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THE UTILIZATION OF DIETS CONTAINING UNTREATED RICE STRAW, UREA-AMMONIA TREATED RICE STRAW AND WATER HYACINTH (*Eichhornia crassipes, Mart*)[1]

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This experiment was undertaken to study the efficiency of utilization of rice straw and rice straw-water hyacinth based diets by yearling native cattle and water buffaloes. Twelve cattle and twelve buffaloes were randomly assigned to the following treatment: a) untreated rice straw (C), b) rice straw stored for 3 weeks after spaying with a solution containing 5.0% urea and 0.3% salt (w/w) at 1:1 ratio (TS) c) rice straw and water hyacinth at 3:1 ratio, dry basis and stored after spraying with the urea solution as in b (TSW 1) d) rice straw and water hyacinth at 1:1 ratio, dry basis and stored after spraying with the urea solution as in b (TSW 2). Inclusion of water hyacinth with the straw resulted in an increase in protein content of the diet compared to TS alone (TS, 6.2%; TSW 1, 7.9%; TSW 2, 8.3%). Voluntary dry matter intakes were greater for diet TSW 1 and TSW 2 at 99 & 93 g/kg $W^{.75}$/d compared to C at 83 g/kg $W^{.75}$/d. Digestion coefficients of DM, CP and ADF were significantly enhanced in rations containing the higher level of water hyacinth (TSW 2).
Weight changes of the animals recorded during the 110 day-feeding period were -34, 7, 133 and 23 g/d ($P < .05$) for cattle and -182, 79, 232 and 329 g/d ($P < .05$) for buffaloes on respective treatments. Digestibility by water buffaloes and native cattle was similar, however, the buffaloes tended to be more efficient in utilizing protein.
It appears that utilization level of water hyacinth should be in the range of 30-40% of ration DM, particularly in straw-based diet.
The results of this experiment, demonstrate that water hyacinth can be a potential unconventional feed resource for ruminants specially for use by small farm holders.

Key words: rice straw, urea-ammonia treatment, water hyacinth, native cattle, water buffaloes

Cattle and swamp buffaloes in Thailand have to rely mainly on rice straw as a feed in the dry season during which they cannot maintain body weight (Wanapat 1981). Consequently, numerous attempts have been made to increase the nutritive value of the rice straw. Urea-Ammonia treatment of straw has been shown to increase intake and digestibility of rice straw by cattle and to increase liveweight (Wanapat et al 1982). Water hyacinth (*Eichhornia crassipes*), a water weed, has been a major ecological and economic problem both in the tropics and subtropics. Under suitable conditions of temperature (between 28°- 30°C) and pH (4.0-8.0), water hyacinth can double its population every seven days to yield 930-2900 tons/ha annually (Lareo and Bressani 1982). The plant has been used as animal feed in rations for swine (Pathak et al 1979), laying hens (Handy et al 1978), sheep (Baldwin et al 1975, El-Serafy et al 1979), buffaloes (El-Serafy et al 1980, 1981) and cattle (Reddy and Reddy 1979, Reddy and Mohan Reo 1979, Reza and Khan 1981). Nevertheless, utilization of the biomass as a feed for ruminants needs to be investigated further. Recently, Dolberg et al (1981) and Lareo and Bressani (1982) in reviews demonstrated the potential use of water hyacinth as a feed resource for both human and animals.

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The experiment described here was undertaken to study the utilization of water hyacinth as a part of straw based diets by swamp buffalo and native cattle.

Materials and Methods

Animals: Twelve 2-year old water buffalo and twelve native cattle steers were randomly alloted to receive four different rations in a randomized complete block design experiment. The initial mean liveweight of the cattle was 125 $\pm$ 4.2 kg and buffaloes was 220 $\pm$ 10.4 kg. The animals were treated for internal and external parasites. Each group of 3 animals was housed separately in a 3 x 10 m pen paved partially with concrete. Water and mineralized salt were available at all times. The animals were weighed every fortnight after being fasted for at least 12 h. Small mud-swamps were also given to the buffaloes at the time of regular pen clean-ups.

Diets: Rice straw used in the experiment was collected at one time from nearby rice paddies following harvest in December. It was then chopped into approximately 15 cm lengths by a small locally made chopper.

Water hyacinth was harvested by hand from a lake. Both the stem and leaf fractions were hand-chopped to lengths similar to the chopped straw and sun-dried for 4 days after which the water hyacinth contained about 60% moisture.

