REPLACEMENT VALUE OF COPRA CAKE (*COCOS NUCIFERA*) IN DIETS CONTAINING INCREASING LEVELS OF DRIED BREWER'S GRAINS ON VOLUNTARY DRY MATTER INTAKE AND NUTRIENT UTILIZATION OF GOATS ON A BASAL DIET OF GUINEA GRASS (*PANICUM MAXIMUM*)

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Four (4) growing Anglo Nubian x Fiji local goats, 18 months old, mean pre-trial live body weights of 14.4 ± 1.2 kg were used in a randomized 4 x 4 Latin square design, to investigate the effects of replacement of copra cake with increasing levels of dried brewer's grains (DBG) on voluntary dry matter intake, body weight change, feed efficiency and nutrient utilization. Four concentrate mixtures (diets) were compounded, and these were designated as the Control, D_1, D_2 and D_3 and had 0, 35, 55 and 75 % DBG, respectively. These concentrate mixtures were fed for a 21-day period, separated by a 7-day adaptation period. There was no significant difference ($P > 0.05$) in the voluntary dry matter intake (DMI) of goats in the four concentrate mixtures. DMI expressed on metabolic weight basis for goats on 0, 35, 55 and 75% DBG concentrate mixtures were 36.6, 38.5, 36.1 and 35.6 g/kg $W^{0.75}$/day, respectively and these were not statistically significant ($P > 0.05$). Total DMI (forage + concentrate), digestible energy; crude protein and metabolizable energy intakes were similar among goats in the concentrate mixtures. There was significant difference ($P < 0.05$) in the body weight change (BWC) of the goats fed mixtures. Nutrient digestibility of goats in the concentrate mixtures was high. In conclusion, the results obtained in this study indicated that brewer's grains in its' dried form is a potential feedstuff in the concentrate mixture of goats and can replace a portion of copra cake in the diets of ruminant livestock.

goats; dried brewer's grains; copra cake; DMI; nutrient digestibility

INTRODUCTION

Goat is an important livestock in the Pacific Island countries (PICs) due to its high efficiency and ability to adapt to variable management systems under difficult climatic conditions (A m o a h , 1985). One of the factors militating against improved productivity in livestock industry in the PICs is the unavailability of sufficient feeds, lack of technical know-how on the processing of available ones and their incorporation in complete diets in stock nutrition. This has therefore necessitated the need to look inward into locally available and potential feed resources.

Copra cake and brewer's grains are available in most PICs with substantial population of ruminant livestock. Therefore with technical knowledge the smallholder farmer can economically and judiciously utilize in stock nutrition in the PICs. The idea of incorporating dried brewer's grain (DBG) into the livestock feeding system arose primarily from the desire to investigate available cheap and alternative feed resources for livestock in the PICs.

Brewer's grain is an important agro-industrial by-product that results from the manufacture of beer as extracted residues of malt (generally barley). It contains the insoluble material remaining after the process of mashing and cooking with water, which includes the fibre fractions, fats, proteins, together with residues of starch and dextrin. It constitutes a quality byproduct and the major use of this material has been used as a feed for livestock (B o v o l e n t a et al., 1998). B o v o l e n t a et al. (1998) and A n i g b o g u (2003) reported that dry brewer's grains could profitably be used in growing fattening diets for lambs. The concentration of fibre fractions and the low protein degradability means that the brewer's grains are preferentially used for feeding ruminants. Spent grains generated every year by the Western Samoa Breweries Ltd., are under utilized, regarded as environmental nuisance, therefore their economic value for livestock production are not yet fully appreciated.

Copra cake is an important byproduct of the coconut crushing industry after the oil is removed and is a local and readily available feed resource in all PICs. It could double as a protein and energy source in livestock feed (G a l g a l et al., 1994). Samoa produces approximately 1000 tons of copra cake annually (Coconut Oil Products Factory Source, personal communication, 2003).

Except for the report of A r e g h e o r e and T i n g (2002), there is scant information on the potential of dried brewer's grains as livestock feed. It is imperative to

investigate its feeding characteristics, productive responses, potentiality and to identify its optimum inclusion level in the concentrate mixtures of growing goats. The objective of this study therefore was to investigate the effects of replacing copra cake with increasing levels of dried brewer's grains on voluntary dry matter intake, body weight change and apparent nutrient digestibility of growing goats fed a basal diet of guinea grass (*Panicum maximum*) in Samoa.

