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Study on Voluntary Intake and Digestibility of Banana Foliage as a Cattle Feed

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Abstract: The fresh and chopped banana plants were compared with that of the ensiled materials having them fed to mature bulls. Sixteen (16) young bulls approximately 3 years of age and weighing approx. 370 kg were used. The bulls were divided into 4 groups and were randomly allocated to the experimental diets e.g., T_1= banana pseudostem ensiled with 5% molasses, T_2= banana pseudostem ensiled with 5% molasses and 10% straw, T_3= chopped fresh banana pseudostem with 5% molasses, T_4= urea (3%)-molasses (15%)-straw (82%). All the diets were enriched with 3% urea. All the animals received 60 g/d of mineral supplement including sodium sulphate and dicalcium phosphate. The daily average dry matter intake in percent live weight was 1.33, 2.73, 1.20 and 2.50, respectively. Dry matter digestibility was significantly ($p<0.01$) higher in the T_2 (78%) fed animals than T_1 (59%), T_3 (65%) and T_4 (62%). In T_2 and T_3 diets NH_3-N concentration were relatively high which ranged from 54.87 to 238.56 mg/L and 42.15 to 188.47 mg/L, respectively. The 48 h in sacco degradability of washed straw in response to feeding T_1, T_2 and T_3 diets were 50, 51 and 51%, respectively. The ME intake was significantly ($p<0.01$) higher in T_2 (1300 KJ/kg $W^{0.75}$/d) than that of T_4 (945 KJ/kg $W^{0.75}$/d), T_3 (498 KJ/kg $W^{0.75}$/d) or T_1 (515 KJ/kg $W^{0.75}$/d). It may be concluded that both the preserved and fresh chopped banana whole plants had digestibility of 59 to 78% and their intake in native bull ranged from 1.20 to 2.73% live weight.

Key words: Digestibility, voluntary intake, Banana foliage

Introduction

Bangladesh has a large livestock population that services the power requirements for cropping and transport in general and also provides meat and milk. On the basis of the livestock populations and the available forage resources the livestock industries require to mobilize and use efficiently all available feed resources. Forage is often critically short in the long wet season when 40-60% of cropping land may be in undated depending on the intensity of the monsoon and animals often depend on crop residues and grasses of poor feeding value in the dry season. There is particularly a shortage of quality fodder for the dairy cows bred for their capacity to produce milk. For this reason the BLRI has commenced a program to harness under-utilized resources of forage in this country particularly targeting potentially high digestibility forages for an intensive dairy industry.

Amongst the likely forages the aerial parts of the banana plant are highly digestible by ruminants (Ffoulkes and Preston 1977). However, despite an apparent high metabolizable energy content, banana forage is poorly consumed. It is deficient in nutrients needed for efficient microbial digestion of the carbohydrates in the rumen which could limit it's value as a feed, but it is also low in dry matter and could contain secondary plant compounds that also limit it's intake by cattle. The quantity of banana foliage as a waste product of the fruit crop is high and wild banana plants also grow in areas such as the hill tracts close to the sea in the southern areas.

