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Effects of Water Hyacinth or Water Lettuce Substitution for Guinea Grass on Nutrient Digestibility by Growing Sheep

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Abstract

Two *in vivo* digestion trials were conducted (using the total collection method) to study the effects of water hyacinth *(Eichhornia crassipes)* or water lettuce *(Pistia stratiotes)* substitution for guinea grass (GG) on nutrient digestibility by growing sheep. Each trial involved 24 ram-lambs fed diets contain in various levels of ground water hyacinth (WH) or water lettuce (WL) hay. In trial I, a control diet made up of 46% ground maize, 30% ground GG hay, 15% groundnut cake, 8% cane molasses and 1% oyster shell was compared with diets in which 10, 20, or 30% WH hay replaced the same amounts of GG hay in the diets. Trial II was conducted in a similar manner using 10, 20 or 30% WL hay as replacements for equal amounts of GG hay. In trial I, the digestion coefficients for dry matter (DDM), organic matter (DOM), rude fiber (DCF) and gross energy (DGE) amoung the WH treatments were not different (P>0.05). Digestion coefficient for crude protein (DCP) was lower (P<0.05) for the WH-30 diet than for the other diets. The percent digestible ether extract (DEE) was higher (P<0.05) for the WH-0 and WH-10 diets than for the WH-20 and WH-30 diets with no differences (P>0.05) between either the WH-20 and WH-10 diets or WH-20 and WH-30 diets. The percent digestible ash (DAsh) among the experimental diets followed the general trend WH-10>WH-0>WH-20>WH-30 (P<0.05). The coefficients of digestible nitrogen free extract (DNFE) among the various diets followed the trend WH-30 = WH-10> WH-0>WH-20 (P<0.05). In trial II, there were no differences (P>0.05) among the WL treatments for DDM, DOM, DNFE and DGE. The percent DCP followed the trend (WL-0>WL-10 WL-30>WL-20 (P<0.05). Results obtained for percent DCF showed higher values (P<0.05) for the WL-20 and WL-30 diets than for the WL-0 and WL-10 diets with no differences (P>0.05) between either the WL-20 and WL-30 diets or the WL-0 and WL-30 (P<0.05). The results showed that WH and WL hays could be incorporated into the diets of growing sheep at levels of up to 30% with reasonably good levels of utilization and that WH and WL hays compared favourably with GG hay as roughages for growing sheep. However, the high level of ash in the aquatic weeds may limit the amount that could be successfully incorporated into livestock diets without adverse effects.

Introduction

Water hyacinth, *Eichhornia crassipes* which has its origin in South America (pieterse, 1978; and Becker et al., 1987) is regarded as the most noxious of all aquatic weeds and has exhibited the most spectacular example of explosive infestation (Little, 1969). Other noxious aquatic weeds include water lettuce *(Pistia stratiotes)*; hydrilla *(Hydrilla verticilata)*; water fern *(Azolla species)*; and salvinia *(Salvinia species)*. Aquatic weeds have caused obstructions in economically important waterways and lakes, blocked canals and pumps in irrigation projects and interfered with drainage and hydro-electricity production. Floating mats of aquatic weeds will drastically reduce penetration of light and thus, inhibit growth of phytoplankton. Under such dense mats, oxygen concentration will be depleted while carbon dioxide and acidity will be relatively high. Aquatic weeds provide a favourable habitat for mosquitoes which are vectors of diseases such as malaria, encephalitis and filariasis. In addition, fresh water snails which are intermediate hosts for the insidious, debilitating disease, schistosomiasis (bilharzia), have been found attached to the roots of certain aquatic weeds (National Academy of Sciences, 1976). Aquatic weeds also hinder boat traffic and interfere with fishing and fish culture. Pieterse (1978) pointed out that evaporation from water covered by aquatic weeds may be up to six times higher than that from open water. This problem is severe in tropical countries where warm water and increasing numbers of dams and irrigation projects foster the growth of aquatic weeds.

The negative effects of aquatic weeds on aquatic environment have led to considerable interest in the utilization of these weeds as livestock feeds (Baldwin, 1975; Surat and Singh, 1980; and Grandi, 1981). In this regard, most work have been done on water hyacinth. Data on the digestibility of most species of aquatic weeds by various classes of livestock and the optimum amounts that could be incorporated into their rations are inadequate and contradictory. Although Hentges (1970) observed no toxic effects on cattle fed fresh and sun-dried water hyacinth, Kashem *et al* (1983) observed that cattle fed fresh water hyacinth developed digestive disturbance attributed to high potassium and chloride intake. Kiflewahid (1975) suggested that fresh water hyacinth could be used to make up to 24% of the total diet of steers and that addition of energy or protein -rich feedstuffs, withering, drying, grinding or pelleting would increase the dry matter intake of the plant. Becker *et al.* (1987) found that water hyacinth silage could be successfully incorporated into ruminants' ration up to a level of 35%. In trials with buffalo steers fed hay, haylage and silage of water hyacinth, El-Serafy *et al.* (1981) observed that the animals consumed all forms of the water hyacinth, gained weight and were in positive nitrogen balance. Solly *et al.* (1983) substituted 50% of para grass with water hyacinth in the diets of newly weaned goats and observed similar performance with the standard group.

