NUTRITIONAL STUDIES ON THE USE OF BANANA WASTE SILAGE IN FEEDING LACTATING COWS

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ABSTRACT

Eight Holstein Friesian dairy cows (450 Kg) in their third lactation season, producing (10-12 Kg/day) in average, were allotted in a double 4x4 Latin squares arrangement (28 day periods) to evaluate the effect of feeding dairy cows on banana (***Musa acuminata*** L.) waste silage (BWS) alone or treated with urea 3% (BWUS) or inoculant, mixed bacteria (BWIS) at the rate of 10g/2L water/ton. Silage making resulted in decreasing CF and cell wall components, but increased EE and ash contents. Inoculant increased the apparent digestibility of all nutrients, followed by silage treated with urea then the untreated control silage. Feeding values were highest for BWIS (63.69% TDN, 9.30% DCP and lowest for (BWS) (60.94% TDN, 8.0% DCP). Higher digestibility of ADF and NDF was observed by (BWIS). Total VFA's were significantly ($P<0.05$) increased in (BWIS) than other silages. No significant differences were found among groups concerning all blood parameters. The highest milk yield was recorded for cows fed BWIS. It could be seen that ensiling (BW) with mixed bacteria (inoculant) resulted in reduce in feed cost and get benefit from milk production.

INTRODUCTION

In Egypt, animals suffer from under feeding and mal-nutrition due to the shortage of locally produced feeds which are not sufficient to cover the nutritional requirements of the animals.

This shortage of feed and low genetic potentiality of the local farm animals are the major factors which responsible for their low productivity of meat or milk. However, only 4.43 million tons of crop residues out of 13.7-15.2 million tons produced are used for feeding ruminants **(Hathout and El-Nouby, 1990)**.

It was suggested that efforts should be done to use efficiently all the available by-products and wastes to overcome inadequacy of animal nutrition and increase the productive potential of the local animals to the rise demands on animal protein due to higher growth of both economy and human population. Roughage, such as rice straw, corn cobs, rice hulls, cotton stalks, sugar beet pulp and other wastes such as banana plant waste were used by several works **(Abd El-Malik, 1972; Bendary, 1991 and Mohsen *et al.*, 1999)**.

The annual cultivated area from banana plants in Egypt is about 39,000 feddans (Ministry of Agriculture and Land Reclaiming, 2003). The wet materials (leaves and pseudo stems) is about 1,400,000 tons estimated to about 98,000 tons dry matter.

This wastes are now carried out from the field and burned, causing environmental pollution. The potential use of the banana plants wastes in the ruminant rations has been investigated before **(Geoffroy, 1985; El-Said, 1994; and El-Shewy, 1998)**. Banana wastes can be readily ensiled, because of their high content of fermentable carbohydrates **(Viswanathan *et al.*, 1989)**.

This work aimed to study the effect of feeding banana waste silage alone or treated with urea or inoculant on its chemical composition, digestibility of the nutrients, rumen fermentation and degradability, milk yield and composition of dairy cows and some blood parameters.

MATERIALS AND METHODS

Three under ground trenches with capacity of 15 tons (5 ton each) were used for ensiling the fresh banana plant leaves and stem (banana by-product), which collected after harvesting immediately, then they were chopped (20-25 cm) and left for sun dried for 7-10 days to reach a moisture content of about 65-70%. The silage was prepared by filling successive layers of the chopped materials and heavily trodden before adding the next layer. However, each layer was consisted of the banana wastes and chopped rice straw (RS) 2:1. Molasses was added at the rate of 3% in all silages.

The first trench had no additives, banana waste silage (BWS). Urea (U) was added at the rate of 3% and dissolved in water to reach the rate in the second trench (BWUS). Inoculant (I) was added to the chopped material in the third trench at the rate of 10 g mixed bacteria/2L water/ton as described by **Mahmoud (2005)**. After filling the trenchs with the materials they were pressed well, then covered by thin layer of polyethylene sheet. Soil layers of approximately 20 cm thickness were covered the polyethylene sheet then tires to get anaerobic conditions for 6 weeks.

