PRELIMINARY OBSERVATIONS ON THE USE OF ANHYDROUS AMMONIA WITH AND WITHOUT MOLASSES FOR THE PRESERVATION AND UTILIZATION OF ENSILED SISAL PULP[1]

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Three experiments were conducted to examine the process of ensiling sisal pulp with $_{NH3}$, and a fourth experiment to ensile sufficient-sisal pulp either with or without NH treatment, to test the quantity of both types of silage in a feeding trial with cattle. In the first experiment, anhydrous $_{NH3}$ gas was introduced at the bottom of a 1.2 m silo filled with sisal pulp. Two vertical cores of silage were removed from the silo, the first after one week. and the other after 3 weeks. Samples of silage juice were taken at intervals aloe?, the profile and analysed for $_{NH3}$, ,!Brix and pH. The diffusion of $_{NH3}$ was very slow and after 3 weeks it was only partially mixed with the lower half of the silage (up to 0.6 m). The pH was related to $_{NH3}$ concentration, varying from pH 3.6 to 4.2 at low levels of NH up to pH 10 at the bottom of the silo.

To investigate the use of an ammonia solution to overcome the problem of mixing with the silage, Experiment Two was carried out. The gas was bubbled into a solution of molasses/water (50/50, by weight) and samples were taken with time to estimate the $_{NH3}$ content, temperature and pH of the solution. After approximately 25 min, the $_{NH3}$ in solution reached a plateau concentration of about 60 g $_{NH3}$-N/litre. The pH, as expected, was closely related to the concentration of $_{NH3}$, increasing from pH 6.5 with no $_{NH3}$ present to 10.9 at the upper level. Temperature of the solution also increased with time as the gas bubbled through it.

In Experiment Three solutions of molasses/water, containing different amounts of $_{NH3}$-N were mixed with fresh pulp in the ratio 1 kg solution : 9 kg pulp, and ensiled for 35 d. At the end of this time, the juice from. each silage was analysed for $_{NH3}$, !Brix and pH. The concentration of $_{NH3}$ in the juice was directly related to the amount of $_{NH3}$ added to the silage and the ph remained constant at about 4. Final concentrations of ammonia in the silage in excess of 0.45% (fresh basis) appeared to prevent the loss of sugars, which occurred at lower levels, or in tile absence of ammonia.

Finally, two silos of 6 t capacity were used to prepare a sufficient quantity of silage for a feeding trial, with 8 animals. For one group of 4 animals, the silage was prepared by the method described in Experiment Three, using a moderately high level of $_{NH3}$ in solution (about 44 g $_{NH3}$ /kg of molasses/water) which was mixed with fresh pulp at the rate of 100 kg/t prior to ensiling The sisal pulp was ensiled without additives for the other group of animals. All animals were given 2 kg of sunflower seed meal. Animals receiving the treated silage grew faster (1.51 vs 0.95 kg/d). The higher growth rate was associated with a higher level of feed intake (5.40 vs 4.81 kg DM/d) and a more efficient feed conversion ratio (3.58 vs 5.06). There was also less spoilage of treated silage on the often face from which it was being taken, than there was in the case of the untreated silage.

Key Words: Sisal pulp, silage, anhydrous ammonia

There is considerable potential for cattle production from the pulp and bagasse produced as by-products of the sisal (Agave fourcroides) industry, since large quantities of both by-products are currently discarded.

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The costs of transportation and occasional mechanical failures in the factory mate the daily supply of fresh pulp difficult. Therefore, means of storing reserves of this material for cattle feed must be developed to facilitate day to day feedlot management. There are several possible methods of achieving this. One is to dry the pulp at the production factory, reducing the water content of the pulp from 80% to less than 10%. Another method, which is less costly, is to ensile the freshly produced pulp.

Fresh sisal pulp contains approximately 21% dry matter (DM), crude protein (DM basis) and about 10% soluble sugars (DM basis). pH of the fresh pulp is normally low (pH 3.9 to 4.1).