The chopped straw or straw and water hyacinth were then spread out on a concrete floor which had been lined with plastic sheets. The diets used in the study were: untreated rice straw (C); urea-ammonia treated rice straw and water hyacinth (3:1, dry basis) (TSW 1); urea-ammonia treated rice straw and water hyacinth (1:1, dry basis) (TSW 2).

The three urea-treated diets were prepared by sprinkling a solution of 5% urea and 0.3% salt by weight over the straw or straw and water hyacinth using a garden watering can. One liter of solution was applied to each kg of the diet. All feeds were mixed throughly and stored in a "Kra-Chur" (bamboo rice hauler). The stacks were made air-tight and kept for 3 weeks before feeding to the animals. Three tons of each diet was prepared each time.

Feeding: The diets were offered ad libitum for the experimental period of 110 days with feed given twice daily at 0900 and 1500 h. Feed refusals were collected and weighed daily and amounted to about 10% of the feed offered.

Samples of feed and faeces were taken once a month for two consecutive days. During each collection period, fecal samples were collected by the grab-sampling method twice a day to ensure representative uncontaminated samples. Samples of stored feeds were also collected daily prior to feeding and after feeding (refusals) to measure DM intake (DMI) by the animals.

Analyses: All diets and fecal samples were dried at 70°C in an air-draught oven for two days before grinding in a Wiley mill using a 1 mm screen. They were then analysed for dry matter (DM), ash and crude protein (CP) contents (AOAC 1975), acid-insoluble ash (AIA) acid-insoluble ash (AIA) (Van Keulen and Young 1977), acid-detergent fiber (ADF) (72% H_2SO_4) and acid-detergent lignin (ADL) (Goering and Van Soest 1970). Digestibility was determined by using AIA as an internal indicator. Analyses of variance were performed on the data and the treatment means were statistically tested by Duncan's Multiple Range Test (Steel and Torrie 1960).

Results and Discussion

Diet Composition: Table 1 presents the chemical composition of the diets used in the experiment. Rice straw contained 14.6% ash, 3.5% CP, 49.2% ADF and 3.9% ADL on a dry basis while water hyacinth had 19.6% ash, 11.4% CP, 40.3% ADF and 4.6% ADL. However, the chemical composition of water hyacinth varies considerably according to when it is harvested (Reza and Khan, 1981) and there is variation between varieties and plant parts. Water hyacinth leaf contains more protein than other parts of the plant. In addition, the protein quality of water hyacinth leaves as judged by pattern of aminoacids (Table 2) is considered to be good. The TSW 2 diet had a higher dry matter content than did other rations. This could be due to variable amount of moisture content attained after sun-drying. Crude protein contents of the diets were increased by both urea-ammonia treatment and water hyacinth. Acid-detergent fiber and ADL of the diets varied from 50-58% and from 3.9-5.1%, respectively. The temperature and pH of the different diets during the third week of storage (see Table 1) indicate that the storage efficiency and process in all the "Kra-Chur" used were quite similar.

Table 1:
Chemical composition (% of DM) of the experimental diets

Item	Dry matter	Ash	Crude Protein	Acid-detergent fiber	Acid-detergent lignin	pH	°C
Diets,							
Control (C)	95.1	17.3	4.0	53.1	3.9	-	-
Urea-NH_3 treated straw (TS)	48.6	17.5	6.2	58.4	5.0	8.9	42
Urea-NH_3 treated straw and water hyacinth[a] (3:1, TSW 1)	55.5	17.5	7.9	54.8	5.1	8.7	41
Urea-NH_3 treated straw and water hyacinth[a] (1:1, TSW 2).	60.8	17.2	8.3	50.4	4.8	9.0	45

[a] Both leaf and stem

Dry Matter Intake (DMI) and Growth of Native Cattle: Estimates of DMI were expressed as kg/d & g/kg $W^{.75}$/d and it was found that absolute intake ranged from 3.03 to 3.49 kg/d with no difference between diets. A significant increase ($P< 0.05$) was observed when water hyacinth was substituted for rice straw at 50% (from 86.6 to 95.8 g/kg $W^{.75}$/d). However, during the feeding regime, it was obvious that cattle tended to prefer TSW 1 to TSW 2. They readily consumed TSW1 whereas in TSW 2, they selected for straw particlues and left water hyacinth behind. This result might have contributed to the utilization of the diet and weight change of cattle, as presented in Table 3. The animals receiving diet C lost body weight but animals fed diet TSW1 had the highest weight gain of 133 g/d. Inclusion of water hyacinth in urea-ammonia treated rice straw rations may have increased the content of readily available carbohydrate and protein; therefore, the cattle fed on these ensilages could at least maintain body weight. Surat and Singh (1980) also reported that fresh water hyacinth could supply maintenance requirement of nutrients in rams.

