# VOLUNTARY INTAKE BY CROSSBRED ANGLO-NUBIAN GOATS OF WATER HYACINTH (*EICHHORNIA CRASSIPES*) FED IN TWO STATES PLUS GUINEA GRASS (*PANICUM MAXIMUM*) IN CONFINEMENT

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Chemical composition of water hyacinth, guinea grass and diets based on two states of presentation of water hyacinth: fresh and dry at 50% of total daily forage allowance were compared. Additionally, twelve crossbred Anglo-Nubian goats about 14–16 months old and pre-experimental body weight of 22.1 ± 0.9 kg were used in a completely randomized design experiment to investigate voluntary feed intake, growth rate, feed efficiency and apparent nutrient digestibility coefficients of water hyacinth diets. The diets were (1) 100% guinea grass, (2) 50% guinea grass + 50% fresh water hyacinth and (3) 50% guinea grass + 50% dry water hyacinth. The crude protein content of water hyacinth leaves was higher than that of the stem and stem + leaves. Crude protein, crude fibre and ether extract contents of diet 2 were higher than diets 1 and 3. Goats on diet 1 (100% guinea grass) were significantly higher in daily live weight gain ($P < 0.05$) than those on diets 2 and 3, respectively. Diet 2 goats were significantly better in live weight gain than those on diet 3 ($P < 0.05$). Average daily voluntary feed intake was significantly higher in diet 2 than in diets 1 and 3, respectively ($P < 0.05$). Feed efficiency was better in goats offered 100% guinea grass diet than diets 2 and 3 fed goats ($P < 0.05$). Dry matter digestibility was lower ($P < 0.05$) in goats offered diet 3 (50% guinea grass + 50% dry water hyacinth). Crude protein digestibility was higher in diet 2 followed by diet 3 and the least in diet 1 (100% guinea grass diet). Crude fibre digestibility was significantly different ($P < 0.05$) among the three diets. Ether extract digestibility was significantly lower in 100% guinea grass diet ($P < 0.05$) than in diets 2 and 3. Diet 3 was higher in apparent digestibility coefficient of ether extract compared to diet 2. Total digestible nutrients (TDN) was more in diet 1 ($P < 0.05$), while diets 2 and 3 had similar TDN values. The fresh water hyacinth diet was nutritionally superior to that of the dry water hyacinth diet. Nutrient composition of water hyacinth can be compared with any conventional forage. Average daily live weight gain of goats offered fresh or dry water hyacinth in conjunction with guinea grass demonstrated that goats could be sustained on a mixed forage diet involving water hyacinth. Data on

voluntary feed intake, live weight gain and nutrient utilization demonstrated that water hyacinth can be used with other forages as a cheap source of feed during the dry season in the Pacific Island countries.

water hyacinth; guinea grass; goats; feed; growth; nutrient digestibility

## INTRODUCTION

Water hyacinth (*Eichhornia crassipes* [Mart] Solms-Laubach) is a large, floating tropical aquatic plant with attractive, pale-violet and broad, bright green leaves on long stems (Becker et al., 1987). It is a menacing weed in many parts of the world. It establishes itself in nutrient rich water bodies. Urban dams and waterways are particularly at risks of its inversion because apart from effluent from industrial and domestic that is deposited in them, rivers that feed them bring a lot of nutrient from farming sector.

The weed is viewed as a problem to water hydrology and to navigation with small crafts. The destructive effect of water hyacinth comes from enormous mass growth of the plant that causes blocking of navigable water, blocking irrigation ditches, obstruction of fishing grounds and breeding ground for disease carriers.

As a forage, water hyacinth can be fed as a fresh fodder, as hay or silage either alone or combined with other components. Its feeding in the fresh form alone is not advocated because of its high water and ash contents (Osman et al., 1975). Dutta et al. (1984) reported that fresh form is toxic to goats. When fed alone it has low palatability, causes digestive disturbance because of high alkali content that limits its intake in the fresh form (Hentges, 1970) and strongly reduces dry matter intake of animals (Becker et al., 1987).