Eight Holstein-Friesian cows in their third lactation season were used in duplicated 4x4 Latin-squares design with each period lasting 28 day **(Steel and Torrie, 1980)**. Cows were paired according to body weight (450 Kg in average) and previous milk records (10-12 Kg/day in average). Each diet was fed by two cows during four periods each consisted of 28 days. The first 21 days was preliminary period followed 7 days collection period. Milk yield was recorded individually on two successive days. milk samples were collected twice daily for 7 days through the collection period from all cows.

Milk samples were collected from each cow evening and morning for estimation of milk yield production **(Galatov, 1994)**. Milk samples (100 ml each) were chemically analyzed for total solid (TS), solid not fat (SNF), protein, fat and lactose using a Milk 0-Scan-133 B as described by **Mahmoud, (2005)**.

Four experimental rations were used in this study:

1- Concentrate feed mixture (CFM) consisting of 35% yellow corn, 29% wheat bran, 12% soybean meal, 13% linseed meal, 7% molasses, 2% limestone, 1.5% salt and 0.5% vitamins + rice straw (RS) ad libitum (control).
2- CFM + BWS.
3- CFM + BWUS.
4- CFM + BWIS.

The CFM was fed to the control group to supply CP requirements, while in the other groups, cows were fed silage ad libitum **(NRC, 1990)**. The actual consumed silage was recorded. The offered CFM was calculated to supply the rest of CP of these rations to be comparable to the control group.

Four digestibility trials were conducted using three mature Barki rams, with an average of 50 Kg body weight and three years old. The animals were housed in metabolic cages and fed the experimental rations for 15 days as preliminary period followed by 7 days collection period. Feces samples (10%) were taken and dried at 65°C for 16 hours. The daily dried feces samples from each animal were thoroughly mixed and ground for chemical analysis. During the collection period the urine was also collected in large polyethylene bottles containing 20 ml of H2So4 (10%) to prevent losses of ammonia nitrogen. Urine samples (5%) were taken daily in clean bottles and stored in a refrigerator until used. Samples of feeds and feces were analyzed for crude protein (CP), crude fiber (CF), ether extract (EE) and ash, while the urine samples were analyzed for nitrogen (N) according to **AOAC (1990)**.

Rumen fluid samples were taken at 0, 3 and 6 hours post feeding from three fistulated adult female Barki sheep weighing approximately 47 Kg body weight for each treatment, were analyzed immediately for pH using Orian 680 digital pH meter. Samples were strained through four layers of cheese cloth. For each sampling time, rumen fluid samples were preserved for the determination of ammonia nitrogen concentration by using magnesium oxide (MgO) as described by **AOAC (1990)**. Total volatile fatty acids (VFA.s) concentration were determined by using steam distillation method **(Warner, 1964)**.

For the degradability of the feeds, nylon bags were used for each of the four rations, the evaluated using the three fistulated sheep. Bags (6 cm x 12 cm and 52 µm pore size) containing 5 g of ground samples of each diet were incubated in the ventral part of the rumen and were removed after 3, 6, 12, 24, 48 and 72 h as described by **Mahmoud (2005)**. In situ degradation of DM and CP in the rumen was calculated using the non linear non logged model proposed by **Ørskov and McDonald (1979)** $P = a + b (1-\exp^{-ct})$ where P is a degradation rate at time t, a is an intercept representing the portion of DM or CP solubilized at initiation of incubation (time, 0), b is the portion of DM or CP potentially degraded in the rumen, c is a rate constant of degradation of fraction b, and t is a time of incubation.

Cell wall were analyzed for acid detergent fiber (ADF), neutral detergent fiber (NDF) and acid detergent lignin (ADL) using tecator fibretic system. Hemicelluse and cellulose were determined by difference between NDF and ADF and ADF and ADL respectively according to **Van Soest (1990)**.