Little work has been done on the use of banana forage as a feed. Pieltain *et al.* (1999) studied on the nutritive value of banana (*Musa acuminata* L.) by-products for maintaining goats. They observed that banana by-products had both a relatively low degradability and digestibility, with derived metabolizable energy content (MJ ME per kg dry matter (DM) of 6.54 for leaves, 6.66 for pseudostems and 8.24 for raceme stems. Daily voluntary intake (g DM per kg M-0.75) was 66.4 for leaves, 19.3 for pseudostems, and 15.3 for raceme stems. On these results, pseudostems and raceme stems would provide less than 0.30 of maintenance ME needs of goats. However, rations based only on banana leaves should meet move than 0.85 of the maintenance energy needs. Braimah and Van Emden (1999) studied on evidence for the presence of chemicals attractive to the banana weevil, cosmopolites sordidus (Coleoptera. Curculionidae) in dead banana leaves. They reported that dead-leaf-based attractants could be used in combination with microbial such as entomogenous fungi and nematodes in integrated management of *C. sordidus*. Lekasi *et al.* (1999) studied on decomposition of crop residues in banana-based cropping systems of Uganda. They reported that the organic resources decomposed in the order bean trash> banana peel> maize stover = banana pseudostems> banana leaves. Exclusion of soil macrofauna (2-5 mm) delayed decomposition of banana pseudostems, when applied as mulch. When field availability and tissue concentrations are taken into account, banana leaves and banana trash have the greatest potential to recycle N (25 and 29 kg/ha/yr, respectively) and banana leaves and pseudostem recycle the greatest amounts of K (43 and 26 kg/ha/yr). The combined contribution of banana leaves, pseudostems, maize stover and bean trash to recycling nutrients in this farming system was 69 kg N and 147 kg K/ha. Ranzani and Sturion (1998) studied on amino acid composition evaluation of edible mushrooms (*Pleurotus* spp.) cultivated on banana leaves. They observed that the protein of the studied species is incomplete, although of high biological value, comparable to meet. Saikia *et al.* (1997) studied on wild banana plants (*Musa* spp.) as source of fibre for paper and cordage industries. They reported that the banana plants would be good source of raw material for cordage industry and a supplementary source for pulp and paper industry. Bekunda and Woomer (1996) studied on organic resource management in banana-based cropping systems of the lake Victoria basin, Uganda. They observed that farmers are developing strategies to resist fertility depletion, in part through better recycling of on-farm resources and intercropping but greater reliance upon external inputs may be required to ameliorate declining banana yields. Shem *et al.* (1995) studied on prediction of voluntary dry-matter intake, digestible dry-matter intake and growth rate of cattle from the degradation characteristics of tropical foods. They observed that dry-matter intake, digestible dry-matter intake and growth rates by cattle fed on crop residues and forages could be predicted well using the rumen degradation characteristics of the foods.

As part of a program to develop under-utilized resources the following studies were initiated to identify the primary limitations to intake and determine the best means of using banana foliage and pseudostem as a feed resource for cattle production. Banana plants are cut off at the base following harvest each year, as fruits are produced from the new shoots that arise from the stoloniferous rooting system. Therefore, banana foliage tends to be available in large amounts in the wet season and for effective utilization of this foliage for a longer period, it must be preserved immediately after harvest. For this reason, research was initially established to produce silage as the most feasible process for preservation. The purpose of this experiment was to obtain information on yield, chemical composition, nutritive value and voluntary intake of banana silage.

Materials and Methods

The present study was conducted at the Animal Research Farm at Pachutia, Bangladesh Livestock Research Institute (BLRI), Savar, Dhaka. The mature whole banana plants after harvesting were collected from the side of duckweed pond of Animal Research Farm at Pachutia, BLRI. An intake and digestibility trial was conducted with indigenous (*Bos indicus*) mature bulls for 24 days during October-November 2000.

Ensiling: Whole mature plants were used to prepare silage. The banana plant was chopped. The leaves were chopped whole whereas the pseudostem was chopped after splitting longitudinally into lengths with a machine. The chopped materials were placed in layers in a pit and mixed with varying amounts of molasses or straw, or both according to the mixtures indicated in Table 2. The materials were compressed by a tractor to exclude air and left for 30 days prior to use.

Table 1: Yield and chemical composition of banana by-products (leaves, stems and mid rib)

Parameter	Banana leaf	Banana stem	Banana mid rib
Yield/plant (kg, DM)	0.575	1.144	0.298
DM (%, DM)	20.99	5.93	9.43
OM (%, DM)	90.24	89.45	91.55
CP (%, DM)	8.78	7.28	4.57
ADF (%, DM)	39.17	48.44	43.67

Table 2: Silage mixes as made the figures in brackets indicate the mix on a dry matter basis

Silage mix	A (% wet weight)	B (% wet weight)
Banana foliage (%)	95 (70)	85 (40)
Molasses (%)	5 (30)	5 (15)
Straw (%)	0	10 (45)

Experimental animals and diets: Young bulls (16) approximately 3 years of age and weighing approx. 370 kg were used. The bulls were divided into 4 groups and were allocated randomly to the experimental diets shown in Table 3. Three animals had permanent cannula in the rumen and these were allocated to group 1, 2 and 4. All treatments were offered ad libitum. Animals were not given any concentrate mixture. All the animals received 60 g/d of mineral supplement including sodium sulfate and dicalcium phosphate which provided sulfur, calcium and phosphorus.