Despite the above-mentioned obstacles, the utilization of water hyacinth as an animal feed has been reported (Baldwin et al., 1975; Reddy, Mohan Rao, 1979; El-Serafy et al., 1981; Becker et al., 1987), and it is a cheap source of roughage for ruminants (Reza, Khan, 1981). In the Pacific Island countries, where low quality roughage and scavenging remains the major way by which small ruminants are fed during the dry season (Aregheore, 1999), water hyacinth could be investigated in conjunction with indigenous pasture species in rations for ruminants (Reddy, Mohan Rao, 1979).

To improve its acceptability, water hyacinth can be processed as hay or silage either alone or combined with other components. Bagnall et al. (1974) observed that a reduction in the ash content and subsequently the



addition of high proportions of additives and protein improves its acceptability when offered to ruminants. The silage can be successfully used up to 35% level in a ration while the green fodder should be limited to 10–20% of the ration (Knab, 1982 – cit. Becker et al., 1987).

Except for the recent report of Cawa (1999), no scientific information is available in the Pacific Island countries on the utilization of water hyacinth as an animal feed. This study was therefore designed to investigate the effects of two states of presentation of water hyacinth on voluntary feed intake by crossbred Anglo-Nubian goats in confinement in the tropical environment of Samoa.

## MATERIAL AND METHODS

### Site and processing of water hyacinth

The experiment was conducted at the University of the South Pacific, School of Agriculture, Alafua Campus, Apia, Samoa. Water hyacinth was harvested fresh and cut with a bush knife into pieces of about 5 cm long. The roots and stems were removed. Only the leaves were used in each of the diets reported.

### Experimental design and diets

The design of the experiment was a 2 (states of presentation of water hyacinth: fresh and dry) x 1 (level of presentation: 50% of total daily forage allowance) completely randomized design experiment. Water hyacinth was defined as fresh when harvested within 2–4 hrs before feeding and defined as dry when oven dried at 50 °C for 24 hrs before feeding. The samples of fresh and dry water hyacinth were separately mixed with guinea grass (*Panicum maximum*) at 50 : 50 (w/w). Also a control diet made up of 100% guinea grass was offered. The three diets in the trial were (1) 100% guinea grass, (2) 50% fresh water hyacinth + 50% guinea grass and (3) 50% dry water hyacinth + 50% guinea grass (Table I). The water hyacinth used throughout the period was harvested from the same spot from an open water drainage system around the Fugalei Crop Market in Apia, Samoa, while the guinea grass was harvested from a re-growth at the site of the goat unit.

### Animals

The goats used in the trial were twelve crossbred Anglo-Nubian goats about 14–16 months old, and pre-experimental body weight of 22.1 ± 0.9 kg. They were randomly divided into three experimental diets based on weight.

I. Treatments – diets

| Diets | States |
|---|---|
| 1 | 100% guinea grass (*Panicum maximum*) |
| 2 | 50% guinea grass + 50% fresh water hyacinth |
| 3 | 50% guinea grass + 50% dry water hyacinth |

Each treatment group has four replicates. The goats were drenched with a dewormer (Levicare, Anoare, Birkenhead, Auckland, New Zealand), and allowed free access to fresh clean water.

The goats were allowed to feed on each dietary treatment for 5 days as adjustment period before the trial started. At the end of the adjusted period 3.0 kg of each of the experimental diet was divided into two equal portions and offered at 8.00 and 16.00 hr. To allow voluntary feed intake and live weight gain/loss to be determined each animal was fed *ad libitum*. The offer was increased or decreased depending on intake of the animals. At early morning feeding refusals of previous day's feed was weighed and sampled. Only initial and final live weights were used to determine live weight gain/loss.