Early observations on the ensiling process showed that it was difficult to obtain a product of constant composition; some silos maintained a low pH throughout the ensiling period, while in other silos, there was considerable browning, elevated pH and high silo temperatures (approximately 49'). Once silos were opened, deterioration of the silage was rapid. Every day a substantial part of the silage face had to be removed to obtain the fresher pulp inside, as the dry surface material was less palatable to the cattle than was the fresh silage.

Traditionally, compaction has been the most important element in silage making, in order to ensure an adequate anaerobic fermentation in the silo and the production of a low pH. Recent advances in the use of chemical additives have made it possible to produce chemically restricted fermentations which result in acceptable silages of improved nutritional value (McDonald and Edwards 1976; Barry 1976).

Alvarez and Preston (1976) found that aqueous ammonia had beneficial effects on the ensiling of chopped sugar cane by preventing the alcoholic fermentation which normally occurs. The aqueous ammonia also contributed significantly to the total N content of the ensiled material. Godoy et al (1979) have examined the use of aqueous ammonia as a preservative for ensiled sisal pulp in small scale silos and although the preliminary results were good, the extensive use is somewhat limited due to the cost of the material.

The present series of experiments were conducted to examine the value of gaseous, anhydrous ammonia as a preservative in silage making from sisal pulp, and to evaluate this silage in a feeding trial.

Materials and Methods

The examination of the ensiling process was carried out in three experiments.

Experiment One: was to measure the diffusion of the gas up the silo during a three week period. Anhydrous ammonia gas was introduced into the base of 2 concrete cylindrical silo of sisal pulp (500 kg capacity). In order to sample a vertical profile of the silage, two tubes of stiff wire mesh (l cm holes), approximately 1.2 m in height and with a diameter of 10 cm, here filled with fresh sisal pulp and placed vertically in the silo. After a period of 7 d, one tube was withdrawn and the space previously occupied by the tube rapidly filled with fresh pulp and compacted well. Three weeks after ensiling, the remaining tube was removed. Samples of ensiled pulp at 15 cm intervals were taken from loot!: cores and stored at -5 C for analysis of pH, Brix and $_{NH3}$ levels.

Experiment Two: In order to measure the solubility of anhydrous ammonia in a mixture of molasses and water (50:50 w/w), the gas was bubbled through a 50 kg sample of this solution and l kg samples were removed every 5 min during a 30 min period. The temperature, pH and ammonia concentration were estimated for each sample.

Experiment Three: The l kg samples of the ammoniated molasses/ water mixture taker. during Experiment 2 were mixed with 9 kg of fresh sisal pulp and ensiled separately in sealed glass jars for 5 weeks. At the end of this period, measurements were made of the pH , Brix and ammonia concentrations in the samples.

Based on the results of Experiments 2 and 3, Experiment 4 was designed to test the quality of the NH_3 -treated and untreated silages as cattle feeds.

Experiment Four: (i) Silos: Two silos were constructed, each to contain 6 t of fresh sisal pulp. The silage in one silo was prepared with 100 kg of an ammoniated (4% NH_3-N, w/v) molasses/water mixture/t of fresh pulp. The solution was ammoniated as described in Experiment 3. The other silo contained only fresh pulp without additives. Measurements of pH, Brix and NH_3 levels were made in both the treated and untreated silos after 28 and 60 d. Samples were taken at 15 cm intervals along a vertical profile through the silo by the technique described in Experiment 1.

(ii) Animals and Dietary Treatments: Eight Brown Swiss x Zebu bulls of 230 kg average liveweight were housed individually on slatted floors. Four bulls received treated silage ad libitum and the other four the untreated silage. All animals received 2 kg of sunflower seed meal and 50 g of a mineral/trace element mixture before the pulp was fed. A solution of urea in water (50/50, w/w) was mixed with the ensiled pulp at the time of feeding to provide 8 g urea/kg fresh pulp. The animals were weighed after one week on the diets and then again after 35 d. During this 42 d period, the voluntary intake of each animal was measured.