Table 3: Diets fed to bulls in the digestibility trial (Urea was given daily at 3% of dry matter offered, molasses was provided at 5% of the wet weight of the basal diet)

Name of group	Diet	Additives
Group 1	Silage A	Urea
Group 2	Silage B	Urea
Group 3	Rice straw	Urea and molasses
Group 4	Fresh banana chopped	Urea and molasses

Table 4: Chemical composition (%) of banana pseudostem and leaf ensiled with 5% molasses (BEM), banana pseudostem and leaf ensiled with 5% molasses and 10% straw (BEMS), fresh banana pseudostem and leaf with 5%molasses (FBM) and urea-molasses-straw (UMS)

Composition	UMS	BEM	BEMS	FBM
Dry matter 62.5	14.6	28.19	10.1	
Organic matter	84.8	89.5	91.1	90.3
CP (N × 6.25)	8.9	15.8	16.7	16.7
ADF	42.1	41.2	39.6	36.4
CF	31.6	33.8	33.7	28.8

Digestibility trial: The bulls were fed the experimental diet in single pens for a preliminary period of 14 days. They were then transferred to metabolic crates for 10 days. Three days were allowed for the animals to adjust in the crates and then the digestibility trial was carried out. Feed was given each day in two equal amounts in a way that the animals left about 10% of the total as measured on the following day. Faeces and urine were collected daily. A 10% sample was collected after proper mixing from each collection and stored. Urine was collected in appropriate HCl at $-20\ ^{0}C$ until further processing. Daily sample of feed, feed refusals, faeces and urine were stored deep-frozen. Samples were bulked, sampled and analyzed in duplicate. Animals were weighed at day 0, day 14 and day 24.

Rumen parameters measurement: Samples of rumen contents were taken from the cannulated bulls on day 24, before feeding in the morning and at 1, 2, 3 and 6 hours after the animal was offered it's morning feed. Rumen samples were measured for pH with paper indicators and then placed in one container for ammonia analysis. Dacron bag digestibility of washed straw was determined by incubating the dried and ground (hammer milled through 4 mm sieve) samples in the rumen of BEM, BEMS and FBM fed animals respectively for 8, 16, 24, 48 and 72 hours following the method of Bhargava and Orskov (1987). Data on DM degradability of washed straw for BEM, BEMS and FBM fed rumen environment were then fitted to the exponential model $Y = a + b\ (1\text{-}e^{-ct})$ of McDonald (1981) using the NAWAY computer programme.

Chemical analysis: Samples of feeds, refusals and faeces were analyzed for dry matter (DM), organic matter (OM) and nitrogen (N) according to AOAC (1984). Urinary N was also measured in the same way. The acid detergent fibre (ADF) was determined according to Georing and van Soest (1970).

Silage: The pH of silage was measured from the samples that were being fed to the cattle after opening the silage clamp. A sample was squeezed in a muslin bag and the pH was estimated by indicator paper.

Statistical analysis: Analysis of variance of the data was done to determine the effect of treatment using completely randomized design (Snedecor and Cochran, 1967).

Results

Quality of silage: The chopped banana plants were preserved successfully with molasses with or without using straw as absorbents. The pH of silage A and silage B were 4.3 and 4.4, respectively.