### Digestibility study

An adaptation period of 7 days was allowed to get the animals adjusted to cages. Faeces were collected each morning before feeding. This was followed by 7 days collection period. The total daily faecal output for each animal was weighed before 25% of the sample was removed for dry matter determination. They were later dried in a forced draught oven at 70 °C for 48 hours. Daily samples of faeces and diets were then bulked separately and milled with a simple laboratory mill and stored in airtight bottles until required for analysis.

### Analytical procedures

The AOAC (1990) method was used for nutrient contents of diets and faecal samples. All analyses were done in triplicate. Dry matter was determined by drying at 102 °C for 24 hours, ash by firing at 600 °C for 24 hours, and protein by the micro-Kjeldahl procedure. Gross energy values were determined by a bomb calorimeter (Adiabatic bomb, Parr Instrument Co., Moline, IL) using thermochemical benzoic acid as standard.



### Statistical analysis

The data obtained from these analyses were used in computing the digestibility of nutrients and energy (GE MJ/kg). Data on voluntary forage intake, growth rate, feed efficiency and nutrient digestibility were statistically evaluated according to standard analysis of variance (Steel, Torrie, 1980) and where significant differences occur, Bonferroni *t*-statistics were utilized for comparisons among treatment means (Gills, 1978).

## RESULTS

A representative analysis of water hyacinth (leaves, stem and stem/leaves) in Apia, Samoa, is given in Table II, while Table III presents the proximate chemical composition of the three experimental diets. The crude protein con-

II. Representative chemical composition of water hyacinth

| Nutrients | Water hyacinth leaves | Water hyacinth stem | Water hyacinth stem/leaves |
|---|---|---|---|
| Dry matter | 69.9 | 51.5 | 86.9 |
| Crude protein | 23.9 | 6.3 | 6.6 |
| Crude fibre | 10.5 | 15.2 | 14.6 |
| Ether extract | 1.4 | 0.9 | 1.3 |
| Ash | 15.6 | 18.7 | 16.6 |
| Gross energy MJ/kg of DM | 12.3 | 8.6 | 10.5 |

III. Proximate chemical composition of diets

| Nutrients (%) | Diets | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Dry matter | 84.5 | 87.6 | 93.7 |
| Crude protein | 7.0 | 8.9 | 6.4 |
| Crude fibre | 10.8 | 14.6 | 19.8 |
| Ether extract | 1.0 | 2.0 | 0.5 |
| Ash | 10.5 | 15.5 | 16.4 |
| Nitrogen free extract | 55.4 | 53.9 | 53.8 |
| Gross energy MJ/kg of DM | 13.8 | 12.6 | 13.3 |

tent of water hyacinth leaves was higher than that of the stem and the stem + leaves. Crude fibre was high in the stem and this was closely followed by the stem + leaves. The ash contents of the three parts were high. Crude protein, crude fibre and ether extract contents of diet 2 were higher than in diets 1 and 3. However, its gross energy was lower than those of diets 1 and 3 (Table III).

Performance characteristics of the goats offered the different diets (Table IV) showed that goats on diet 1 (100% guinea grass) were significantly higher in daily live weight gain ($P < 0.05$) than those on diets 2 and 3, respectively. Diet 2 fed goats were significantly better in live weight gain than those on diet 3 ($P < 0.05$). Average daily voluntary feed intake was significantly higher in diet 2 than in diets 1 and 3, respectively ($P < 0.05$). Feed efficiency was better in goats offered 100% guinea grass diet than diets 2 and 3 fed goats ($P < 0.05$). Feed efficiency followed the pattern of daily live weight gain.

Table V presents data on apparent nutrient digestion coefficients. Dry matter digestibility was lower ($P < 0.05$) in goats offered diet 3 (50% guinea grass + 50% dry water hyacinth). Although, diet 2 fed goats (50% guinea grass + 50% fresh water hyacinth) was 2.9 units higher in DM digestibility than diet 1, the difference was of no statistical significant value ($P > 0.05$). Crude protein digestibility was higher in diet 2 followed by diet 3 and the least diet 1 (100% guinea grass diet).