Blood samples were taken from each cow before feeding at the end of the collection period of each trial, from the Jugular vein using heparinized tube and blood plasma was separated by centrifugation at 4000 rpm for 20 minutes then stored at -20 °C until analysis. Plasma total protein (TP) was determined as described by **Henry *et al.* (1974)**. Albumin (A) concentration by **Doumas *et al.* (1977)** Globulin was estimated by difference between TP and albumin. Blood urea by **Henry and Todd (1974)** using commercial kits-Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) by **Reitman and Frankel (1957)**.

Data were statistically analyzed using the least squares analysis of variance using General Linear Models (GLM) procedure **(SAS, 2000)**.

RESULTS AND DISCUSSION

The chemical composition of concentrate feed mixture (CFM), rice straw (RS), banana waste (BW), banana waste silage (BWS), banana waste urea silage (BWUS) and banana waste inoculant silage (BWIS) are presented in Table (1). It could be seen that making silage caused decrease in CF, ADF, NDF and hemicellulose but increased EE and ash contents. However the reduction in NDF was superior in both BWUS and BWIS, it was 14.29 and 15.87%, respectively. These may could be due to the effect of the enzymes produced by the anaerobic bacteria in the silage. This result is agree with that obtained by **El-Shewy (1998).** Average feed intake, digestibility coefficients of the nutrients and nutritive value for the tested rations are presented in Table (2). Feed intake of CFM was significantly

(P<0.05) higher in the control group compared with the other tested groups, while it was the lowest in BWIS compared with either control or BWS and BWUS. There were no significant differences between BWS and BWUS. The roughage percentage of total DM intake was between 26 and 42 with significant differences (P<0.05) between the control and the other groups, being the highest in BWIS followed by BWS then BWUS. Average digestibility coefficients for DM, OM, CP, CF, ADF, NDF and cellulose were higher (P<0.05) in BWIS compared with control and BWS groups, while the digestibility of EE was not significant. These may could be due to high ash content. These results agree with those obtained by **Poyyamozhi and Kadirzel (1986)**. Available OM for ruminal bacteria can be estimated from the composition of feed stuffs as non-structural carbohydrates **(Sniffen *et al.*, 1992)**. Because of the relatively high lignifications of the banana fiber, only 41% of structural carbohydrates were available **(Sniffen *et al.*, 1992)**. On the other hand, particularly all CP was available because of the small amount of protein linked to ADF. The improvement in the nutrients digestibility in CP and CF record for urea ensiled roughages does not appear to be only due to satisfy the requirements of nitrogen for rumen microbes which may have been at least partially or completely met **(Salman, 1991)**.

Table (1): The chemical composition of experimental silages and different ngredients fed to lactating cow (on Dry matter basis, %).

Item	CFM	RS	BW	BWS	BWUS	BWIS
DM	88.95	88.57	7.40	32.38	30.65	35.19
OM	90.32	83.06	84.55	74.55	75.21	76.54
CP	15.88	3.19	6.36	6.73	7.89	6.94
CF	9.72	36.32	32.69	29.73	27.31	25.06
EE	2.72	0.84	0.78	1.71	1.57	1.86
NFE	62.00	42.71	44.72	36.38	38.44	42.68
Ash	9.68	16.94	15.45	25.45	24.79	23.46
ADF	12.33	55.56	49.05	46.42	42.32	41.96
NDF	24.92	79.82	76.54	69.77	65.60	64.39
ADL	9.59	26.63	22.08	19.28	17.07	17.80
Hemicellulose	12.54	24.26	27.49	23.35	23.28	22.43
Cellulose	2.77	28.93	26.97	27.14	25.25	24.16

Table (2): Feed intake, digestibility coefficients of the nutrients and nutritive values of the experimental rations.