Feed intake: All the bulls remained in good health except for one on diet FBM, which was culled. Fresh roughage, total dry matter (DM) and digestible organic matter intake of four groups of animals are shown in Table 5. Total DM intake (115 g/kg $W^{0.75}$/d) was significantly ($p < 0.01$) higher in the BEMS fed animals than the UMS (112 g/kg $W^{0.75}$/d), BEM (59 g/kg $W^{0.75}$/d) or FBM (53 g/kg $W^{0.75}$/d) fed animals. Digestible OM intake was also significantly ($p < 0.01$) higher in the BEMS fed animals than the UMS, BEM or FBM fed animals.

Digestibility: Whole gut digestibility of DM, OM, N and ADF are shown in Table 6. Digestibilities were significantly ($p < 0.01$) higher in the BEMS fed animals than the UMS, BEM or FBM fed animals. Digestibilities of OM were 61, 81, 67 and 65% and of ADF were 62, 79, 62.0 and 73 percent, respectively for the BEM, BEMS, FBM and UMS fed animals. N digestibility were 74, 86, 58 and 62 percent, respectively for the BEM, BEMS, FBM and UMS fed animals.

Table 5: Intake by animals fed on either banana pseudostem and leaf ensiled with 5% molasses (BEM), banana pseudostem and leaf ensiled with 5% molasses and 10% straw (BEMS), fresh banana pseudostem and leaf with 5% molasses (FBM) or urea-molasses-straw (UMS)

Parameter	BEM	BEMS	FBM	UMS	SED	Significance
Fresh roughage intake (kg/d)	33.00	30.20	48.30	15.90	7.36	$p<0.01$
Total DM intake (kg/d)	4.85	9.35	4.74	9.90	1.12	$p<0.01$
Total DM intake (g/kg $W^{0.75}$/d)	59.00	115.00	53.00	112.00	17.35	$p<0.01$
Roughage DM intake (kg/100 kg liveweight)	1.33	2.73	1.20	2.50	0.46	$p<0.01$
Digestible OM intake (g/kg$W^{0.75}$/d)	33.00	84.00	32.00	61.00	13.93	$p<0.01$

DM = Dry matter, OM = Organic matter

Table 6: Digestibility (%) of different nutrients in banana pseudostem & leaf ensiled with 5% molasses (BEM), banana pseudostem & leaf ensiled with 5% molasses and 10% straw (BEMS), fresh banana pseudostem & leaf with 5% molasses (FBM) or urea-molasses-straw (UMS)

Parameter	BEM	BEMS	FBM	UMS	SED	Significance
DM	59	78	65	62.3	4.73	$p<0.01$
OM	61	81	67	64.5	4.79	$p<0.01$
N	74	86	58	62	3.86	$p<0.01$
ADF	62	79	62	73	4.34	$p<0.01$

DM = Dry matter, OM = Organic matter,
ADF = Acid deterfent fibre

Rumen pH: The pH of rumen fluid is shown in Table 7. Although there are some diurnal changes, all diets had almost similar range of rumen pH of 7.0-8.5.

Table 7: The pH of rumen fluid in the BEM, BEMS and FBM fed animals

After the morning meal (hours)	BEM	BEMS	FBM
0	7.0	8.0	8.0
1	7.5	8.0	8.5
2	8.0	8.0	8.0
3	8.0	8.5	8.5
6	8.5	8.5	7.5

Table 8: The NH_3-N concentration (mg/l) of rumen fluid in the BEM, BEMS and FBM animals

After the morning meal (h)	BEM	BEMS	FBM
0	50.89	54.87	42.15
1	98.61	214.71	188.47
2	97.81	238.56	158.25
3	97.01	177.33	134.39
6	43.74	142.34	120.48

Rumen NH_3-N content: In BEMS and FBM diets NH_3-N concentration were relatively higher which ranged from 54.87 to 238.56 mg/l and 42.15 to 188.47 mg/l, respectively than the BEM diet (43.74 to 98.61 mg/d) (Table 8).