Crude fibre digestibility was significantly different ($P < 0.05$) among the three diets. Diet 3 (50% guinea grass + 50% dry water hyacinth) was significantly higher in crude fibre digestion followed by diet 2, while the least digestion of crude fibre was obtained in diet 1. Ether extract digestibility was significantly lower in 100% guinea grass diet ($P < 0.05$) than in diets 2 and 3. Diet 3 was higher in apparent digestibility coefficient of ether extract compared to diet 2. However, the digestibility of nitrogen free extract (NFE) was significantly lower in diet 3 ($P < 0.05$). Between diets 1 and 2 there was no significant difference in the digestibility of NFE ($P > 0.05$). Total digestible nutrients (TDN) was more in diet 1 ($P < 0.05$), while diets 2 and 3 had similar TDN values. In the digestibility of energy, no significant differences were observed among the three diets ($P > 0.05$).

IV. Performance characteristics of goats fed the experimental diets

| Parameters | | Diets | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Initial average body weight | (kg) | 22.7 ± 1.23 | 22.0 ± 0.98 | 21.6 ± 0.46 |
| Final average body weight | (kg) | 29.2 ± 1.63 | 24.3 ± 2.10 | 23.0 ± 0.81 |
| Body weight gain | (kg) | 6.5 ± 0.40 | 2.3 ± 1.12 | 1.4 ± 0.35 |
| Daily average live weight gain | (g/day) | $162^{a}$ | $58^{b}$ | $35^{c}$ |
| Average daily feed intake | (g/day) | $517^{b}$ | $533^{a}$ | $489^{c}$ |
| Feed efficiency | (feed/day) | $3.2^{a}$ | $9.2^{b}$ | $13.9^{c}$ |

a, b, c – mean values on the same row with different superscripts differ significantly ($P < 0.05$)

V. Apparent digestibility coefficients of diets

| Nutrients (%) | Diets | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Dry matter | $73.3 \pm 0.69^{a}$ | $76.2 \pm 0.42^{a}$ | $64.9 \pm 0.08^{b}$ |
| Crude protein | $71.0 \pm 0.06^{b}$ | $77.0 \pm 0.14^{a}$ | $74.0 \pm 0.62^{ab}$ |
| Crude fibre | $26.1 \pm 1.00^{c}$ | $47.8 \pm 1.02^{b}$ | $83.0 \pm 0.08^{a}$ |
| Ether extract | $59.7 \pm 1.42^{c}$ | $72.3 \pm 0.74^{b}$ | $76.6 \pm 0.48^{a}$ |
| Nitrogen free extract | $84.5 \pm 0.94^{a}$ | $83.6 \pm 0.88^{b}$ | $61.6 \pm 0.64^{c}$ |
| Total digestible nutrients | $56.1 \pm 1.32^{b}$ | $56.5 \pm 0.58^{b}$ | $65.1 \pm 0.94^{a}$ |
| Gross energy | 76.8 ± 1.00 | 74.8 ± 0.82 | 76.2 ± 1.04 |

a, b, c – mean values on the same row with different superscripts differ significantly ($P < 0.05$)

## DISCUSSION

The proximate chemical composition of nutrients of the water hyacinth is close to the values reported by Reddy et al. (1985) and Reza and Khan (1981). However, it has been observed that water hyacinths vary in nutrient composition according to fertility of water at the harvest site, stage of plant growth and processing method (Stewart, 1970; Boyd, 1972). The same is true for land forages (Baldwin et al., 1974).