Item	Control	BWS	BWUS	BWIS
DM intake, g/h/d				
CFM	915 [a]	730 [b]	710 [b]	630 [c]
RS	320	--	--	--
Silage	--	460	380	450
Daily DM intake, g	1235	1190	1090	1080
R:C ratio	26:74	39:61	35:65	42:58
Digestibility coefficients, %:				
DM	61.77 [c]	68.30 [b]	69.40 [ab]	70.66 [a]
OM	64.99 [c]	70.34 [b]	70.94 [b]	72.42 [a]
CP	58.51 [c]	67.03 [b]	67.30 [b]	76.60 [a]
CF	41.00 [c]	56.72 [b]	60.50 [a]	62.50 [a]
EE	76.14	77.03	79.82	82.63
NFE	73.14 [b]	75.73 [a]	74.66 [a]	73.99 [ab]
ADF	35.11 [c]	37.23 [b]	38.38 [b]	40.64 [a]
NDF	56.72 [d]	58.64 [c]	60.74 [b]	62.31 [a]
ADL	20.82 [b]	22.36 [ab]	23.64 [a]	23.84 [a]
Hemicellulose	84.64 [b]	86.80 [a]	87.87 [a]	88.06 [a]
Cellulose	61.58 [b]	62.96 [b]	64.19 [a]	63.86 [a]
Nutritive value:				
TDN	59.55 [d]	60.94 [c]	62.37 [b]	63.69 [a]
DCP	7.31 [d]	8.00 [c]	8.68 [b]	9.30 [a]

Means within rows with different superscript are significantly differ at ($P<0.05$).

The average nutritive values as TDN and DCP % were significantly among different silages. TDN and DCP were significantly ($P<0.05$) higher in BWIS than that of BWS, BWUS and control. These improvement is associated with, the increased digestion in fibrous materials in addition to the increased bacterial degradation of cell wall content. However, the lower TDN values of BWS in the present study than that obtained by **Blaha and Mudrik (1981)** may be due to the variation in the proportion of the fresh leaves and pseudo stems mixtures and the presence of rice straw in the silage and the ensiling processing which affects on silage quality.

Data on milk yield and composition are presented in Table (3). It could be noticed that the lowest ($P<0.05$) mean milk yield was observed for cows fed the control ration, while the highest ($P<0.05$) mean was recorded for animals fed BWIS. Ration contained inoculant (mixed bacteria) silage was exceed the control ration by 25.6%. While cows fed BWS or BWUS caused significant increase by 12.6% and 16.4% respectively. The results of 4% FCM yield showed the same trend. There were significant differences between treatments. Cows fed BWIS gave the highest ($P<0.05$) FCM and exceed the control ration by about 23.5%. Milk-lactose percentage showed a significant ($P<0.05$) difference between treatments.

Table (3): Milk yield and composition of lactating cows fed on experimental silages.

Item	Control	BWS	BWUS	BWIS
Milk yield, Kg, day	12.17^{c}	13.70^{b}	14.15^{b}	15.29^{a}
4% FCM	10.89^{c}	12.50^{b}	13.04^{b}	14.14^{a}
Fat	0.40^{c}	0.47^{b}	0.49^{b}	0.55^{a}
Protein	0.38^{c}	0.42^{b}	0.43^{b}	0.48^{a}
Lactose	0.53^{b}	0.58^{a}	0.58^{a}	0.61^{a}
Milk composition (%):				
Total solids	11.70	11.69	11.68	11.69
Fat	3.30^{b}	3.42^{ab}	3.48^{ab}	3.57^{a}
Protein	3.08	3.10	3.10	3.13
Ash	0.98	0.97	1.00	1.00
Lactose	4.34^{a}	4.20^{ab}	4.10^{b}	3.99^{c}

Means with different superscripts in the same row are different at ($P<0.05$).

