

# Voluntary Intake and Digestibility of Fresh, Wilted and Dry *Leucaena* (*Leucaena leucocephala*) at Four Levels to a Basal Diet of Guinea Grass (*Panicum maximum*)

Eroarome Martin Aregheore\*

The University of the South Pacific, School of Agriculture, Animal Science Department

Alafua Campus, Private Mail bag, Apia, Samoa

**ABSTRACT :** Sixty crossbred Anglo-Nubian goats (growing females), 18-24 mo of age, with a mean pre-experimental live weight of  $20.9 \pm 0.44$  kg were used to investigate voluntary dry matter intake (DMI) and digestibility of supplements of *Leucaena leucocephala* (LL) leaves to a basal diet of guinea grass. The experiment was a 3 forms of presentation: fresh, wilted and dry  $\times$  4 levels of supplementation: 10, 20, 30 and 40% of total forage allowance with LL leaves. The goats were assigned based on weight and age to one of the twelve diets in a randomized manner and each level had five animals (replicates) per diet for 56 days. The form of presentation of LL leaves had effects on dry matter (DM) and nutrient composition. DM and NDF were higher in the dry LL leaves ( $p < 0.05$ ). In the diets, CP increased as the level of supplementation with LL leaves increased ( $p < 0.05$ ). Mean CP was similar in the fresh ( $14.8 \pm 3.5\%$ ), wilted ( $14.3 \pm 3.3\%$ ) and dry forms ( $13.9 \pm 3.1\%$ ). Neutral detergent fibre (NDF) decreased linearly ( $p < 0.05$ ) with increase in levels of supplementation. Organic matter (OM) followed the trend of CP concentration ( $p < 0.05$ ). Drying was observed to reduce the availability of CP at the different levels of supplementation and subsequently this affected the NDF of the diets. DM intake of the goats on the fresh and wilted LL leaves was significantly higher ( $p < 0.05$ ) than in those on the dry LL leaves. DM intake of the basal diet was observed to decrease as the level of supplementation ( $p < 0.05$ ) increased regardless of the form of presentation of LL. Growth rate was best ( $p < 0.05$ ) on the fresh form followed by wilted and the least in the dry form. Growth rate decreased linearly ( $p < 0.05$ ) with increase in the level of supplementation in the dry form. The form of presentation and level of supplementation influenced DM, CP and OM digestibility ( $p < 0.05$ ). Except for NDF, the digestibility of DM, CP and OM were better ( $p < 0.05$ ) in the goats on fresh LL leaves compared to the wilted and dry leaves. Based on the data on DMI, growth rate and apparent nutrient digestibility coefficients, the results suggest that LL leaves is best utilized when fed fresh or wilted to goats. In the dry form of presentation, the best level of supplementation without a reduction in voluntary DMI and growth rate is the 20%. In the fresh and wilted form, LL leaves could be fed up to the 40% level with improved DMI, growth rate and nutrient utilization. (*Asian-Aust. J. Anim. Sci.* 2002, Vol 15, No. 8 : 1139-1146)

**Key Words :** *Leucaena Leucocephala*, Fresh, Wilted, Dry, Goats, DM Intake, Growth, Digestibility

## INTRODUCTION

The importance of browse in the diets of tropical ruminants has been well documented (Reynolds and Adediran, 1988; Ash, 1990; Mtenga and Madsen, 1992; Larbi et al., 1993; Devendra, 1995; Jabbar et al., 1997; Mandal, 1997; Aganga et al., 1999; Aregheore, 2000a). *Leucaena leucocephala*, a highly productive and palatable tropical legume, is one of the most widely used forage trees in agropastoral enterprises as it provides a number of other resources (e.g., fuelwood, green manure and shade) apart from its protein-rich forage (Brewbaker et al., 1985; Morris and Du Toit, 1998). Increased levels of *Leucaena* in the diet of ruminant animals have been shown to increase forage dry matter (DM) intake and live-weight (LW) gains (Walwynni et al., 1972; Jones, 1977; Yates and Panggabean, 1988; Quirck et al., 1990; Petty et al., 1998; Morris and Du Toit, 1998).

A major problem in utilization of *Leucaena* by livestock is the presence of the non-protein amino acid mimosine in the forage. Ingestion of large quantities of mimosine can lead to acute and chronic toxicosis, weight loss and death (Hammond, 1995; Morris and Toit, 1998). The presence of DHP (3-hydroxy-4(1H)-pyridone), a degradation product of mimosine, tends to depress rumen cellulolytic activity and cause rumen stasis (Jones and Wilson, 1987; Adejumo and Ademosun, 1991). Mimosine toxicity in *Leucaena* diets can be limited by the introduction of mimosine degrading organisms into the rumen (Reynolds and Adediran, 1985; Ademosun et al., 1988; Jabbar et al., 1997; Morris and Toit, 1998).

Guinea grass (*Panicum maximum*) is a native pasture in most Pacific Island countries and like most tropical grasses grows rapidly during the rainy season and declines in nutritive value during the dry season. Goats grazing guinea grass alone grow and reproduce slowly in the dry season. There are reports that productivity of ruminant animals, for example goats browsing *Leucaena* can be improved by providing mineral supplementation (i.e., phosphorus and sodium) and high energy forage, such as grasses, since

\* Corresponding Author: Eroarome Martin Aregheore. Tel: +685 21-671-x229, Fax: +685-22-933, Email: aregheore-m@samoa.usp.ac.fj

Received July 26, 2001; Accepted April 10, 2002

*Leucaena* is inherently low in phosphorus, sodium and digestible energy (Morris and Du Toit, 1998).