The major issue in this trial was to investigate the effectiveness of water hyacinth offered in two states (fresh and dry) plus guinea grass in diets of crossbred Anglo-Nubian goats in terms of growth promoting ability, voluntary feed intake, feed efficiency and nutrient utilization. Among goats in the three treatments, there was no forage refusal throughout the experimental period. The method of preparation (chopping) of the water hyacinth and guinea grass before mixing may be implicated in the voluntary feed intake. All conditions being equal goats consume and obtain their nutrients from herbage that grows on unimproved pasture. Goats are selective feeder (Lu, 1988) and are also well known for utilizing a wide spectrum of native forages (Becker, Lohrman, 1992). The non-refusal of the foliage in either the

fresh or dry states indicates that water hyacinth is an accepted forage in the nutrition of goats. The results obtained on voluntary feed intake supports earlier views expressed on the utilization of water hyacinth as an animal feed (Baldwin et al., 1975; Reddy, Mohan Rao, 1979; El-Serafy et al., 1981; Becker et al., 1987). This also supports the report that water hyacinth could be utilized in conjunction with indigenous pasture species in rations for ruminants (Reddy, Mohan Rao, 1979). Although animals offered 50% guinea grass + 50% fresh water hyacinth had a higher voluntary feed intake, live weight gain was significantly higher in 100% guinea grass fed goats. The low live weight gain obtained in the goats offered fresh or dry water hyacinth in comparison to those on 100% guinea grass may be due to the high ash content of water hyacinth. High ash content in the form of silicium has been reported to be present in water hyacinth. Van Soest and Jones (1968) suspect an impairment of availability of organic contents (cell-wall carbohydrates) due to silicium compounds. It has been suggested that soluble silicium compounds affects digestibility through lytic enzyme inhibition and insoluble compounds through cell-wall incrustation (Van Soest, Lovelace, 1969). The low live weight gain obtained in goats on the dry water hyacinth diet may also be due to low dry matter content of the diet. Low dry matter content of a diet leads to lower intake of nutrients and that ultimately results in low live weight gain.

In this trial, feed intake was not impaired in the 2 states (fresh or dry) of presentation of water hyacinth diets. This suggested that the ash content of water hyacinth used in this trial was low and therefore did not affect voluntary feed intake. The inclusion of guinea grass may have diluted the ash content and hence the high feed intake observed in goats offered diet 2 (50% guinea grass + 50% fresh water hyacinth). The low live weight gain in the goats offered fresh or dry water hyacinth diet may also be due to insufficient energy and protein intake (Aregheore, 1999).

Apparent digestibility coefficients of all nutrients improved with the water hyacinth diets in conjunction with guinea grass (Table V). Digestibility, however, was higher in the dry water hyacinth diet. The reason that could be adduced to this trend may probably due to lower degradation rate and longer rumen retention of the diet. The longer the retention of a diet in the rumen the more digested it becomes because it allows time for extensive microbial digestion. For diets 1 and 2 forages offered were fresh, therefore ther was faster degradation rate and a lower rumen retention time. However, the fresh water hyacinth diet was nutritionally superior to that of the dry water hyacinth diet.

The nutrient composition of water hyacinth can be compared with any conventional forage and the average daily live weight gain obtained in goats



offered fresh or dry water hyacinth in conjunction with guinea grass demonstrated that goats could be sustained on a mixed forage diet involving water hyacinth. The results of this trial demonstrated that the nutritive value of water hyacinth could be improved by mixing with indigenous pasture species or other feed components. In conclusion, data on voluntary feed intake, live weight gain, feed efficiency and nutrient utilization demonstrated that water hyacinth can be used with other forages as a cheap source of feed during the dry season in the Pacific Islands countries. Throughout the experiment period there was no feed refusal or body weight loss and animals did not show any sign of stress or ill health. This further demonstrated that water hyacinth could be used in diets for maintenance, production and growth of goats without deleterious effects.