Rumen degradability: Rumen degradability of washed straw at different rumen environment such as BEM, BEMS and FBM diets fed animals at different hours of incubation (Table 9). The 48 hours in sacco degradability of washed straw in response to feeding BEM, BEMS and FBM diets fed animals were 50, 51 and 51%, respectively. The rate of degradation were 0.038, 0.031 and 0.038 and the fractional outflow rate at 5% level were 32, 22 and 31%, respectively for the washed straw in response to BEM, BEMS and FBM fed diets rumen environment.

Table 9: Rumen degradability of washed straw from different rumen environment at different hours of incubation

Hours of incubation	BEM	BEMS	FBM
8	26.08	11.33	20.76
16	28.79	20.20	35.26
24	41.24	33.77	39.88
48	50.22	50.97	50.61
72	52.49	58.81	59.69
a	13.16	-5.54	8.05
b	42.87	72.65	53.56
c	0.038	0.031	0.038
RSD	3.58	2.18	2.97

N utilization: Total N intake was significantly ($p<0.01$) higher in BEMS (3073 mg/kg $W^{0.75}$/d) than those fed UMS (1580 mg/kg $W^{0.75}$/d), BEM (1487 mg/kg $W^{0.75}$/d) or FBM (916 mg/kg $W^{0.75}$/d) (Table 10). Faecal N excretions were significantly ($p<0.01$) affected by the diets, but the types of diet did not affect ($p>0.05$) urinary N excretions. Animals fed on BEMS, BEM, UMS and FBM attained N equilibrium of 2191, 749, 700 and 180 mg/kg $W^{0.75}$/d, respectively.

Energy utilization: The metabolizable energy (ME) intake was estimated from the digestible OM intake as ME intake (MJ/d) = Digestible OMI (kg/d) × 15.46 (ARC, 1980). The digestible OM intake was significantly ($p<0.01$) higher in BEMS (6.86 kg/d) than that of UMS (5.42 kg/d), FBM (2.85 kg/d) or BEM (2.70 kg/d) (Table 11). The ME intake was also significantly ($p<0.01$) higher in BEMS (1299 kJ/kg $W^{0.75}$/d) than that of UMS (945 kJ/kg $W^{0.75}$/d), FBM (498 kJ/kg $W^{0.75}$/d) or BEM (515 kJ/kg $W^{0.75}$/d).

Body weight gain: Body weight gain, feed conversion ratio and feed conversion efficiency of four groups of animals are shown in Table 12. During the 24 days of intake and digestibility trial, the live weight gain was significantly ($p<0.01$) higher in UMS (920) fed animals than that of BEM (614 g/d), FBM (345 g/d) or BEMS (159 g/d). However, better feed conversion ratio was found in BEM (8.74 kgDM/kg gain) fed animals than that of UMS (11.45 kgDM/kg gain), FBM (16.62 kgDM/kg gain) or BEMS (57.15 kgDM/kg gain).

Discussion

The digestibilities of banana forage or silage are high but intake is low. It may be due to the physical constraint attributable to the high moisture content of this material. Total DM intake was significantly higher (2.6 kg/100 kg live weight) in the BEMS fed animals than the BEM (1.3 kg/100 kg live weight) or FBM (1.3

Table 10: Nitrogen utilization by animals fed on either banana pseudostem and leaf ensiled with 5% molasses (BEM), banana pseudostem and leaf ensiled with 5% molasses and 10% straw (BEMS), fresh banana pseudostem and leaf with 5% molasses (FBM) or urea-molasses-straw (UMS)

Parameters	BEM	BEMS	FBM	UMS	SED	Significance
Total N intake (g/d)	122	249	126	140	28.62	$p<0.01$
Total N intake (mg/kg $W^{0.75}$/d)	1487	3073	1422	1580	452.01	$p<0.01$
Faecal N Exc. (mg/kg $W^{0.75}$/d)	383	440	355	595	94.15	$p<0.01$
Urinary N Exc. (mg/kg $W^{0.75}$/d)	355	442	381	287	126.97	$p>0.05$
N balance (mg/kg $W^{0.75}$/d)	749	2191	687	700	373.43	$p<0.01$