Table 2:
Pattern of aminoacid content of water hyacinth (g/100 g protein)

Amino acid	Water hyacinth		
	Leaves[1]	Leaves[2]	Stems[2]
Asparagine	-	13.6	3.4
Threonine	4.3	7.3	1.6
Serine	-	7.3	1.8
Glutamine	-	15.0	3.0
Glycine	-	15.1	3.2
Alanine	-	13.4	2.9
Valine	5.6	10.1	2.0
Methionine + cystine	2.7	-	-
Isoleucine	4.7	7.2	1.4
Leucine	8.3	13.2	2.7
Phenylalanine + tyrosine	8.8	10.3	1.9
Histidine	2.2	2.6	0.6
Lysine	5.7	6.4	1.6
Arginine	5.2	5.7	1.1
Proline	-	8.1	1.7

[1] Lareo and Bressani (1982)
[2] Wanapat M (1983 unpublished data)

It is interesting to note that when water hyacinth substituted for straw to give a 1:1 ratio in the diet, the cattle selectively ate the straw. This appears to be due to a preference by the cattle for straw as the rice straw and water hyacinth were chopped to approximately the same length and mixed in equal proportions. However, due to low DM content of water hyacinth, the absolute amount of water hyacinth in the ensilage accounted for large quantily.

Dry Matter Fed Intake (DMI) and Growth of Water Buffaloes: The DMI by buffaloes increased when water hyacinth was included in the diet, and this was particularly so at 25% straw and 75% water hyacinth (TSW 1). The DMI was greater for TSW 1 than for TSW 2 (111 and 90 g/kg $W^{\cdot 75}$/d), but the acceptance of the two diets was similar. Liveweight gain was greater ($P<.05$) when buffaloes were fed diets containing treated rice straw and water hyacinth when compared to gains with TS or the C diets (Table 3). Higher weight gain of the buffaloes fed TSW 2, despite the lower dry matter intake compared to TSW 1, was possibly due to a result of having significantly higher digestible nutrients as shown in the same Table.

Buffaloes had significantly higher ($P<.001$) intakes (kg/d) than cattle across all diets, but this may have been due to the greater liveweight of the buffaloes since intakes in g/kg $W^{\cdot 75}$ were not significantly different, buffaloes had significantly higher liveweight gain thancattle.

Inclusion of water hyacinth in the ensilages enhanced crude protein digestibility while dry matter & ADF digestibility were only improved at the higher level of inclusion of water hyacinth (Table 3). Treatment of the straw increased the digestibility of ADF.

Digestibility of some Nutrients by Water Buffaloes (Table 3): Buffaloes fed on TSW 2 had a higher digestibility of DM, CP, and ADF than the other rations. These results together with the data obtained in cattle revealed that the higher digestibility may be a consequence of the higher CP, more readily available carbohydrate and essential minerals (Surat and Singh 1980) when water hyacinth was incorporated in ensilages. Water hyacinth in these rations may act as a catalytic supplement to stimulate feed intake and/or productivity. Wanapat et al (1983) reported a similar effect of supplementing cassava leaves to urea-treated rice straw fed to water buffaloes. However, El-Serafy et al (1981) concluded that water hyacinth hay, water hyacinth haylage, water hyacinth silage, could meet at least maintenace requirement of energy and digestible protein for growing buffalo steers. But better utilization of water hyacinth was found when it was incorporated with straw at a 1:1 ratio (Reza and Khan 1981).

The ability to digest DM, CP and ADF did not differ significantly ($P< 0.05$) between native cattle and water buffaloes although the buffaloes showed a trend for higher CP digestibility than did cattle.

The incorporation of water hyacinth into diets based on rice straw markedly imroved the nutritive value of the rations. In a situation where basal roughage is relatively limited, water hyacinth can substitute for the roughage with satisfactory results. These were demonstrated by El-Serafy et al (1979) where berseem hay was replaced by water hyacinth hay up to 75% and by Juul-Nielsen et al (1982) where rice straw was replaced by water hyacinth up to 40%. A summary of results obtained by other researches is prsented in Table 4.