The objectives of this study were (a) to evaluate the nutritive values of water hyacinth and water lettuce hays as roughages for growing sheep; and (b) to observe the effects of substituting the aquatic weeds for guinea grass on nutrient digestibility by the animals.

Materials and Methods

Chemical analyses and two *in vivo* digestion trials were conducted to achieve the objectives of the research. Freshly harvested water hyacinth (WH), water lettuce (WL) and guinea grass (GG; which served as the control being a typical tropical terrestial forage and was harvested between the sixth and seventh weeks of regrowth) were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), crude fiber (CF), ether extract (EE) and ash as described by the Association of Official Agricultural Chemists (AOAC) (1975) Nitrogen free extract (NFE) was obtained in the usual manner. Other samples were sun-dried for 72h and used as feed ingredients for the in vivo digestion trials. In vivo digestion trials.

Two digestion trials were conducted with West African Dwarf ram-lambs weighing an average of 11.8kg. Each trial involved 20 ram-lambs alloted (at random by weight) to four treatments with six lambs per treatment. Trial I compared a control diet containing 46% ground maize, 30% chopped guinea grass hay, 15% groundnut cake, 8% cane molasses and 1% oyster shell with similar diets in which water hyacinth hay was incorporated at levels of

10, 20, or 30% of the diets as replacements for guinea grass hay. Trial II was conducted in a similar manner except that water lettuce hay was used instead of water hyacinth hay.

Each trial consisted of a 14-day pre-adjustment period, a 7-day adjustment period and a 7-day collection period. During the preadjustment period, animals in each treatment were housed together in separate covered pens bedded with wood shavings and fed the experimental diets *ad libitum* (animals had been on a diet similar to the control for some time). The lambs readily consumed the various diets after a few days of adaptation. After pre-adjustment, animals were housed in individual metabolism cages designed for the total separation of faeces and urine. Animals were kept in the cages during the adjustment and collection periods and feed offered was reduced to 70% of *ad libitum* consumption (about 500g/head/day, DM basis) during these periods. The chemical composition of the WH, WL and GG used for the digestion studies are shown on table I. The ingredient composition of the experimental diets for trials I and II are shown on tables II and III, respectively. The chemical composition of the experimental diets for trials I and II are shown on tables IIand III, respectively. Daily feed was divided into two equal parts and fed at 0800 and 1600h. Fresh, clean water and trace-mineralized salt licks were available to all animals *ad libitum* throughout the experimental periods.

Grab samples (about 50) of each experimental feed were collected during each feeding and kept in air-tight polythene bags. Total daily faeces voided by each experimental animal was weighed during the collection period and ten percent aliquot samples were kept in labelled plastic bags at 5°C. At the end of each trial, daily subsamples of each experimental diet were mixed together, ground in a Wiley mill (20-mesh screen) and kept in covered plastic containers for further analyses. Cumulative faecal samples of each experimental animal were dried in an oven at 60°C for 48h, ground and kept in similar manner as the feed samples. The experimental feed and faeces were analyzed for DM, OM, CP, CF, EE and ash as described previously. Gross energy was determined using a ballistic bomb calorimeter. Digestibility coefficients for the various components of each diet were obtained for each trial by the methods described by Schneider and Flatt (1975).

Statistical analyses

Data for the *in vivo* digestion coefficients were analyzed by the use of a one-way analysis of variance as described by Neter and Wasserman (1977). Means were compared using Duncan's new multiple range test as described by Steel and Torrie (1980).

Results and Discussion

The digestion coefficients for individual components of the diets containing various levels of WH hay as replacements for GG hay (trial I) are presented on table VI. Digestion coefficients for dry matter (DDM), organic matter (DOM), crude fiber (DCF) and gross energy (DGE) among the different diets were not significantly different ($p>0.05$). However, values obtained were reasonably good for the type of diets used. This suggests that WH hay could be incorporated into the diets of growing lambs up to a level of 30% without any adverse effects on the digestibility of these nutrients when compared with values obtained for a typical terrestial tropical forage. Digestibility of crude protein (DCP) was lower ($P<0.05$) for the WH-30 diet than for the other diets, indicating that incorporation of WH into the diets of growing sheep at levels greater than 20% would adversely affect the % CP digestibility. However the fact that WH contains higher level of CP than GG (11.3 and 6.7%, respectively;

table I) makes this result less meaningful since the total amount of CP in the diets would increase with increasing levels of WH. Thus, the amount of digestible CP would increase with increasing levels of WH in the diets.