It has been reported that drying or wilting may influence chemical composition and digestibility (Mahyuddin et al., 1988; Palmer and Schlink, 1992; Smith et al., 1995) and voluntary intake (ILCA, 1990) of some tropical browse species. Goats consume fresh browse leaves more than dried leaves. To preserve for future use and to reduce the effects of some inherent anti-nutritive factors present in the leaves of some browse species either drying or wilting is employed at the on-farm level of production. The objective of this experiment was to investigate the effects of different forms (i.e., fresh, wilted and dry) of presentation and four levels of supplementation (i.e., 10, 20, 30 and 40) of *Leucaena leucocephala* on performance of goats fed a basal diet of guinea grass in confinement.

## MATERIALS AND METHODS

### Diets, feeding and management

A re-growth of guinea grass (*Panicum maximum*) was harvested cut with a bush knife into pieces 7 to 8 mm in length and fed fresh as the basal diet. This diet was supplemented with leaves from *Leucaena leucocephala* re-growth, either fresh, wilted or dry. These were offered at 10, 20, 30 and 40% of the total daily forage allowance. The basal and supplemental components of the diets were offered separately.

An adaptation period of 7 d was allowed for goats to adapt to the experimental diets before the 8-wk growth trial. The basal diet and *Leucaena* were fed *ad libitum* to allow 10 to 20% refusals. Feeds offered and refused were recorded on a daily basis to estimate voluntary DM intake. Cleaning of pens and removal of refusals from the previous day was done daily before supplying each day's ration. All goats were allowed free access to mineral/vitamin blocks and drinking water *ad libitum*. The mineral/vitamin block contained salt (NaCl), 120 g/kg calcium, 60 g/kg phosphorus, 150 mg/kg copper, 1.5 mg/kg cobalt, 7.5 mg/kg iodine, 600 mg/kg manganese, 750 mg/kg iron, 600 mg/kg zinc, 1.5 mg/kg selenium; Vitamins A, D and E with copra meal and molasses added.

### Animals, treatment and experimental design

The experiment was conducted using a total of 60 growing crossbred female Anglo-Nubian goats of 18 to 24 mo of age with a mean pre-experimental LW of  $20.9 \pm 0.44$  kg. During the experiment, goats were randomly assigned based on weight and age to one of the twelve diets. The animals were individually penned under a common roof. The design of the experiment was a 3 (forms of *Leucaena*: fresh, wilted or dry)  $\times$  4 (levels of guinea grass supplementation at 10, 20, 30 and 40% of total dry matter

intake) arrangement of treatments in a randomized manner with five animals (replicates) per diet.

*Leucaena* leaves were defined as fresh or wilted, respectively, if harvested within 2 or 26 h of feeding. The dried leaves were harvested from the same site, at the same stage of maturity and sun-cured before the start of the experiment. The levels of guinea grass supplementation were calculated as percentage of total *ad libitum* daily forage allowance.

### Digestibility study

At the end of the growth trial, the goats were used to determine digestibility of the diets for 7 days. Total daily faecal output for each animal was weighed before a 25% sample was removed for DM determination. Faeces were dried in a forced air oven at 70°C for 24 h. The daily samples of faeces and diets were bulked separately and milled with a simple laboratory mill to pass a 1.7 mm sieve and stored in air tight bottles until required 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 24 h, and protein by a micro-Kjeldahl procedure (AOAC, 1995). Neutral detergent fibre (NDF) was determined by a procedure of Van Soest et al. (1991). Minerals (calcium and phosphorus) were determined using an atomic absorption spectrophotometer (GBC 908 AA, Scientific Equipment Pty Ltd, Dandenong, Victoria, Australia), as described by AOAC (1995). All analyses were conducted in triplicate.

### Statistical analysis

Data on voluntary feed intake, growth rate and apparent nutrient digestibility coefficients were analyzed at 3 (forms of leucaena)  $\times$  4 (level of guinea grass supplementation) factorial treatment arrangements in a randomized complete block design. Forms of leucaena, levels of supplementation and interactions between these effects were fitted in a full analysis of variance (ANOVA) (Steel and Torrie, 1980). Where significant differences were observed between forms, levels of supplementation and interactions between these effects, treatment means were partitioned to test linear, quadratic and cubic orthogonal contrasts using the General Linear Model (GLM) procedures (SAS, 1988).

## RESULTS

### Dry matter, crude protein, P and Ca of fresh, wilted and dry LL leaves

The crude protein (CP) content increased as the level of *Leucaena* supplementation ( $p < 0.05$ ) increased in the different forms of LL leaves used for the diets. CP was

greater in the fresh ( $31.2 \pm 0.4\%$ ), followed by wilted ( $29.3 \pm 0.8\%$ ) and the least in the dry ( $27.5 \pm 1.01\%$ ) form (table 1). CP concentrations were 3.7 and 1.8 g/100 g higher in the fresh and wilted LL leaves respectively, than in the dry form. NDF content was higher ( $p < 0.05$ ) in the dry form than in the fresh or wilted forms. Organic matter concentrations (OM) followed the trend of CP concentrations. The form of presentation of *Leucaena leucocephala* leaves affected the concentration of P, but not Ca concentration. The Ca:P ratio was 8:1 for the LL leaves.