Milk fat increased ($P<0.05$) for BWIS compared with control group. Results of ruminal pH, ammonia nitrogen (NH_3-N concentration and total volatile fatty acid (VFA's) concentration are presented in Table (4). The differences among treatments concerning pH values were significant ($P<0.05$). There are significant differences observed in NH_3-3 and VFA's concentrations among the different rations. The VFA's concentration was significantly ($P<0.05$) increased in BWIS group than other experimental groups as the result of the higher digestibility of CF. **Doane *et al.* (1997)** indicated that the gas and VFA's production are correlated with NDF disappearance.

Table (4): Rumen activity of lactating cows fed the experimental silages.

Item	Control	BWS	BWUS	BWIS
pH	6.34^{b}	5.97^{c}	6.48^{a}	5.97^{c}
NH_3-N(mg/100ml)	11.71^{c}	12.75^{b}	13.37^{a}	12.96^{b}
Total VFA's mM/100ml	4.85^{c}	6.88^{a}	6.51^{b}	7.01^{a}

Means with different superscripts in the same row are different at ($P<0.05$).

Estimates of ruminal degradation constants (a, b and c) fitted with rates of DM, OM and CP disappearance for silages are presented in Table (5). Predicted constants were less in BWS or BWUS compared to BWIS for DM, OM and CP degradability. However BWIS had more soluble, degradable fractions (a and b), in the same time it had undgradable fraction (μ), and had more effective degradability (ED) than other silages. **Sniffen *et al.* (1992)** suggested that a low degradation of banana by products.

Table (5): Degradation kinetics of DM, OM and CP for experimental silages.

Item	Degradability constant, (%)				ED with passage rate at 3%
	a	B	c	u	
	Dry matter (DM)				
BWS	20.65 ^{bc}	27.20 ^{c}	0.057	52.15 ^{a}	38.41 ^{c}
BWUS	20.97 ^{ab}	28.80 ^{b}	0.059	50.23 ^{a}	40.01 ^{b}
BWIS	22.64 ^{a}	30.90 ^{a}	0.056	46.46 ^{b}	42.69 ^{a}
	Organic matter (OM)				
BWS	21.92	30.41 ^{bc}	0.046	47.67 ^{a}	40.22 ^{c}
BWUS	21.76	32.39 ^{b}	0.050	45.85 ^{a}	41.99 ^{b}
BWIS	21.79	33.31 ^{a}	0.052	44.90 ^{b}	44.23 ^{a}
	Crude protein (CP)				
BWS	21.95 ^{b}	32.89 ^{c}	0.053	45.16 ^{a}	42.94 ^{c}
BWUS	24.50 ^{a}	35.41 ^{b}	0.050	40.09 ^{b}	46.55 ^{b}
BWIS	24.35 ^{a}	38.13 ^{a}	0.053	37.52 ^{c}	48.65 ^{a}

Means in the same column with different superscripts are significantly different at ($P<0.05$).

a= soluble degradable fraction
b= degradable fraction
c= rate of degradation
ED= effective degradability
u= ruminaly undegradable fraction [100-(a+b)]

The values of some selected blood plasma parameters are presented in Table (6). No significant differences were detected among rations for all blood parameters. Moreover, they were within the normal average as described by **Stanek *et al.* (1992)**.

It was noticeable that rations contained inoculant silage (BWIS) showed the lowest feed cost per ton of 4% FCM (Table 7), followed by (BWUS) and the control ration (LE 992.4, 1102.2 and 1094.0), respectively. Banana Waste Silage was the expensive one (LE 1173.7). However, from the economic point of view, the reduction in feed cost per ton of 4% FCM over the control ration was about LE 101.60 for feeding (BWIS). So, it could be concluded from this study that its very promising to minimize the pollution of environment through ensiling BW especially with inoculant which considered as an additional feed resource to cover apart of the gap in ruminant feeds in Egypt.

Table (6): Blood plasma parameters of lactating cows fed the experimental silages.