MATERIALS AND METHODS

Experimental site

The experiment was conducted in the Goat unit of the University of the South Pacific, School of Agriculture (USP, SOA), Alafua campus, Apia, Samoa.

Animals

Four growing Anglo-Nubian x Fiji local goats, 18 months old with mean pre-trial live body weights 14.4 ± 1.2 kg, were allotted to a randomized 4 x 4 Latin square design. The goats were fed on each mixture for a 21-day period before it was changed. The first 7 days being for adaptation and adjustment of intake, the final 14 days for measurement of body weight change and digestibility study. Goats were individually housed in metabolic cages under a common roof.

Feeds

The feedstuffs and ingredients used were cassava flour, whole breadfruit flour, dried brewer's grains (DBG), copra cake (CC), mineral/vitamin premix and salt. Whole cassava tubers of a sweet variety (*Manihot dulcis*) were harvested washed and chopped into chips with a bush knife. Breadfruits were also chopped into chips in the same way as the cassava tubers. Both the cassava and breadfruit chips were oven dried to a constant moisture level and milled at CCK factory, Apia. The resultant products after milling were designated as whole breadfruit flour (WBF) and cassava flour (CF), respectively. Batch of wet brewer's grains supplied by the Western Samoa Brewery Ltd. to the University of the South Pacific, Livestock Farm were spread on dry concrete floor and turned regularly until they were dry. The CC was purchased from Coconut Oil Products Factory (COPS) at Vaitele, Samoa. The feedstuffs and ingredients were then compounded into four concentrate mixtures in which the copra cake was replaced by varying levels of DBG. The concentrate mixtures were designated as control, D_1, D_2 and D_3 and had 0, 35, 55 and 75% dried brewer's grains, respectively. Table 1 presents the percentage composition of feedstuffs and ingredients used in the diets.

Goats were weighed prior to being allocated to a new concentrate mixture. The goats received the concentrate mixture *ad libitum* however, feed offered was adjusted daily for increased or decreased intake by keeping the refusal rate at ~ 10–20% of the intake. The basal diet of guinea grass (*Panicum maximum*) was harvested fresh daily and chopped with a manual chaff-cutter into pieces of 10 mm before being fed to the animals according to the specified feeding times. The forage was sampled every week for dry matter determination.

Feed refusals were collected each day and weighed in order to assess the level of intake before any feed is offered. The goats had access to ample drinking water. Records of feed intake and body weight changes were kept. The difference between the initial and final weights was used to compute body weight change of goat in each concentrate mixture and period.

Digestibility studies

During the 7-day digestibility study, faeces of each goat were collected each morning before feeding to determine daily total faecal output for each goat, before 25% of the amount collected was removed for dry matter determination. Samples of faeces, concentrate mixtures and forage were dried in a forced-air oven at 70 °C for 48 h and daily samples bulked for each goat, milled with a simple laboratory mill and stored in air-tight bottles until required for analysis. Sub-samples of refusals collected were also dried at 90 °C, bulked for each goat, milled with a simple laboratory mill and stored in air-tight bottles for analysis.

Analytical procedures

Dry matter was determined by drying at constant weight at 70 °C for 24 h in a forced-air oven, ash by incineration at 600 °C for 2 h. Protein content was determined by the micro-Kjeldahl procedure according to AOAC (1995). Fibre fractions, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin were determined by the procedures of Van Soest et al. (1991). The NDF was assayed with sodium sulfite, without alpha amylase and was expressed with residual ash. While gross energy values were determined with a bomb calorimeter (Adiatic bomb, Parr Instrument Company, Moline, IL., USA) using thermochemical benzoic acid as a standard.