Results

The diffusion of NH_3 gas through sisal pulp silage and the effect of NH_3 concentration -in the silage juice on pH measured in Experiment 1 are shown in Table 1. After one week, the NH_3 had partially mixed with the bottom 30 cm of silage and after three weeks, this had increased to about half of the silo (approximately 60 cm). Increase in pH was associated with high levels of NH_3 in silage juice (> 1 g NH_3 -N/lOO ml). The high pH and the loss of sugars (Brix!)in the top 45cms of silage after three weeks corresponded with the visual observation that there was poor preservation of this portion.

The high Brix readings in the juice, from the base of the silo, where the ammonia concentration was greatest, might have been the result of solubilization of the hemicellulose fraction of the pulp. Ammonia treatment of cereal straw has-been reported to have this effect (Tejada 1979)

The results of Experiment 2 are given in Figure I. In Experiment the concentration of NH_3 and pH increased with time as the NH gas was bubbled through the solution of molasses/water (Figure 1). The curves of NH concentration and pH, with time, appeared to reach plateau values after approximately 25 min and at this stage NH_3 level in the air above the tank became noticeably higher. The temperature of the solution increased linearly with time over the period of the experiment from 35 to 67°.

Table 1:
Effect of anhydrous ammonia introduced at the silo base (105-120cm) on pH, Brix and NH_3-N concentration (mg NH_3-N/100 mg liquid) (Experiment 1)

Measurements	pH		Brix		NH_3-N,mg/100ml
Time, weeks	1	3	1	3	
0 - 15	4.2	7.0	6.0	3.0	16
15 - 30	3.6	7.0	8.6	3.0	20
30 - 45	3.6	6.9	10.0	3.0	127
45 - 60	3.9	5.8	10.0	8.5	371
60 - 75	4.2	7.8	10.0	12.5	1288
75 - 90	8.6	8.3	10.0	16.0	2194
90 - 105	9.5	8.6	13.4	18.0	2857
105 - 120	10.2	8.4	20.0	18.0	3845

In Experiment 3, there was a close relationship between the concentration of NH_3 in the molasses/water mixture and in the silage juice extracted after 35 d (Figure 2). Although there was a range in NH_3 concentration in the different silage juices from 26 to 556 mg NH_3-N/ 100 ml juice, there was no major effect on pH (3.8 to 4.1) associated with this variation.

Brix values were increased by addition of molasses, as would be expected. There is evidence that increasing ammonia concentration up to 4.5% in the molasses supplement (0.45% in the silage, fresh basis), helped to prevent the loss of augers which apparently took place at lower concentrations of ammonia (Table 3).

The large quantities of silage prepared for the feeding trial demonstrated the same characteristics as were observed in the experimental silos used in Experiment 3, and these have been summarized in Table 2. There were no signs of deterioration of silage below 15 cm from the surface. The addition of NH_3 to the silage resulted in an increased concentration of NH_3-N in the silage juice (306 vs 28mg NH N/100ml) but there was no effect on pH.

The results of tile feeding trial are shown in Table 4, Over the 35 d period, the animals given the NH_3-treated silage grew more quickly than those given the untreated silage (1.5 vs 0.95 kg/d). The higher rates of liveweight gain were associated with increased levels of feed intake and with a more efficient feed conversion ratio. It was observed during the feeding trial that the deterioration of the silage on the face from which it was being removed was far more extensive in the case of the untreated than the treated silage.

Figure 1 :
Increase in NH_3 concentration and pH in a solution of molasses and water as anhydrous NH_3 was bubbled through it

