The place of silage in ruminant production in the humid tropics.

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Introduction

In many developing countries of the humid tropical region of Southeast Asia, ruminant livestock production is mainly carried out by smallholders who are largely dependent on natural forages for their feed resources. Natural forages grow freely along the roads and on idle agricultural land. In Malaysia, as in many humid tropical countries, green forages are plentiful for most of the year. However, at times, e.g. during a drought, livestock farmers will experience a shortage of forages and feeding of ruminant livestock will become a problem. Fodder conservation is promoted with the main objective of ensuring feed availability during periods of feed limitation (Mohd Najib *et al*. 1993).

Justification for feed conservation

For subsistence farmers, with a few animals, harvesting of livestock feed from roadsides and unused agricultural land is becoming less common. The economic boom in the eighties and early nineties has changed the dairy livestock perspective of Southeast Asian farmers. As they become more progressive, the need for feed security in their ventures must be ascertained. Also as they become more affluent, social activities within the community increase.(Hassan Wahab and Devendra 1982).

The farmers lack time for cutting forage, especially during the main crop-planting period and harvesting season, and especially during major festive and religious events. In addition, rainfall in recent years has been less reliable. Production of dry matter can be reduced tremendously during prolonged droughts, whilst excessive rainfall causes flooding that can affect production, harvesting and transportation. As the nations become more developed, the accessibility of animals to roadside pastures becomes limited for reasons of safety to motorists. Nowadays, the super highways are out of bounds to animals.

It is becoming increasingly clear that the rising population has put increased pressure on agricultural land use in this part of the world. There is increasing use of gazetted grazing land for intensive crop production. This has resulted in reduced availability of free feed resources from common grazing lands. Hence, forage conservation is needed during periods of high forage productivity. Silage making of forages, that are plentiful during the wet season, is one of the answers to feed shortages in other parts of the year.

Silage making in the tropics

The silage concept is more relevant to temperate regions that have distinct seasons than to the evergreen tropics. Nevertheless, over time, in Malaysia the objective of silage production has become more relevant to fulfil the forage needs for smallholder dairy farmers. Silage making is less dependent on weather conditions than hay making is.

The reasons for the major interest in silage conservation in the tropics are many. As the countries of the tropics become more developed the aspirations of the farmers also become more sophisticated. No longer are they content with labour intensive and mundane chores like cutting grasses every day for ruminants, irrespective of the climatic conditions. Many of them are looking for alternatives where cheap animal feed can be obtained, stored and utilised at their convenience. Silage making offers a solution.

In addition, the progressive farmers are keeping more animals and are aware of the need for nutritious forages for their animals. As livestock husbandry becomes more a financial investment than a form of social security, farmers want an assurance of readily available good quality feed for their animals. Silage making offers one option to secure feeds during seasons of high production for conservation and storage and use in periods of relative shortage. The silage can be kept for months or even years. Silage can be used at any time as and when required, especially during periods of drought (Koon 1993).

Silage quality

Maize silage has been the basic fodder for cattle in North America and to a lesser extent in Europe. Maize has a high rate of conversion of radiant energy into plant matter. The high starch content of the grain makes the energy content of maize higher than that of hay or forage sorghum and thus is good material for silage production (Mooi 1991). On the other hand, many available tropical forages and agro-by-products are generally low in nutritive quality. Silage made from these forages is possible, but are not able to sustain high animal productivity because of their low digestible energy content. New methods of silage making may be needed. In Malaysia, the oil palm plantations produce an abundance of pruned fronds every week, which can be exploited as animal feeds. Although the nutritive quality of palm fronds is low, there is a need to develop proper ensiling processes to upgrade the frond silage quality without much nutrient deterioration. A new approach to silage production from tropical forages is an area that needs to be further explored.

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Silage making activities of the department of veterinary services Malaysia

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The Department of Veterinary Services (DVS) in Malaysia undertakes silage making as a form of fodder conservation. This activity has been pursued since the sixties. Silage crops involve grasses, maize and forage sorghum varieties. Silos include horizontal ground types, such as wooden and concrete bunkers, earthen trenches and surface stacks. Receptacles such as plastic bags and drums are also used for silage making. Mechanised film wrapping of small round grass bales to produce "silawrapped" grass silage is also carried out.