Statistical analysis

Data on voluntary dry matter intake, body weight change and apparent nutrient digestibility coefficients were statistically evaluated using analysis of variance (ANOVA) with goats, period and concentrate mixture included as the main effects and where significant differ-

Table 1. Percentage composition of experimental diets

	Diets: Levels of dried brewer's grains (DBG)*			
	Control	D_1	D_2	D_3
Ratio (DBG : CC)	0 : 100	48.9 : 51.1	76.9 : 23.1	96 : 3.4
Ingredients, % DM				
Dry brewer's grains	0.00	35.00	55.00	75.00
Copra cake	71.50	39.00	22.00	4.00
Whole breadfruit flour	20.50	18.00	15.00	13.00
Cassava flour	6.00	6.00	6.00	6.00
Mineral-vitamin premix[a]	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
Calculated analysis (%)				
Crude protein	16.60	16.50	16.30	16.60
Gross energy (MJ/kg DM)	14.20	14.50	14.70	13.80

* control (0 % DGB), D_1 = 35% DBG, D_2 = 55% DBG, D_3 = 75% DBG

[a] Summit multi-mineral salt/vitamin (Auckland, New Zealand): The mineral/vitamin block contains salt (NaCl), 120 g/kg calcium, 60 g/kg phosphorus, 60 mg/kg manganese, 150 mg/kg copper, 1.5 mg/kg cobalt, 7.5 mg/kg iodine, 600 mg/kg manganese, 750 m/kg iron, 600 mg/kg zinc, 1.5 mg/kg selenium, vitamin A, D and E

ences were found, least significant difference was utilized for comparisons among treatment means (Minitab, 2000).

RESULTS

Table 2 presents a proximate chemical composition of feedstuffs used in the concentrate mixtures. Copra cake and dried brewer's grain have relatively high dry matter (DM) content. Copra cake has a crude protein value of 24.2% while DBG has a higher value for crude fibre (22.2%) and other fibre fractions (NDF, ADF and ADL). Whole breadfruit flour and cassava flour have low DM and CP contents.

Table 3 presents a proximate chemical composition of concentrate mixtures and forage fed to the goats. Fibre contents of the mixtures increased with incremental levels of dried brewer's grains whereas non-fibre carbohydrates (NFC = 100 – /NDF + crude protein + fat + ash/) decreased with higher levels of DBG. The forage was low in DM and CP but had high fibre content.

Table 2. Proximate chemical composition of feedstuffs used in the concentrate mixtures

Nutrients (%)	Feedstuffs*			
	CC	WBF	CF	DBG
Dry matter	97.8	83.5	88.9	93.3
Analysis on DM basis				
Crude protein	24.2	5.9	4.2	18.1
Ether extract	9.6	1.7	0.3	2.2
Neutral detergent fibre	20.3	36.6	36.9	42.8
Acid detergent fibre	29.1	22.9	23.9	30.9
Acid detergent lignin	15.9	11.5	7.7	18.1
Gross energy (MJ/kg DM)	14.9	13.1	13.8	15.7

*CC – copra cake, WBF – whole breadfruit flour, CF – cassava flour, DBG – dry brewer's grains

Voluntary dry matter (DM) intake, body weight change (BWC), protein and digestible energy intake of the goats is presented in Table 4. Voluntary forage intake was significantly ($P < 0.05$) higher in goats on 75% DBG. Forage and concentrate intakes were similar among goats on 0, 35 and 55% DBG. Total voluntary feed intake (forage + concentrate) was not significantly different ($P > 0.05$) among goats in the concentrate mixtures. DM intake expressed on metabolic weight basis for goats was also not statistically significant ($P > 0.05$).

Body weight change of goats on the mixtures that had copra cake replace with DBG 55 and 75% were similar. Also total DMI, daily crude protein and metabolizable energy intakes were similar among goats in the four concentrate mixtures.

Apparent nutrient digestibility coefficients of goats on the concentrate mixtures with varying levels of DBG are presented in Table 4. Except for the digestibility of acid detergent lignin that was low in the control diet ($P < 0.05$), digestibility of other nutrients was high and within the same level among goats in the different concentrate mixtures.