#### Dry matter and nutrient composition of diets

The form of presentation and level of supplementation affected DM content ( $p < 0.05$ ) of the diets (table 2). DM concentrations for all forms of presentation of LL leaves with the basal diet of guinea grass were observed to decrease ( $p < 0.05$ ) with increase in the level of supplementation. CP concentration increased with increase in the level of supplementation within each form of presentation ( $p < 0.05$ ). Mean CP concentrations were  $14.8 \pm 0.25\%$ ,  $14.3 \pm 0.32\%$  and  $13.9 \pm 0.13\%$  for fresh, wilted

and dry forms, respectively. Statistically, there were no significant differences in CP concentration of the diets between the different forms of presentation.

The form of presentation and level of supplementation of LL leaves with the basal diet had effects on the concentration of NDF and ash. NDF concentration followed the pattern of DM concentration. Drying was observed to increase the fibre concentration of the LL leaves ( $p < 0.05$ ). In the various diets, the OM contents decreased linearly ( $p < 0.05$ ) with incremental levels of supplementation of the forage with the LL leaves. The basal diet and the various levels of *Leucaena* were high in DM content and in other nutrients.

#### Voluntary dry matter intake (total intake)

Dry matter intake (DMI) of the basal diet was observed to decrease as the level of supplementation ( $p < 0.05$ ) increased regardless of the form of presentation of LL leaves in the total diet (table 3). In the fresh and wilted form, the intake of the basal diet was significantly higher ( $p < 0.05$ ) than in the dry form. Comparison of LL leaves at all levels

**Table 1.** Chemical composition of *Leucaena leucocephala* and guinea grass, (*Panicum maximum*)

Leucaena leucocephala	Nutrients					
	DM	CP % DM	NDF % DM	OM % DM	Phosphorus g/kg	Calcium g/kg
Fresh	$43.8 \pm 0.40^c$	$31.2 \pm 0.4^a$	$38.6 \pm 0.8^c$	$95.0 \pm 1.02^a$	$0.24 \pm 0.01$	$1.85 \pm 0.00$
Wilted	$68.5 \pm 0.28^b$	$29.3 \pm 0.8^b$	$44.4 \pm 0.6^b$	$94.0 \pm 0.9^a$	$0.24 \pm 0.01$	$1.85 \pm 0.01$
Dry	$89.0 \pm 0.62^a$	$27.5 \pm 1.0^b$	$59.5 \pm 0.4^a$	$90.5 \pm 0.01^b$	$0.20 \pm 0.01$	$1.85 \pm 0.01$
Guinea grass*	$82.2 \pm 0.10$	$7.0 \pm 0.25$	$56.0 \pm 0.5$	$84.0 \pm 0.2$	$0.42 \pm 0.01$	$0.45 \pm 0.00$

±SEM-Standard error of mean.

<sup>a,b,c</sup> Means within each column followed by a different superscript differs ( $p < 0.05$ ).

**Table 2.** Chemical composition of the diets supplemented with four levels (10, 20, 30 and 40%) of *Leucaena leucocephala*

	Level of supplementation (%)				SEM	Contrast		
	10	20	30	40		Linear	Quadratic	Cubic
Fresh								
DM, %	79.8	68.4	63.0	54.0	0.36	<0.01	<0.01	<0.01
CP, % DM	10.1	13.2	16.4	19.5	0.25	<0.01	<0.01	<0.96
NDF, % DM	58.9	53.3	49.9	43.4	0.38	<0.01	<0.31	<0.02
OM, % DM	89.1	89.0	90.0	90.7	0.39	<0.01	>0.36	>0.46
Wilted								
DM, %	85.0	82.8	81.4	79.0	0.38	<0.01	>0.83	>0.31
CP, % DM	9.9	12.9	15.8	18.7	0.32	<0.01	>0.62	<0.20
NDF, % DM	58.9	55.4	54.5	53.1	0.35	<0.01	<0.02	<0.09
OM, % DM	89.1	90.0	91.0	91.0	0.37	<0.01	<0.25	>0.50
Dry								
DM, %	92.0	90.0	89.0	87.0	0.29	<0.01	>1.00	<0.15
CP, % DM	9.8	12.5	15.3	18.0	0.13	<0.01	<0.01	>0.52
NDF, % DM	66.4	60.6	58.3	56.3	0.35	<0.01	<0.01	<0.08
OM, % DM	88.0	90.0	91.0	91.0	0.30	<0.01	<0.01	>1.00

<sup>a</sup> Probability for linear, quadratic and cubic trends,  $p < 0.05$  (significant);  $p > 0.05$  (not significant).

**Table 3.** Voluntary intake (g DM kg<sup>-1</sup> BW<sup>0.75</sup> day<sup>-1</sup>) of guinea grass [*Panicum maximum*, (PM)] based diet supplemented with fresh, wilted and dried leaves of *Leucaena leucocephala* (LL) at four levels by crossbred Anglo-Nubian goats; and proportion of (% day<sup>-1</sup>) of *Leucaena leucocephala* refused (LLR) and in total feed consumed (LLTI)