The percent digestible ether extract (DEE) was higher (P<0.05) for the WH-0 and WH-10 diets than for the WH-20 and WH-30 diets with no differences (P>0.05) between either the WH-0 and WH-10 diets or the WH-20 and the WH-30 diets, indicating that the optimum level of DEE would be obtained when WH supplies 10% of the total diet. However, the low levels of EE in the various diets (3.6-4.5%; table IV) make this result less meaningful. The coefficients of digestible ash (DAsh) among the diets followed the general trend WH-10>WH-0>WH-20>WH-30 (P<0.05), showing that DAsh decreased with increasing levels of WH in tne diets. However, WH contains substantially higher levels of ash than GG (43 and 10.6%, respectively; table I) and the ash content of the diets increased with increasing level of WH. Thus, the amount of digestible ash would increase with increasing levels of WH in the diets. It should be noted that the high levels of ash in aquatic weeds may limit the amount that could be successfully incorporated into livstock diets. Diets containing 30% WH resulted in 15.7 and 14.9% ash, respectively (tables IV and V). These values are higher than those normally obtained in conventional sheep diets. Although no mineral toxicity symptoms were observed for animals in this study, higher levels of aquatic weeds in the diets of live stock could result in digestive disturbances as was observed by Kashem *et al;* (1983). The percent digestible N-free extract (DNFE) among the various diets followed the general trend WH-30 = WH-10> WH-20> WH-30 (P<0.05).

Table VII shows the digestion coefficients (%) for individual components of the diets containing various levels of WL hay as replacements for GG hay (trial II). There were no significant differences (P>0.05) among the various diets in DDM, DOM, DNFE and DGE, and the values obtained were similar to those obtained in trial I. Thus, WL hay could also be incorporated into the diets of growing lambs up to a level of 30% as replacements for GG hay with no adverse effects on the digestibilities of these nutrients. DCP tended to decrease (P<0.05) with increasing levels of WL in the diets. This shows that WL protein was less readily digested by growing lambs than GG protein. However, the fact that WL contains higher amount of CP than GG (15.4 and 6.7%, respectively) makes this result less meaningful. The results obtained for DCF showed higher values (P<0.05) for the WL-20 and WL-30 diets than for the WL-0 and WL-10 diets with no differences (P>0.05) between either the WL-20 and WL-30 diets or the WL-0 and WL-10 diets. This indicates a higher digestibility potential for the CF content of WL than that of GG. The Dee for the various diets was in the order WL-30>WL-0>WL-20 = WL-10 (P<0.05), while the percent DAsh followed the trend WL-20> WL-10 = WL-0>WL-30 (p<0.05).

Conclusions

Utilization of the diets offered to growing lambs was not affected when WH or WL hay was incorporated up to a level of 30% as replacements for GG hay. Thus, WH and WL hays compared favourably with GG as roughages for growing sheep. The aquatic weeds contain high level of ash which may limit the amount that could be successfully incorporated into livestock diets without adverse effects.

TABLE I: CHEMICAL COMPOSITION OF WATER HYACINTH, WATER LETTUCE, AND GENIES GRASS FORAGES

Item	Water hyacinth	Water lettuce	Guinea grass
Dry matter (DM, %)	10.2	5.2	33.1
Gross energy (kcal/g,DM)	2.2	2.6	3.5
Analysis, % of DM			
Organic matter (DM)	57.0	64.4	89.4
crude protein (CP)	11.3	15.4	6.7
Crude fiber (CF)	11.7	15.0	30.2
Ether extract (EE)	3.4	3.4	2.4
Ash	43.0	36.6	10.6
N-free extract (NFE)	30.6	29.6	50.1

TABLE II: INGREDIENT COMPOSITION (% DM BASIS) OF THE DIETS FOR *IN VIVO* DIGESTION TRIAL I

Ingredient	Treatment			
	WH-0[a]	WH-10[b]	WH-20[c]	WH-30[d]
Maize	46	46	46	46
Guinea grass hay	30	20	10	-
Water hyacinth hay	-	·10	20	30
Cane molasses	8	8	8	8
Oyster shell	1	1	1	1
Groundnut cake	15	15	15	15

[a]Water hyacinth supplied 0% of the total diet.