DISCUSSION

The various feedstuffs and ingredients were compounded into four concentrate mixtures in a way to meet the nutritional requirements of growing goats in Samoa. CC is gritty and the grittiness depends on the method used for oil extraction. The CP content of CC seems higher than the values previously reported by

Table 3. Proximate chemical content of experimental concentrates and forage

	Diets: Levels of dried brewer's grains (DBG)*				
	Control	D_1	D_2	D_3	Forage
Ratio (DBG : CC)	0 : 100	48.9 : 51.1	76.9 : 23.1	96.6 : 3.4	–
Nutrient (%)					
Dry matter	84.7	78.1	79.4	80.7	35.0
Analysis on DM basis					
Crude protein	16.6	16.5	16.3	16.6	7.0
Ash	7.9	3.8	2.8	6.7	9.8
Ether extract	5.2	8.8	9.1	5.8	2.2
Neutral detergent fibre	37.7	35.9	38.3	40.2	55.2
Acid detergent fibre	27.8	22.1	23.0	35.6	30.18
Acid detergent lignin	17.9	18.2	18.2	19.6	21.7
Non fibre carbohydrate (NFC)**	32.6	35.0	33.5	30.7	25.8
Energy (MJ/kg DM)	14.2	14.5	14.7	14.9	13.8

* Control (0% DGB), D_1 = 35% DBG, D_2 = 55% DBG, D_3 = 75% DBG
** Non-fibre carbohydrates (NFC): 100 – (NDF + crude protein + fat + ash)

Table 4. Voluntary feed intake, body weight change, feed efficiency, protein and digestible energy intake

	Diets: Levels of dried brewer's grains (DBG)*			
	Control	D_1	D_2	D_3
Ratio (DBG : CC)	0 : 100	48.9 : 51.1	76.9 : 23.1	96.6 : 3.4
Parameters				
Forage	62.6^b	61.2^b	61.9^b	70.4^a
Concentrate	58.8	68.8	57.6	46.5
Total dry matter intake (g)	121.4	130.0	119.5	116.9
Dry matter intake (g/kg$W^{0.75}$/day)	36.6	38.5	36.1	35.6
Initial body weight (kg)	14.1	14.3	14.8	14.6
Final body weight (kg)	15.40	18.1	23.6	23.4
Body weight change (kg)	1.3^c	3.8^b	8.8^a	8.8^a
Body weight change (g/d)	6^c	18^b	42^a	42^a
Daily protein (N x 6.25) intake (g/kg$W^{0.75}$/day)	12.7	13.2	12.2	12.8
Digestible energy (MJ/kg/DM)	10.8	10.9	10.3	11.2
Metabolizable energy intake (Kj/kg$^{0.75}$/day)	413.9	422.0	372.3	396.8
Nutrients digestibility (%)				
Dry matter	74.8	75.9	69.6	76.1
Organic matter	78.4	78.1	74.1	76.4
Crude protein	76.3	80.1	74.6	77.1
Neutral detergent fibre	63.3	68.7	72.9	73.4
Acid detergent fibre	66.2	73.5	73.9	75.1
Acid detergent lignin	48.9^a	63.1^b	66.8^b	66.3^b
Energy	75.9	75.6	70.2	74.8
Total digestible nutrients (TDN)	79.3	79.7	75.0	75.8

* Control (0% DGB), D_1 = 35% DBG, D_2 = 55% DBG, D_3 = 75% DBG
a, b, c – figures in the same row not marked by the same prefix are significantly different from each other ($P < 0.05$)

Aregheore (2001), and the differences might be due to the method used in the oil extraction. Also, the CP, NDF, ADF, ADL and gross energy contents of the DBG are higher than the values previously reported by Aregheore (2001) and Aregheore, Ting (2002) in Samoa. The differences observed might be due to the type of grains and drying method used. However, the CP value is similar to that reported by Anigbogu (2003) for dried brewer's grain in Nigeria. The low CP content of cassava and breadfruit flours are characteristics of roots and starch fruits.

The CP of the concentrate mixtures used in this trial is higher than the values reported earlier by Aregheore and Ting (2002) for similar age of goats. The variation might have occurred due to the source of protein used in the concentrate mixtures. Aregheore and Ting (2002) used urea as the protein source in brewer's grains based diets. Nutrient content of the forage (Guinea grass) is similar to that reported by Gohl (1981).

DMI of the goats in the concentrate mixtures supports the reports of Bovolenta et al. (1998) in Italy and Anigbogu (2003) 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.