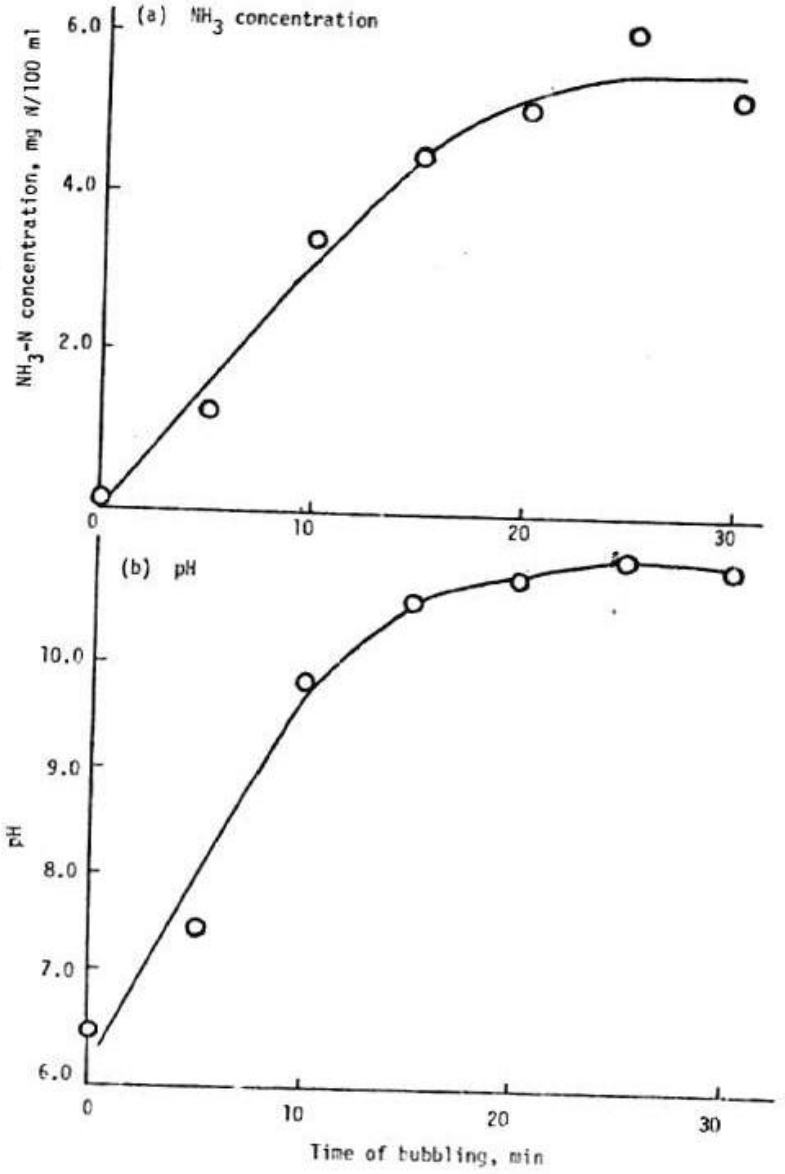

Figure 2:
The effect of the amount of NH_3 added to sisal pulp on the concentration of NH_3 in the! silage juice

