schidigera saponin* powder in the concentrate mixtures. Daily Protein Intake (DPI) was 9.8 12.9, 13.6 and 14.2 (g kg^{-1} $W^{0.75}$/day) for rams on D1, D2, D3 and D4, respectively and it followed the pattern of CP digestibility. DPI improved with incremental levels of *Yucca schidigera* saponin powder in the DBG based concentrate mixtures.

DISCUSSION

This trial was carried out during the dry season period and the CP content of the batiki grass is consistent with value reported for batiki grass in Samoa by Aregheore [17] in the dry season period. Also, the average CP content of the concentrate mixtures did not differ from values used by Rokomatu and Aregheore [18] for sheep during the cool/dry season in Fiji.

Voluntary intake of the concentrate portion improved with incremental levels of *Yucca schidigera* saponin powder and this seems to indicate that Yucca saponin powder has a positive effect on feed intake. This however, contradicts Kaya *et al.* [19] who did not observe improved feed intake when Yucca extract was included in concentrate supplements for Awassi lambs. The differences observed might be due to the form and levels of the inclusion of Yucca saponin. While, Kaya *et al.* [19] used Yucca extract, this trial used *Yucca schigidera* saponin powder in the concentrate mixtures.

Total DMI obtained is higher than values reported earlier for rams of the Fiji Fantastic sheep by Rokomatu *et al.*, [18]. However, the total DMI observed is within values reported for rams that weighs between 50 to 60 kg [20].

Live Weight Gains (LWG) of the rams are higher than values reported by Rokomatu and Aregheore [21] for rams of the same breed in Fiji and the difference might be due to the inclusion of *Yucca schigidera* saponin powder in the concentrate mixtures. The improved live weight gain of the rams on *Yucca schigidera* saponin powder based concentrate mixtures (D2, D3 and D4) are consistent with Hale *et al.*, [22] who reported similar trend with lamb. Goodall and Matsushima [23, 24]; Goodall *et al.* [25, 26] also reported improved average daily gains in finishing steers fed high grain diets that were supplemented with Yucca saponins.

The inclusion of *Yucca schidigera* saponin powder in the concentrate mixtures improved voluntary DMI and Daily Live-weight Gains (DLWG) and this is consistent with Aregheore [26] who observed improved feed intake and live-weight gain in goats fed urea-ammoniated maize stover with incremental levels of *Yucca schigidera* saponin powder. The above observations therefore indicate that *Yucca schidigera* saponin powder has potentials to improve feed intake and also stimulate growth.

Yucca saponins play important role in animal nutrition because of their chemical structures. The biological effects of *Yucca schidigera* saponin on ruminant digestion and performance have generally been attributed to its content of steroidal saponins [11]. Due to the surfactant power of *Yucca schidigera* saponin, nutrient absorption is better from the cell membranes of the intestinal wall and this result in increasing the intestinal flora activity [27]. As a result of these effects, feed efficiency of livestock fed diets containing *Yucca schidigera* saponin improves and this observation supports our data. In our trial the rams that had *Yucca schidigera* saponin had improved and better feed efficiency compared to the control (D1).

CP digestibility was comparatively lower in rams on D1. Yucca saponins have strong anti-protozoal activity and this may serve as an effective defaunating agent for ruminant [28]. A possible reduction in the protozoa populations in the rumen of the rams on yucca based diets (D2, D3 and D4) might have contributed to improve nitrogen utilization and increased microbial flow to the intestine [29], which subsequently enhanced the growth performance of the rams.

The improved Daily Protein Intake (DPI) of the rams on the *Yucca schidigera* saponin based concentrate mixtures (D2, D3 and D4) indicates reduced N loss. This

will contribute to reduce the environmental impact of ruminants, because N contributes to environmental pollution as ammonia in the air and as nitrate in ground water [30]. The incorporation of saponins into ruminant diets in particular roughage-based diets has been reported to be advantageous because it would lead to higher microbial yield and lower emission of environment polluting gases, (CO_2 and CH_4) [14].

CONCLUSIONS

The improved perfomance in terms of voluntary DMI, FE, DPI, CP digestibility and subsequently DLWG of the rams on DBG based concentrate mixtures with incremental levels of *Yucca schidigera* saponin powder suggest that levels higher than 160 mg should be evaluated in further studies with DBG based concentrates for rams. The performance of rams that had *Yucca schidigera* saponin powder based DBG concentrate mixture was above those of the control (0 mg *Yucca schidigera* saponin powder) and this demonstrate that *Yucca schidigera* saponin powder has the potential to improve voluntary DMI and also live weight gains of rams and therefore suggest that levels higher than 160 mg used in this trial should be evaluated in DBG based concentrate mixtures for rams in further studies.

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