	Level of supplementation (%)				SEM	Contrast		
	10	20	30	40		Linear	Quadratic	Cubic
<b>Fresh</b>							Probability <sup>a</sup>	
Average daily gain (g/kgBW <sup>0.75</sup> )	79	98	112	114	5.81	<0.01	>0.07	>0.76
PM consumed (g/kgBW <sup>0.75</sup> )	520	476	419	378	9.71	<0.01	>0.86	>0.51
LL consumed (g/kgBW <sup>0.75</sup> )	87	142	206	252	3.44	<0.01	<0.20	<0.09
Total DM intake (PM+LL) (g/kgBW <sup>0.75</sup> )	607	618	625	630	12.21	>0.05	>0.83	>0.99
LLR (%)	13.0	29.0	31.3	37.0	0.98	<0.01	<0.01	<0.01
LLTI (%)	14.3	15.9	32.9	40.0	1.03	<0.01	<0.02	<0.01
DM/gain (g/g) feed conversion ratio	7.7	6.3	5.6	5.5	0.37	<0.01	>0.99	>0.93
<b>Wilted</b>								
Average daily gain (g/kgBW <sup>0.75</sup> )	78	82	98	102	5.37	<0.01	>0.99	>0.33
PM consumed (g/kgBW <sup>0.75</sup> )	553	462	397	294	5.46	<0.01	>0.31	<0.02
LL consumed (g/kgBW <sup>0.75</sup> )	80	138	195	238	1.82	<0.01	<0.01	<0.17
Total DM intake (PM+LL) (g/kgBW <sup>0.75</sup> )	633	600	592	532	5.89	<0.04	<0.01	>0.99
LLR (%)	20.0	31.0	35.0	40.5	0.87	<0.01	<0.01	>0.05
LLTI (%)	13.1	23.0	32.7	44.7	0.78	<0.01	<0.05	>0.48
DM/gain (g/g) feed conversion ratio	7.9	7.3	6.1	5.2	0.63	<0.01	>0.66	>0.
<b>Dry</b>								
Average daily gain (g/kgBW <sup>0.75</sup> )	61	60	51	46	2.85	<0.01	>0.49	>0.039
PM consumed (g/kgBW <sup>0.75</sup> )	420	391	381	353	2.67	<0.01	>0.85	<0.01
LL consumed (g/kgBW <sup>0.75</sup> )	78	124	142	138	1.57	<0.01	<0.01	>0.40
Total DM intake (PM+LL) (g/kgBW <sup>0.75</sup> )	498	515	523	491	3.37	>0.40	<0.01	>0.06
LLR (%)	22.0	38.0	52.7	65.5	0.90	<0.01	<0.05	>0.88
LLTI (%)	15.7	24.1	27.2	27.9	0.98	<0.01	<0.01	>0.52
DM/gain (g/g) feed conversion ratio	8.2	8.6	10.2	10.6	0.63	<0.01	>0.85	>0.20

<sup>a</sup> Probability for linear, quadratic and cubic trends,  $p < 0.05$  (significant);  $p > 0.05$  (not significant).

of supplementation indicated that the intake of the guinea grass (basal diet) was higher ( $p < 0.05$ ) at the 40% level of supplementation in the dry form than in the wilted. But the intake of the basal diet in the fresh form was higher than in both the wilted and dry forms of presentation of LL leaves.

The goats readily accepted and consumed the *Leucaena* leaves in all forms of presentation and also at the different level of supplementation. However, voluntary DMI by the goats on the fresh and wilted *Leucaena leucocephala* leaves was relatively higher, while intake at the dry form was significantly lower ( $p < 0.05$ ).

#### Growth rate and feed conversion ratio (DM/gain)

Growth rate was influenced ( $p < 0.05$ ) by the form of presentation and the level of supplementation of LL leaves to the basal diet (table 3). In the fresh and wilted forms, growth rate was observed to improve ( $p < 0.05$ ) with increase in the level of supplementation. However, growth rate of the goats offered LL leaves in the dry form, decreased linearly ( $p < 0.05$ ) with increase in the level of supplementation. Amongst the three forms of presentation, growth rate was highest ( $p < 0.05$ ) in the fresh followed by wilted and the least in the dry form. Also the form of presentation and level of supplementation affected ( $p < 0.05$ ) feed conversion

ratio (DM/gain) among the goats.

#### Apparent nutrient digestibility coefficients

The form of presentation and level of supplementation influenced DM digestibility (table 4) as well as other nutrients ( $p < 0.05$ ). The digestibility of DM, CP and OM were better ( $p < 0.05$ ) in the goats on fresh form of *Leucaena leucocephala* leaves diet than those on the wilted and dry forms of presentation. The digestibility of CP increased with incremental levels of supplementation of the basal diet with LL leaves in the fresh and wilted forms of presentation ( $p < 0.05$ ) than in the dry form of LL leaves. However, NDF digestibility was higher for all levels of presentation in the dry form than in the fresh and wilted forms of presentation ( $p < 0.05$ ). OM digestibility on the other hand was higher in the fresh and wilted forms than in the dry form of presentation.

## DISCUSSION

#### Nutrient composition of forms of *Leucaena* (fresh, wilted and dry), diets and guinea grass

The reduction in the CP concentration of the dry *Leucaena* leaves was probably due to reactions (e.g.,

**Table 4.** Apparent nutrient digestibility coefficients by goats of Guinea grass (*Panicum maximum*) and *Leucaena leucocephala* at three forms (fresh, wilted and dry) and four levels of supplementation (10, 20, 30 and 40%)