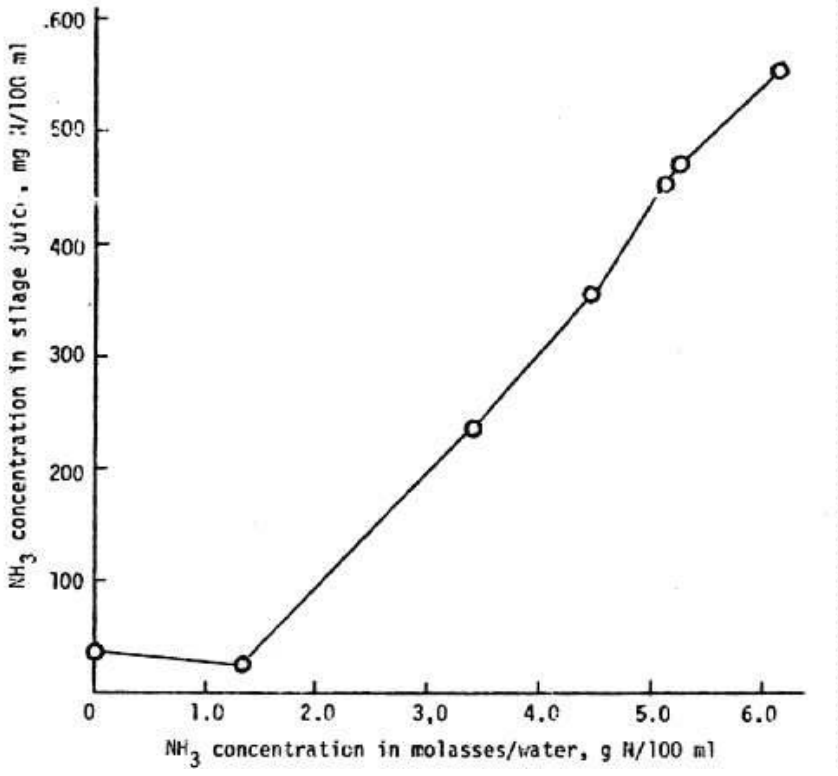

Table 2:
The pH and NH_3 concentration of silage juice from untreated sisal pulp or sisal pulp treated with 4.4 n g NH_3-N/kg pulp added in a solution of molasses/water. Each value represent !the mean of 7 measurements made on the silage between the depths of 15 and 120 on in the silo.

	Untreated silage		SEx	Treated silage		SEx
	28 d	60 d		28 d	60 d	
Silage juice						
pH	3.93	4.11	0.03	4.05	4.19	.03
NH_3 concentration mg NH_3-N /100 ml	28	25	2	306	289	7

Table 3:
Analysis of juice sample of fresh sisal pulp, or pulp ensiled 60A 35 days with molasses or molasses with different levels anhydrous ammonia

Treatment of sisal pulp	NH_3-N mg/100 ml	pH		Brix[1]	
	After	Before	After	Before	After
Entreated (fresh)	25	4.0	4.2	9.5	9.0
Treated					
Molasses (M)	32	4.2	3.7	15	10.5
H +1.33%NH_3-N	26	4.2	3.8	13	11
3.41	238	7.4	4.0	15	12.5
4.45	352	9.8	4.0	15	14
5.11	458	10.2	4.0	15	14
6.02	556	10.4	4.0	15	15
5.20	463	10.7	4.1	15	16

[1] A measure of total dissolved solids does not measure ammonia

Table 4:
Feed intake, liveweight gain and the the feed conversion ratio of bulls fed ensiled sisal pulp either treated with an NH_3/molasses water mixture supplying about 4.4 g NH_3-N/kg sisal pulp, or untreated.

	Without treatment	With NH_3 treatment	SEx
Total intake, kg /d	4.81	5.40	-
Consumption index[1]	1.86	2.17	0.20
Initial liveweight kg	242	223	-
Liveweight gain, kg/d	0.95	1.51	0.17
Feed conversion ratio[2]	5.06	3.58	0.10

[1] kg feed intake/100 kg liveweigt
[2] kg feed/kg gain

Discussion

It is clear that the main limitation to the use of anhydrous NH_3 in the preservation of sisal pulp during ensilage is the very slow rate at which the NH_3 diffuses through the pulp. In Experiment 2, it was shown that ammonia solutions could easily be made (containing up to 6% NH_3-N(w/w)), and subsequently it was demonstrated that by adding the NH_3 in solution to the silage, a satisfactory distribution of the NH throughout the silage was achieved. It was therefore concluded that the easiest method of making the best quality silage with sisal pulp was to bubble NH_3 gas

through a molasses/water mixture (equal quantities by weight) for about 25 min and then to mix this solution with the sisal pulp at 100 kg/t fresh pulp.

The feeding trial was only over a relatively short period and because the animals used were in poor condition it was probable that the high growth rates represented compensatory growth to some extent. Nevertheless, there was a large difference in liveweight gain between the two groups mainly due to an increase in the feed intake when the sisal pulp was treated with ammoniated molasses/water at the time of ensiling. Whether the increased intake was due to an improved palatability of the silage through the presence of molasses is not clear from this experiment.

Another possible way that the treatment of the silage may have improved the level of intake and utilization of the treated silage could be due to an improvement in the nutrition of rumen microorganisms through the supply of additional soluble sugars in molasses and more soluble N as NH_3. An increase in the synthesis of microbial protein in the rumen would be expected to produce the same type of response in animal production that is produced when a high quality bypass protein is fed, that is, to increase feed intake (Kempton et al 1977).

The utilization of sisal pulp ensiled with a solution of NH_3 and molasses/water and fed with a supplement of sunflower seed meal is at present being investigated in a larger scale feeding trial over a longer period.

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