[b]Water hyacinth supplied 10% of the total diet.

[c]Water hyacinth supplied 20% of the total diet.

[d]Water hyacinth supplied 30% of the total diet.

TABLE III: INGREDIENT COMPOSITION (% DM BASIS) OF THE DIETS FOR *IN VIVO* DIGESTION TRIAL II

Ingredient	Treatment			
	WL-0[a]	Wl-10[b]	Wl-20[c]	WL-30[d]
Maize	46	46	46	46
Guinea grass hay	30	20	10	
Water lettuce hay	-	10	20	30
Cane molasses	8	8	8	8
Oyster shell	1	1	1	1
Groundnut cake	15	15	15	15

[a]Water lettuce supplied 0% of the total diet.

[b]Water lettuce supplied 10% of the total diet.

[c]Water lettuce supplied 20% of the total diet.

[d]Water lettuce supplied 30% of the total diet.

TABLE IV: CHEMICAL COMPOSITION OF THE DIETS FOR *IN VIVO* DIGESTION TRIAL I

Item	WH-0	WH-10	WH-20	WH-30
Dry matter (DM, %)	90.1	90.1	90.6	90.5
Gross energy (kcal/ of DM)	5.2	4.9	4.7	4.3
Analyses, % of DM				
Organic matter (OM)	92.7	89.4	86.9	84.3
Crude protein (CP)	13.6	14.0	14.5	14.9
Crude fiber (CF)	9.5	8.7	7.7	6.1
Ether extract (EE)	3.6	4.1	4.4	4.5
Ash	7.3	10.6	13.1	15.7
N-free extract (NFE)	66.0	62.6	60.3	58.8

TABLE V: CHEMICAL COMPOSITION OF THE DIETS FOR *IN VIVO* DIGESTION TRIAL II

Item	WL-0	WL-10	WL-20	WL-30
Dry matter (DM, %)	89.8	89.9	90.0	89.9
Gross energy (kcal/g of DM)	5.2	5.0	4.9	4.8
Analyses, % of Dm				
Oranic matter (OM)	92.1	89.2	87.2	85.1
Crude protein (CP)	13.6	14.5	15.3	16.4
Crude fiber (DF)	9.4	8.5	7.4	6.4
Ether extract (EE)	3.4	3.7	3.8	4.1
Ash	7.9	10.8	12.8	14.9
N-free extract (NFE)	57.7	59.5	62.4	61.5

TABLE VI: DIGESTIBILITY (%) OF INDIVIDUAL COMPONENTS OF THE DIETS CONTAINING VARIOUS LEVELS OFWATER HYACINTH HAY AS REPLACEMENTS FOR GUINEA GRASS HAY IN TRIAL I (MEANS OF SIX RAM-LAMBS)

Component	WH-0	WH-10	WH-20	WH-30
Dry matter (DDM)	66.1	67.3	63.9	67.3
Organic matter (DOM)	68.9	70.4	68.1	71.9
Crude protein (CP)	71.7[b]	70.7[b]	69.1[b]	63.5[a]
Crude fiber (DCF)	35.1	31.0	37.4	37.8
Ether extract (DEE)	84.2[b]	84.8[b]	73.4[a]	75.8[a]
Ash (DAsh)	23.2[b,c]	26.0[c]	20.4[a,b]	17.1[a]
N-free extract (DNFE)	72.2[a,b]	74.1[b,c]	71.0[a]	75.9[c]
Gross Energy (DGE)	68.4	67.2	63.6	69.7

[a,b,c] Means in the same row with different superscripts differ (P<0.05).

TABLE VII: DIGESTIBILITY (%) OF INDIVIDUAL COMPONENTS OF THE DIETS CONTAINING VARIOUS LEVELS OF WATER LETTUCE HAY AS REPLACEMENTS FOR GUINEA GRASS HAY IN TRIAL II (MEANS OF SIX RAM-LAMBS)

Component	WL-10	WL10	WL-20	WL30
Dry matter (DDM)	59.6	57.1	61.2	62.9
Organic matter (DOM)	62.5	61.2	65.5	69.3
Crude protein (DCP)	71.8[c]	69.0[b,c]	62.3[a]	65.1[a,b]
Crude fiber (DCF)	24.2[a]	26.2[a]	40.5[b]	43.8[b]
Ether extract (DEE)	86.7[b]	71.7[a]	77.0[a]	92.1[c]
Ash (DAsh)	17.4[b]	19.2[b]	24.5[c]	13.1[a]
N-free extract (DNFE)	63.5	62.3	68.1	71.8
Gross energy (DGE)	65.8	62.9	66.1	65.7

[a,b,c]Means in the same row with differ (P<0.05).

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