Forms		Levels of supplementation (%)				SEM	Contrast		
		10	20	30	40		Linear	Quadratic	Cubic
Nutrients						Probability <sup>a</sup>			
Fresh	Dry matter	48.5	50.7	58.8	62.6	0.21	<0.01	<0.01	<0.01
	Crude protein	71.3	72.3	73.4	73.1	0.14	<0.01	<0.01	<0.02
	NDF	57.3	52.1	50.1	48.9	0.67	<0.01	<0.01	>0.41
	Organic matter	49.4	49.5	59.6	63.2	0.19	<0.01	<0.01	<0.01
Wilted	Dry matter	44.9	50.3	56.8	60.8	0.28	<0.01	<0.02	<0.01
	Crude protein	68.2	70.2	72.2	72.3	0.32	<0.01	<0.01	>0.21
	NDF	56.3	52.8	50.4	49.9	0.72	<0.01	<0.06	>0.87
	Organic matter	45.5	48.1	56.2	61.4	0.34	<0.01	<0.01	<0.01
Dry	Dry matter	42.8	49.1	54.8	60.2	0.41	<0.01	>0.31	>0.79
	Crude protein	68.0	65.1	63.1	61.8	0.38	<0.01	>0.58	>0.42
	NDF	72.1	68.7	64.2	57.1	0.48	<0.01	<0.01	>0.51
	Organic matter	47.9	51.6	51.5	53.5	0.29	<0.01	<0.01	<0.01

<sup>a</sup> Probability for linear, quadratic and cubic trends,  $p < 0.05$  (significant);  $p > 0.05$  (not significant).

Maillard reactions) which reduced availability of nutrients during drying process. (Holmes, 1980). Such reactions might have resulted in changes in the cell-wall structures. The increased NDF concentration of the dry LL leaves is consistent with Parachristous and Nastis, (1994) who found that drying generally increased NDF and lignin content of browse leaves.

The protein contents of diets at the 10% level supplementation in the wilted and dry forms of presentation were less than 11%. However, they were above 8% CP suggested as adequate to meet requirements for moderate weight gain in goats below which could be considered deficient (Norton, 1994). The drying process did not lower the CP concentration of the diets with 20-40% levels of supplementation with LL leaves below the 11 to 12% CP suggested by the National Academy of Sciences (1981) as adequate to meet requirements for moderate weight gains in goats. Based on the suggestions of Norton (1984) and National Academy of Sciences (1981), the CP contents of the diets were adequate to meet the growth requirements of the goats.

Forages including browses carries higher Ca than P concentration in their leaves and this could be the reason for differences observed in concentrations of the two macrominerals. It was observed that the different forms of presentation of LL leaves had effects on P concentration but not on Ca. The mean P value of  $0.23 \pm 0.01$  g/kg<sup>-1</sup> DM for LL leaves used in this experiment is below the critical level of 1.4 g/kg<sup>-1</sup> DM for P suggested by McDowell, (1985); ARC, (1980) for animal needs. Also, the Ca value of  $1.85 \pm 0.01$  g/kg<sup>-1</sup> DM is below the critical level based on animal needs for Ca at 2.5 g/kg<sup>-1</sup> DM suggested by McDowell, (1985); ARC (1980). The available P and Ca concentrations in the LL leaves are significantly lower than

values reported by Little et al. (1989) for LL leaves. Morris and Du Toit (1988) reported that LL leaves are generally low in P and this was the case with the LL leaves used in this experiment. The P and Ca concentrations of the LL leaves used in this experiment are similar in values to those reported by Wahynni et al. (1972) for *Leucaena leucocephala* leaves in Jakarta, Indonesia.

The decrease in protein concentration observed through the drying of LL leaves might have contributed to the fall in P. This observation confirmed the report that the protein content of forage generally falls with P (Underwood, 1981). The above reasons may be responsible for the difference in the P concentration between the LL leaves in the fresh, wilted and dry forms.

Van Soest (1965) reported that the nutritive value of browse plants could be determined by their chemical composition. From available data, the chemical composition of the diets demonstrated that they were all high in nutritive value. Also, since protein is the most limiting nutrient for grazing animal productivity; the high protein concentration obtained suggested that the diets were adequate to meet the requirements of the growing goats. Also, the DM and CP concentrations of the guinea grass used in this experiment are within the values reported by Cawa (1999) for guinea grass fed to goats in Samoa during the dry season.

#### Voluntary dry matter intake

Fresh forage is the main and often the sole diet of ruminants in the humid tropics (Archimede et al., 1999), although most results that have been obtained so far on chemical composition, intake and total tract digestibility were obtained with dried forage for practical reasons (Minson, 1990). In this experiment, the nutritive value of

*Leucaena leucocephala* was compared at three forms of presentation (fresh, wilted and dry) and the results on intake suggested that goats preferred the fresh and wilted forms of LL leaves than the dry form.

Data on voluntary DM intake of the goats used in this experiment supports the findings of Jabbar et al. (1997), and Archimede et al. (1999) that intake of fresh forage was higher than for dried forage. ILCA (1990) reported a relatively higher intake of fresh *Leucaena leucocephala* leaves than dry leaves by the West African Dwarf sheep. Therefore the relative high DM intake observed for goats on the fresh and wilted LL leaves at the different levels of supplementation may be due to shorter retention time in the rumen due to the low NDF content (table 2), compared to DMI of the goats on dried LL leaves.

It has been reported that *ad libitum* intake is increased by an increase in the protein content of a diet (Smith et al., 1995). The reduced intake of dry LL leaves by the goats supports the finding of Parachristous and Nastis (1996) that drying increase neutral detergent fibre and lignin contents of forage thereby resulting in longer rumen retention time, slower rate of passage and consequently, reduced voluntary intake of dried leaves.