Item	Control	BWS	BWUS	BWIS
Glucose, mg/dl	86.78	84.08	85.55	85.96
Urea, mg/dl	39.59	38.17	42.42	40.13
GOT u/L (AST)	51.75	51.25	51.75	50.50
GPT u/L (ALT)	13.25	11.25	13.25	11.50
Plasma protein p/p, g/dl	8.38	8.28	9.00	8.32
Albumin, g/dl (A)	4.93	4.85	4.98	4.81
Globulin, g/dl (G)	3.45	3.43	4.02	3.51
A/G ratio	1.43	1.41	1.24	1.37

Table (7): Economic evaluation of the experimental rations fed to lactating cows.

Item	Control	BWS	BWUS	BWIS
Average daily DMI, Kg	15.10	15.05	15.95	15.38
Average daily feed cost, LE,h	11.70	13.58	13.25	13.10
Average daily yield of 4% FCM, LE	10.69	11.57	12.03	13.20
Feed cost per ton of 4% FCM, LE	1094.0	1173.0	1120.2	992.4
Feed cost reduction/ton 4% FCM, LE	--	-79.70	-8.20	+101.60

Local price according to year 2003 of feedstuffs (LE/ton):
CFM=1100, rice straw = 100, BWS= 105, BWUS= 129 and BWIS= 113.

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الملخص العربى

دراسات غذائية على استخدام سيلاج مخلفات الموز فى تغذية الأبقار الحلابة

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الهدف من هذه الدراسة هو دراسة إمكانية استغلال مخلفات الموز لإنتاج علف غير تقليدى لتغذية المجترات.

استخدم فى تجارب الهضم ثلاثة كباش ناضجة لكل عليقة وأيضاً ثلاثة نعاج مزودة بفستيولات الكرش لإستخدامها فى تقدير التخمر ودرجة التحلل فى الكرش. كما تم إجراء تقييم إنتاج اللبن وتقدير مكوناته وذلك بإستخدام ٨ بقرات فريزيان حلابة بإستخدام المربع اللاتينى ٤×٤ وذلك بإستخدام العلائق التالية:

١- علف مركز + قش الأرز (عليقة المقارنة)
٢- علف مركز + سيلاج مخلفات الموز (بدون إضافات)
٣- علف مركز + سيلاج مخلفات الموز المعامل ب ٣% يوريا
٤- علف مركز + سيلاج مخلفات الموز المعامل بمخلوط البكتيريا.

ويمكن تلخيص النتائج فى الآتى:

١- أدت السيلجة إلى خفض المحتوى من الألياف الخام وخاصة مكونات الجدار الخلوى وكان ذلك واضحاً فى حالة العليقة رقم (٤).
٢- زادت المعاملة البكتيرية من هضم جميع العناصر الغذائية تلاها السيلاج المعامل باليوريا.
٣- بلغ إنتاج اللبن الشهرى أقصاه للأبقار المغذاة على السيلاج المعامل بالبكتيريا وأقله للأبقار المغذاة على عليقة المقارنة.
٤- لم توجد أى فروق معنوية فى مكونات الدم نتيجة التغذية على العلائق المختلفة.
٥- أظهرت النتائج أن نسبة الفقد فى المادة الجافة كان مرتفعاً فى حالة استخدام السيلاج المعامل بالبكتيريا.
٦- وجد انخفاض قدره ١٠١,٦ جنيها لكل طن من اللبن المعدل (٤% دهن) عند التغذية على السيلاج المعامل بالبكتيريا.

وعلى ذلك يستنتج من هذه الدراسة : أنه ينصح بعمل السيلاج من مخلفات الموز وذلك لتحسين القيمة الغذائية لها وكذلك تقليل التلوث البيئى وكذلك يمكن أن يضاف المخلوط البكتيرى للسيلاج لتقليل تكلفة التغذية والحصول كذلك على أكبر عائد من إنتاج اللبن وكذلك يمكن أن نغطى جزء من الفجوة الغذائية فى مصر.