Table 11: Energy utilization by animals fed either banana pseudostem and leaf ensiled with 5% molasses (BEM), banana pseudostem and leaf ensiled with 5% molasses and 10% straw (BEMS), fresh banana pseudostem and leaf with 5% molasses (FBM) or urea-molasses-straw (UMS)

Parameters	BEM	BEMS	FBM	UMS	SED	Significance
Dig. OM intake (kg/d)	2.70	6.86	2.85	5.42	0.84	$p<0.01$
Est. ME intake (MJ/d)-	41.70	106.10	44.10	83.70	12.95	$p<0.01$
ME intake (kJ/kg $W^{0.75}$/d)	515.00	1299.00	498.00	945.00	284.47	$p<0.01$

-Estimated as ME intake = 15.46 (ARC, 1980)

Table 12: Liveweight gain and feed conversion efficiency of animals fed either banana pseudostem & leaf ensiled with 5%molasses (BEM), banana pseudostem & leaf ensiled with 5%molasses and 10% straw (BEMS), fresh banana pseudostem & leaf with 5%molasses (FBM) or urea-molasses-straw (UMS)

Parameter	BEM	BEMS	FBM	UMS	SED	Significance
Initial weight (kg)	368.00	367.00	384.00	370.00		$p>0.05$
Final weight (kg)	386.00	375.00	394.00	397.00		$p>0.05$
Liveweight gain (g/d)	614.00	331.00	345.00	920.00	315.48	$p<0.05$
Feed conversion ratio (kgDM/kg gain)	8.74	57.15	16.62	11.45	27.99	$p<0.05$

kg/100 kg live weight) fed animals. The DM intake from banana silage found in the present findings are similar with the findings of Ffloulkes and Preston (1977) who found that, by using a ratio of 100:0, 67:33, 33:67 and 0:100 of leaf and stem of banana, the voluntary intakes were 2.29, 1.99, 1.58 and 1.31 kg DM/100 kg live weight/day, respectively.

The diet of BEMS was more digestible (78%) than the FBM (65%), UMS (62%) and BEM (59%). Digestibility of banana forage and straw combined in roughly 50:50 on DM basis was higher than the digestibility of each separately and that feed intake was maintained when straw and silage were approximately 50:50 on a dry matter basis. The DM digestibilities of present findings are similar with the findings of Espejo *et al.* (1978) who reported that the digestibility of the banana forage (by using a ratio of 4:1 of stem and leaf) was 70.2%. Ffloulkes and Preston (1977) also found that the DM digestibility of mixtures of banana pseudostem and leaf (100:0, 67:33,33:67 and 0:100, DM basis) were 65.18, 69.35, 65.90 and 75.43%. In other experiment, using young bulls, Shem *et al.* (1995) reported that the DM intake varied from 2.2 kg for banana pseudostem to 4.77 kg/day for urea-treated maize stover where DM digestibility ranged from 55% for urea-treated maize stover to 77% for banana pseudostem.

The total N intake of FBM fed animals was lower (81 g/d) than the BEM (122 g/d), UMS (140 g/d) and BEMS (249 g/d) fed animals. The results of this study agrees with the findings of Ffloulkes and Preston (1977) who found that the total N intake of mixtures of banana pseudostem and leaf (100:0, 67:33,33:67 and 0:100, DM basis) were 120, 100, 100 and 80 g/d, respectively.

The high digestibility of banana silage/straw materials suggesting that this is a potentially suitable basal forage for dairying. However, there is a need to develop knowledge of the best balance of silage to straw. Generally it appears to be a interactive stimulation of digestibility of banana foliage and straw when these are mixed. The results of this study therefore further suggest that the experiment needs repeating to gain a greater confidence on the potential of straw/banana foliage mixtures and to determine the optimum level of straw that is able to increase intake and digestibility. The growth rates in young animals or the fattening rate of mature animals also needs to be examined based on banana silage/straw.

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