Also chemical reactions (e.g. Maillard reactions) during the drying process might have rendered the dry leaves more bitter (Holmes, 1980) and consequently less palatable to the goats relative to the fresh and wilted leaves. Such chemical reactions might have resulted in changes in cell-wall structures that could inhibit rumen microbial adhesion and subsequent breakdown of DM in the dry leaves. The results obtained on the effects of form of presentation are also in agreement with Palmer and Schlink (1992) that drying depress voluntary intake. The above reasons could be responsible for the differences observed in the DMI of the goats offered the various experimental diets.

The normal voluntary intake for ruminants is 40-90 g/kg BW<sup>0.75</sup> or 1-2.8% of body weight, and the values for the basal diet (guinea grass), the different form of presentation of LL leaves and finally total DM intake (PM+LL) are within this range. Van Soest (1994) reported that voluntary intake is the most important factor that determines the level of efficiency of ruminant productivity. The level of supplementation of LL leaves in the fresh and wilted forms supported a higher intake, however, this was not the case in the dry form of presentation. In the dry form of presentation, the intake of the basal diet was observed to increase up to the 30% level but declined linearly at 40% level.

#### Growth rate and feed conversion ratio (DM/gain)

The improved growth rate observed in the goats on the fresh and wilted LL diets supports the findings of Balogun and Otchere (1995) who reported improved live weight gain in Yankassa rams with increase in the level of *Leucaena*

diets up to 40%. Although, average growth rate declined in the dry form of presentation of LL leaves, goats were able to maintain a steady slow growth rate throughout the experimental period. Data on overall growth rate of the goats used in this experiment are comparable to the results obtained by Susumu (1999) and Solomona (1988) for the same age and breed of goat. However, the growth rates obtained in this experiment are at variance with Jabbar et al. (1997) who reported higher growth rate for dry LL leaves and lower rate for fresh LL leaves. The age and genotype of the goats, and environmental conditions might be implicated for the differences observed in the growth rate of the goats used in this trial and those used by Jabbar et al. (1997). Feed conversion ratio (DM/gain) followed the same pattern as growth rate.

This experiment confirmed with earlier reports (Jabbar et al., 1997; Balogun and Otchere, 1995; Morris and DuToit, 1998; Petty et al., 1998) that the productivity of ruminant on *Leucaena leucocephala* leaves could be improved among other things with the provision of a base fodder (grass) that has high energy content. Aregheore, (2000b) also, reported that in using a browse as a source of nitrogen, feed high in energy should be made available for proper rumen function and increase productivity – growth rate and better feed conversion ratio. The presence of the basal diet in form of guinea grass seems to have influenced the DMI and utilisation of the different diets for growth. NAS, (1977) recommended that the intake of LL leaves should be restricting to below 30% in ruminant diets since at very high levels toxicity may result and consequently animals may die. However, this depends on presence of rumen bacteria that could degrade mimosine.

The usual signs of toxicity from mimosine or its metabolite, DHP were not exhibited by the goats, although the 40% level of LL leaves used in this experiment is higher than the recommended lethal level stipulated by NAS, (1977). The possible reasons for the non-toxicity signs by the goats used in this experiment could be the effect of the basal fodder used, i.e. guinea grass. Another possible reason may be due to the short duration of the trial. The period of this experiment was not long enough for the goats to show signs of toxicity that could occur with long exposure to leucaena. However, prior to the experiment the goats were already exposed to the grazing of fresh *Leucaena* leaves on a free choice basis within the vicinity of the trial.

#### Apparent nutrient digestibility coefficients

The NDF concentration of the diets affected the digestibility of DM and the result obtained supported the report of Aganga and Monyatsiwa, (1999) that the higher the CF content (lignin) of the diets the lower the DM digestibility. Organic matter digestibility (OMD) is used to predict the value of metabolizable energy (ME). The higher

the OMD the higher the expected ME and the feed with higher OMD is expected to provide more energy and therefore more production, i.e. high live weight gain (Aganga and Monyatsiwa, 1999). The above observation was the trend in this experiment with respect to live weight gain. In the fresh and wilted form of presentation of *Leucaena leucocephala* leaves, OMD increased with increase in the level of supplementation, but in the dry form there was a linear decrease in OMD with increase in the level of supplementation with *Leucaena leucocephala* leaves in the diet. This may be the reason for the corresponding low live weight gains obtained in the goats fed the dry LL leaves diets (table 3).

Comparatively, drying depressed the rate of digestion and this could be the reason for the depressed voluntary dry matter intake observed at all the levels of supplementation in the dry form. Palmer and Schlink, (1992) as earlier stated, reported that drying of *Calliandra calothyrsus* depressed the rate of digestion compared to the fresh and wilted form of presentation. This trend therefore could affect the growth performance of the animals in question. The high digestibility of nutrients by the goats on the fresh *Leucaena leucocephala* leaves are in agreement with the findings of Bonsi et al. (1995).

### CONCLUSION

Results suggest that LL leaves should be fed fresh or wilted to crossbred Anglo-Nubian goats in Samoa. However, in the dry form of presentation, the best level of supplementation without a reduction in voluntary DMI and growth rate is the 20%. In the fresh and wilted forms, LL leaves could be fed up to the 40% level with improved animal performance i.e. improved voluntary DMI, growth rate. Also no toxicity symptoms were observed. Norton (1994) reported that the level of supplementation required depends on the quality of the basal diet, but the best animal performance is generally achieved when *leucaena* constitutes 40-60% (DM) of the diet. The acceptance of LL leaves up to the 40% level in the fresh and wilted forms may be associated with the basal diet. Browsers and grasses compliment each other in the provision of nitrogen, energy and other nutrients when fed to ruminant animals. This tree legume, *Leucaena leucocephala*, which is abundant throughout the Pacific Island countries, can play an important role in the efficient utilization of tropical grasses and should therefore form an integral part of ruminant feeding systems.