Table 3:
Voluntary dry matter intake (DMI), weight change and digestibility of some nutrients in native cattle and water buffaloes

	Native cattle (CT)				Water buffaloes (BF)				Animal difference		
	C	TS	TSW 1	TSW 2	C	TS	TSW 1	TSW 2	CT	BF	Sig.
Intake											
DMI, kg/d	3.03^{a}	3.24^{a}	3.30^{a}	3.49^{a}	4.21^{a}	4.75^{a}	6.24^{b}	5.05^{c}	3.26	5.06	***
DMI, g/kg $W^{.75}$/d	86.6^{a}	88.6^{a}	86.8^{a}	95.8^{b}	78.8^{a}	88.2^{b}	111.1^{c}	90.4^{b}	89.4	92.1	n.s.
Weight change g/d	-34^{a}	7^{a}	133^{b}	23^{a}	-182^{a}	79^{a}	232^{b}	329^{b}	32	114	*
Digestibility %											
Dry matter	44.0^{a}	51.6^{ab}	56.4^{bc}	64.3^{c}	50.2^{a}	51.9^{a}	51.8^{a}	65.0^{b}	54.1	54.7	n.s.
Crude protein	20.7^{a}	33.8^{a}	29.3^{b}	45.7^{c}	23.4^{a}	28.6^{b}	28.8^{b}	50.6^{c}	29.9	32.9	n.s.
Acid-detergent fiber	41.7^{a}	47.9^{b}	49.2^{b}	58.2^{c}	43.2^{a}	47.4^{a}	54.9^{b}	61.6^{c}	50.7	50.4	n.s.

abc: Mean on the same row with differ superscripts are significantly different ($P < 0.05$)

C = control (untreated rice straw)

TS = urea-ammonia treated straw

TSW 1 = urea-ammonia treated straw:water hyacinth (3:1, DM basis)

TSW 2 = urea-ammonia treated straw:water hyacinth (1:1, DM basis)

Table 4:
Summary of the results obtained by other researchers

Diet	Animal	DM intake			Digestibility (%)							Balance (g/d)			Reference
		kg/d	% of BW	g/kg $W^{.75}$/d	DM	OM	CP	CF	NDF	ADF	TDN	N	Ca	P	
Water hyacinth hay (WHH)	buffalo steers	-	-	51.9	51.3	-	58.8	49.9	-	-	-	-	-	-	El-Serafy et al (1980)
	sheep	-	-	34.4	46.7	-	52.2	46.6	-	-	-	-	-	-	
Water hyacinth silage (WHS)	buffalo steers	-	-	40.8	66.8	-	68.8	52.3	-	-	-	-	-	-	
	sheep	-	-	31.2	64.2	-	60.1	49.7	-	-	-	-	-	-	
Water hyacinth (fresh)	rams	2.06	-	-	69.2	-	78.7	67.7	-	-	-	7.0	8.3	2.2	Surat and Singh (1980)
WHH	buffalo steers	5.2	1.68	70.4[a]	60.3	63.1	69.5	66.4	70.3	63.1	-	27.1[a]	-	-	El-Serafy et al (1981)
Water hyacinth haylage (WHL)	"	4.6	1.51	63.0[b]	59.3	61.8	65.4	64.5	68.4	60.8	-	29.3[a]	-	-	
WHS	"	4.0	1.29	54.1[c]	58.7	60.7	66.6	61.4	68.7	60.4	-	26.9[a]	-	-	
Berseem hay + rice straw (1:2) + 1.5 kg conc.	Calves (cattle)	4.96	3.01	-	64.2[a]	68.9[a]	73.3[a]	72.3[a]	-	-	-	37.3[a]	11.2[a]	5.5[a]	Reddy and Mohan Rao (1979)
WHH+rice straw (1:1)+1.5 kg conc.	"	3.96	2.40	-	59.0[a]	65.0[a]	67.4[a]	60.3[b]	-	-	-	27.3[a]	9.1[a]	4.7[a]	
WHH+NaOH treated rice straw (1:1) +1.5 kg conc.	"	4.05	2.45	-	63.8[a]	68.9[a]	75.6[a]	66.4[c]	-	-	-	33.6[a]	10.8[a]	5.0[a]	
Water hyacinth (fresh)	cattle	-	-	-	-	-	-	-	-	-	57.9	.27	-	-	Reza and Khan (1981)
Water hyacinth (fresh)+ rice straw (1:1)	"	-	-	-	-	-	-	-	-	-	63.2	2.2	-	-	
Rice straw	Sheep	-	-	52.4	41	-	-	-	-	-	-	-2.5	-	-	Dolberg et al (1981)
Rice straw + water hyacinth (fresh)(2:1)	"	-	-	59.1	48	-	-	-	-	-	-	-2.8	-	-	
Rice straw + water hyacinth (fresh)(2:1) + urea (2%)+ molasses (10%)	"	-	-	66.5	55	-	-	-	-	-	-	4.6	-	-	

[abc] Means within the same column with different superscripts are significantly different ($P < .05$)

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