Goats on the 75% DBG based concentrate mixture had more forage intake and this is consistent with the report of Lechner-Doll et al. (1991), who identified the goats as an 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 due to palatability problem. Ensminger et al. (1990) reported that dried brewer's grains have low palatability. Furthermore the high DM content of the DBG compared to forage could be responsible for the low DMI observed.

Data on body weight changes obtained in this experiment should be treated with caution because the goats were on each concentrate mixture for a short duration and may not exactly reflect the level of animal performance the mixtures might support if fed for a long time. However, the low body weight change observed might probably be due to (i) negative interaction of the copra cake with other feedstuffs and ingredients; (ii) the high dietary fibre content of copra cake which might have interfered with the absorption of other nutrients (fibre in its macro-molecular form, is anti-nutritional due to gel formation (hydrated polysaccharides) (Aregheore, 1999). Also, rancidity is a major problem associated with copra cake and, fatty acids in copra cake have high proportions of Lauric acid (C_{12}), a fatty acid. Lauric acid has antibacterial and antifungal properties (Virgin Coconut Oil Book, 2003), which can seriously affect rumen metabolism and consequently the growth.

The digestibility of nutrients inclusive the fibre fractions in the concentrate mixture were high demonstrating that DBG can replace copra cake up to the 75% level and still satisfy the maintenance and growth requirements of goats without detrimental effects. Bovolenta et al. (1998) and Anigbogu (2003) reported that dry brewer's grains could profitably be used in growing fattening diets for lambs. DBG is a feed that is high in both protein and energy and therefore should be explored in the PICs where brewery industry exists because of its potential. In conclusion, the results obtained in this study indicated that brewer's grains in its dried form is a potential feedstuff in the concentrate mixture of goats and can replace a portion of copra cake in the diets of ruminant livestock. Further studies should be carried out to determine the effects of levels above 75% in the concentrate mixtures of goats.

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Hodnota náhrady kokosových výlisků (*Cocos nucifera*) v krmných dávkách obsahujících zvýšené hladiny sušeného pivovarského mláta s volným příjmem sušiny a využití živin u koz krmených bazální krmnou dávkou Johnsonovy trávy (*Panicum maximum*).

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Do pokusu byly zařazeny čtyři rostoucí kozy plemen anglo-nubijské x místní Fidži ve věku 18 měsíců, s průměrnou živou hmotností před začátkem pokusu 14,4 ± 1,2 kg. Úkolem randomizovaného pokusu latinských čtverců bylo sledovat vliv sušeného pivovarského mláta na volný příjem sušiny, změnu tělesné hmotnosti, účinnost krmiva a využití živin. Čtyři krmné směsi (dávky) byly smíchány a tvořily kontrolu, D_1, D_2, D_3 a obsahovaly 0, 35, 55, resp. 75 % sušeného pivovarského mláta. Tyto směsi se podávaly zvířatům během 21 dnů, oddělených sedmidenním adaptačním obdobím. Nebyl zjištěn významný rozdíl ($P > 0,05$) ve volném příjmu sušiny u koz krmených čtyřmi druhy krmných směsí. Příjem sušiny vyjádřený na základě metabolické hmotnosti pro kozy krmené směsmi s 0, 35, 55 a 75 % sušeného pivovarského mláta byl 36,6; 38,5; 36,1 a 35,6 g/kg $W^{0,75}$ na den a tyto hodnoty nebyly statisticky významné ($P > 0,05$). Celkový příjem sušiny (píce + koncentrát), stravitelné energie, dusíkatých látek a metabolizovatelné energie byl obdobný jako u koz krmených jadrnými krmnými směsmi. Významný rozdíl ($P < 0,05$) byl zjištěn ve změně tělesné hmotnosti u koz krmených směsmi. Stravitelnost živin v jadrných krmných směsích byla vysoká. Výsledky pokusu ukázaly, že pivovarské mláto v sušené formě je vhodným přídavkem do jadrných krmných směsí pro kozy a může v krmných dávkách pro přežvýkavce nahradit kokosové výlisky.

kozy; sušené pivovarské mláto; kokosové výlisky; příjem sušiny; stravitelnost živin

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