### ACKNOWLEDGEMENT

EMA is grateful to Mr. Eteuati Samaseia for taking care of the animals; Mr Daya Perera, the Senior Laboratory

Technician, Messrs Pueta Tanielu, Aitui Selu and others for Laboratory analyses.

### REFERENCES

- Ademosun, A. A., H. G. Bosman and H. J. Jansen. 1988. Nutritional studies with the West African Dwarf goats in the humid tropics. In: Goat Production in the Humid Tropics (Ed. O. B. Smith and H. G. Bosman). Pudoc, Wageningen, The Netherlands, pp. 51-61.
- Adeyemo, J. O. and A. A. Ademosun. 1991. Utilization of *Leucaena* as supplement for growing dwarf sheep and goats in the humid zone of West Africa. Small Rum. Res. 5:75-82.
- Aganga, A. A. and C. B. Monyatsiwa. 1999. Use of browses (*Terminalia sericea*, *Combretum apiculatum* or *Euclea schimperi*) as a supplement for growing Tswana goats. Trop. Anim. Hlth. Prod. 31(5):295-305.
- AOAC. 1995. Official Methods of Analysis, 16th edn. (Association of Official Analytical Chemists, Arlington, VA).
- Ash, A. J. 1990. The effects of supplementation with leaves from the leguminous trees *Sesbania grandiflora*, *Albizia chinensis* and *Gliricidia sepium* on the intake and digestibility of Guinea grass hay by goats. Anim. Feed Sci. Technol. 28:225-232.
- ARC. 1980. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureaux, Farnham, Royal, UK.
- Archimede, H., C. Poncet, M. Boval, F. Nipeau, L. Philbert, A. Xande and G. Aumont. 1999. Comparison of fresh and dried *Digitaria decumbens* grass intake and digestion by Black-belly rams. J. Agric. Sci. (Cambridge), 133:235-240.
- Aregheore, E. M. 2000a. Nutritive and anti-nutritive value of some tree legumes used in ruminant livestock nutrition in the Pacific island countries. J. South Pac. Agric. 6(2):50-61.
- Aregheore, E. M. 2000b. The *in vitro* estimation of energy value and organic matter digestibility of some tropical crop residues and browses used in intensive ruminant livestock production in the dry season. Scientia Agric. Bohem. 31(1):65-75.
- Balogun, R. O. and E. O. Otchere. 1995. Effect of level of *Leucaena leucocephala* in the diet on fed intake, growth and feed efficiency of Yankassa rams. Trop. Glds. 29:150-154.
- Bonsi, M. L. K., P. O. Osuji, A. K. Tuah and N. N. Umuna. 1995. Intake, digestibility, nitrogen balance and certain rumen characteristics of Ethiopian Menz sheep fed teff straw supplemented with cotton seed cake, dry sesbania, dry leucaena or fresh leucaena. Agrofor. Systems, 31:243-256.
- Brewbaker, J. L., N. Hedge, E. M. Hutton, R. J. Jones, J. B. Lowry, F. Moog and R. Van Den Beldt. 1985. *Leucaena*-forage production and use. (Nitrogen Fixing Tree Association: Hawaii).
- Cawa, K. 1999. Performance of crossbred Anglo-Nubian goats fed with Water Hyacinth (*Eichhornia crassipes*) in the South Pacific. B.Agric. Project. School of Agriculture, The University of the South Pacific, Apia, Samoa. p. 20.
- Devendra, C. 1995. Composition and nutritive value of browse legumes. In: Tropical Legumes in Animal Nutrition (Ed. J. P. F. D'Mello and C. Devendra). Cab International, Wallingford. Chapter 3, pp. 49-65.
- Hammond, A. C. 1995. *Leucaena* toxicosis and its control in ruminants. J. Anim. Sci. 73:1487-1492.
- Holmes, W. (Ed.) 1980. Grass, Its Production and Utilization.