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AREGHEORE, E. M. – CAWA, K. (The University of the South Pacific, School of Agriculture, Apia, Samoa):

**Dobrovolný příjem čerstvého a suchého vodního hyacintu (*Eichhornia crassipes*) podávaného spolu s guinejskou trávou (*Panicum maximum*) hybridním anglo-nubijským kozám v období omezených zdrojů krmiv.**

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Práce pojednává o možném krmném využití vodního hyacintu (*Eichhornia crassipes*), který je obávaným tropickým vodním plevelem s obrovským produkčním potenciálem a vitalitou. Působí zarůstání námořních vodních koridorů a zavlažovacích kanálů, odkud musí být kvůli zajištění provozuschopnosti a funkce pravidelně odstraňován. O možnosti využití fytomasy tohoto druhu ke krmení dobytka se zmiňuje celá řada autorů (Baldwin et al., 1975; Reddy et al., 1979; El Serafy et al., 1981; Becker et al., 1987). V období sucha může být vodní hyacint zdrojem vlákniny pro přežvýkavce, ale s ohledem na nízké kvalitativní parametry tohoto krmiva se doporučuje jen 35% maximální podíl v siláži a 10–20% podíl v zelené hmotě (Knab, 1982 – cit. Becker et al., 1987).

Pokusy byly uskutečněny na Zemědělské univerzitě v jižním Pacifiku, kampus Apia, Samoa. Sklizený a vypraný vodní hyacint byl rozsekán na 5 cm dlouhé kousky a fytomasa stonků, listů a oddenků byla zkrmována v množství až do 50 % objemu denní krmné dávky. Byly testovány tyto tři varianty krmných dávek: 1. varianta: 100 % guinejské trávy, 2. varianta: 50 % guinejské trávy + 50 % čerstvého vodního hyacintu, 3. varianta: 50 % guinejské trávy + 50 % suchého vodního hyacintu. Předsoušená fytomasa varianty 3 byla sušena po dobu 2–4 hodin při teplotě 50 °C.

Pokusnými zvířaty byly hybridní anglo-nubijské kozy ve věku 14–16 měsíců a o vyrovnané hmotnosti 22,1 ± 0,9 kg. Prvních pět dní pokusu dostávaly kozy 3 kg krmné směsi (každá varianta) ve dvou stejných dávkách (v 8.00 a 16.00 hodin). Kromě krmné dávky přijímala zvířata krmivo do plné sytosti. Pravidelně byly sledovány změny hmotnosti (přírůstek, resp. úbytek hmotnosti). Stravitelnost byla průběžně hodnocena rozbory fekálií sebraných za sedmidenní periodu, které byly analyzovány ze sušiny stanovené při teplotě 70 °C. Vysoušení bylo prováděno po dobu 48 hodin. Byl vyhodnocován obsah bílkovinného dusíku stanovením mikrokjehdalizací, obsah popelovin (spalováním po dobu 24 hodin při teplotě 600 °C) a obsah celkové energie v kalorimetru. Získaná data byla statisticky vyhodnocena analýzou variance.

Obsah bílkovin v listech vodního hyacintu u krmné dávky 2 (s čerstvým hyacintem) byl vyšší než u krmné dávky 3 se sušeným hyacintem. Kozy, kterým byla podávána krmná dávka 1 (100 % guinejské trávy), dosahovaly nejvyšších denních přírůstků živé hmotnosti. Krmná dávka 2 (50 % guinejské trávy + 50 % čerstvého vodního hyacintu) byla signifikantně výživnější a obsahovala významně vyšší podíl stravitelných bílkovin než krmná dávka 3 (50 % guinejské trávy + 50 % suchého vodního hyacintu). Obsah stravitelné sušiny byl průkazně nejnižší u krmné dávky 3. Éterový extrakt stravitelných látek byl nejnižší u varianty se 100% podílem guinejské trávy. Celková nejnižší stravitelnost byla zjištěna u krmné dávky 3, zatímco u krmných dávek 1 a 2 byla zhruba stejná. Čerstvý vodní hyacint je tedy nutričně vhodnější než sušený. Praktickým závěrem prezentované práce je zjištění, že sušený vodní hyacint stejně jako čerstvý může být vhodným krmivem pro přežvýkavce zejména v době nenadálého sucha, kdy se v oblasti Pacifiku projevuje nedostatek krmiva s vhodným podílem vlákniny.

vodní hyacint; guinejská tráva; kozy; krmivo; růst; stravitelnost živin

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