- British Grassland Society. Blackwell Scientific Publication, London.
- ILCA. 1990. Annual Report 1989. International Livestock Centre for Africa, Addis Ababa, Ethiopia.
- Jabbar, M. A., L. Reynolds, A. Larbi and J. Smith. 1997. Nutritional and economic benefits of *Leucaena* and *Gliricidia* as feed supplements for small ruminants in the humid West Africa. *Trop. Anim. Hlth. Prod.* 29:35-47.
- Jones, R. J. 1979. The value of *Leucaena leucocephala* as a feed for ruminants in the tropics. *World Anim. Rev.* 31:13-23.
- Larbi, A., D. Thomas and J. Hanson. 1993. Forage potential of *Erythrina abyssinica*; intake, digestibility and growth rates for stall-fed sheep and goats in southern Ethiopia. *Agrofor. Systems*, 21:263-270.
- Little, D. A., Supriati Kompang and R. J. Petheram. 1989. Mineral composition of Indonesian ruminant forages. *Trop. Agric. (Trinidad)*, 66(1):33-37.
- Mahyuddin, P., D. A. Little and J. B. Towry. 1988. Drying treatment drastically affects feed evaluation and feed quality with certain tropical forage species. *Anim. Feed Sci. Technol.* 22:69-78.
- Mandal, L. 1997. Nutritive value of tree leaves of some tropical species for goats. *Small Rum. Res.* 24:95-105.
- McDowell, L. R. 1985. Nutrition of grazing ruminants in warm climates. Academic Press, Orlando, Florida, USA.
- Minson, D. J. (Ed.) 1990. Forage in ruminant nutrition, San Diego, California 92101, Academic Press, Inc.
- Morris, C. D. and L. P. Du Toit. 1998. The performance of Boer goats browsing *Leucaena leucocephala* in KwaZulu Natal, South Africa. *Trop. Glds*, 32:188-194.
- Mtenga, L. A. and A. Madsen. 1992. Experiences in protein supplementary feeding in weaned lambs and goat kids in Tanzania: The issue of dietary energy. In: *Small Ruminant Research and Development in Africa* (Ed. B. Ray, S. H. B. Lebbie and L. Reynolds). ILCA, Nairobi, Kenya, pp. 387-400.
- NAS (National Academy of Science). 1977. *Leucaena*-Promising forage and tree crop for the tropics. Washington DC., USA, p. 237.
- NAS (National Academy of Science). 1981. Nutrient requirements of domestic animals. No.15. Nutrient requirements of goats. Washington, DC.
- Norton, B. W. 1994. *Tree legumes in dietary supplements for ruminants*. In: *Forage tree legumes in Tropical Agriculture* (Ed. R. C. Gutteridge and H. M. Shelton). CAB International: Wallington. pp. 192-201.
- Palmer, B. and A. C. Schlink. 1992. The effect of drying on intake and the rate of digestion of the legume *Calliandra calothyrsus*. *Trop. Glds*, 26:89-93.
- Parachristous, T. G. and A. S. Nastis. 1994. Influence of deciduous broadleaved woody species in goat nutrition during the dry season in Northern Greece. *Small Rum. Res.* 20:15-22.
- Parachristous, T. G. and A. S. Nastis. 1996. Changes in chemical compositions and in vitro digestibility of oesophageal fistula and hand plucked forage samples due to drying method and stage of maturity. *Anim. Feed Sci. Technol.* 46:87-95.
- Petty, S. R., D. P. Poppi and T. Triglone. 1998. The effect of maize supplementation, seasonal temperature and humidity on the live-weight gain of steers grazing irrigated *Leucaena leucocephala*/*Digitaria eriantha* pastures in north-west Australia. *J. Agric. Sci. (Cambridge)*, 130:95-105.
- Quirk, M. F., C. J. Paton and J. J. Bushell. 1990. Increasing the amount of *Leucaena* on offer gives faster growth rates of grazing cattle in South East Queensland. *Aus. J. Expt. Agric.*, 30:51-54.
- Reynold, L. and S. O. Adediran. 1988. The effect of browse supplementation on the productivity of west African Dwarf sheep over 2 reproductive cycles. In: *Goat Production in the Humid Tropics* (Ed. O. B. Smith and H. G. Bosman). Pudoc, Wageningen, The Netherlands, pp. 83-91.
- SAS. 1988. SAS/STAT User's guide (Release 6.03) SAS Inst. Inc. Cary, NC.
- Smith, J. W., A. Larbi, M. A. Jabbar and J. Akinlade. 1995. Voluntary intake by sheep and goats of *Gliricidia sepium* fed in three states and at three levels of supplementation to a basal diet of *Panicum maximum*. *Agrofor Syst.*, 32:287-295.
- Solomona, S. L. 1988. The productivity of goats grazing batiki grass pastures and supplemented with locally produced concentrate diets. B. Agric. Special Project. The University of the South Pacific, School of Agriculture, Apia, Samoa. p. 27.
- Steel, R. G. D. and J. H. Torrie. 1980. Principles and Procedures of Statistics. McGraw-Hill, New York. p. 481.
- Susumu, G. 1999. Nutritional value of breadfruit in the diets of growing goats. B. Agric. Special Project. The University of the South Pacific, School of Agriculture, Apia, Samoa. p. 17.
- Topps, J. H. 1992. Potential, composition and use of legume shrubs and tress as fodders for livestock in the tropics. *J. Agric. Sci. (Cambridge)*, 118:1-8.
- Underwood, E. J. 1981. The Mineral Nutrition of Livestock. Commonwealth Agricultural Bureaux, Farnham, Royal, UK.
- Van Soest, P. J. 1965. Symposium on factors influencing voluntary intake of herbage by ruminants: Chemical composition and digestibility. *J. Anim. Sci.* 24:834-843.
- Van Soest, P. J. 1994. Nutritional Ecology of Ruminants, 2nd edn, Cornell University Press, Ithaca, NY, USA.
- Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods of dietary fibre, neutral detergent fibre and non starch polysaccharides in relation to animal nutrition. *J. Dairy Sci.* 74:3585-3597.
- Wahynni, S., E. S. Yulianti, W. Komara, N. G. Yates, J. M. Obst and J. B. Lowry. 1972. The performance of Ongole cattle offered either grass, sun-dried *Leucaena leucocephala* or varying proportions of each. *Trop. Anim. Prod.* 7:275-285.
- Yates, N. G. and T. Panggabean. 1988. The performance of goats offered elephant grass (*Pennisetum purpureum*) with varied amounts of *Leucaena* or concentrate. *Trop. Glds*, 22:126-131.