Horizontal silos have been used for grass, maize and forage sorghum ensilage activities. These horizontal silos consist of mainly above ground wooden bunkers, surface stacks and the below ground earthen trenches. Bunker silos range in size from the small scale 4 m square wooden walled type to large scale permanent twin walled concrete bunkers, each measuring 13 m x 5 m, with walls 1.23 or 1.74 m high. Silage making activities with the larger twin-walled bunkers are highly mechanised. Forage harvesters, both tractor-mounted bin and the tractor-drawn wagon types, as well as tipper lorries are used for the harvesting, transporting and filling of the silage storage. Packing /compaction is achieved by the weight from the wheels of a heavy-duty tractor, driven strategically over the heap. Permanent concrete bunkers are available on several livestock farms for ensilage work.

Earthen trench-type silos, constructed through earth excavation, have dimensions of 20 m x 5 m. Since these trench silos are normally located on selected sloping ground, they usually have a depth of about 3 m at the closed end which decreases to zero at the open end.

The stack system silage has been successfully carried out at the Department's training institute farm between 1983 and 1985. Four hundred tonnes of grass silage from Signal grass (*Brachiaria decumbens*), Kazungula grass (*Setaria sphacelata* cv Kazungula), Guinea grass (*Panicum maximum*) and Napier grass (*Pennisetum* *purpureum*) have been produced using this method during that period.

Between 1985 to 1986, the production of silage from forage sorghum (e.g. Sugargraze and Jumbo varieties), maize as well as Napier grass in small round concrete tower-type silos have been carried out in the northern part of the country. Dairy farmers in the area, which experiences an annual dry period, have been encouraged to conserve fodder in the form of silage to ensure year-round forage availability. Each small tower silo, of 2 m diameter and 3 m height, is capable of ensiling 10 tonnes of fresh material, which resulted in about 7.5 tonnes of silage. During the two-year programme, 250 tonnes of forage sorghum silage, 66 tonnes of maize silage and 30 tonnes of Napier grass silage have been produced.

Increasingly, the use of local crop residues, such as sweet corn stovers and oilpalm fronds, as forage/roughage feed, is also being undertaken through ensilage. Currently, sweet corn stover silage is being produced using container/receptacle type silos consisting of plastic drums and plastic bags. Since the inception of the corn stover ensilage programme in 1994, an estimated 400 tonnes of sweet corn stover silage have been produced for feeding farmers' cattle. Farmers, involved in integration of cattle with oilpalm, have also been encouraged to ensile chopped oilpalm fronds in plastic drums to supplement grazing wherever there is problem of insufficiency of understorey forage. Ensilage in plastic drums has become a popular method of making silage in the country, as the drums are convenient for filling, packing, sealing, handling and feeding-out. Silage making involving mechanised "silawrapping" of small round bales has been introduced in 1991. This method of silage production, which involves mainly grasses, has been undertaken on three ruminant farms as well as on reserve grazing land. Annually, about 500 bales of "silawrapped" silage, equivalent to 15 tonnes, are being produced to feed cattle and sheep during the dry season. Up-to-date, a production of about 290 tonnes of "silawrapped" silage has been achieved.

The Department's ensilage work also involved cultivating a crop of maize on a freshly sown signal grass pasture and harvesting the mixture for ensilage. It successfully tested the concept of cultivating maize as a one-off silage crop on newly developed or redeveloped pasture fields, before the latter is permanently used for grazing. The concept aims at maximising the usefulness of land being developed or redeveloped for permanent grazing.

Basic reasons of failure of silage production in Pakistan

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Introduction

In Pakistan the livestock industry has to face two severe fodder scarcity periods (May-June and October-November) that has a big effect on animal production. Conserving the surplus fodder in the form of silage and using it during shortage periods can avoid these problems. Silage technology was introduced in Pakistan almost two decades ago by different government and international agencies. Despite heavy inputs in terms of time and money, silage production could not get a place in traditional livestock feeding and production systems. The present study was aimed to probe into the question of failure of silage making and feeding in Pakistan.

Materials and methods

150 livestock producing farmers, 50% living in areas under government institutions influence (AUGII) and 50 percent at a distance, in different agricultural communities were selected at random and interviewed for 30 minutes, about silage making, costs, feeding and other allied problems, using a pertested proforma.

Results and discussion

Results of the present study revealed that more that 90% of farmers living in AUGII were aware of silage making and its feeding, whilst only 10% farmers living away (farmers at distance, FAD) have knowledge of this technology (Table 1).

Table 1: Farmers Response about Silage Technology (%)

	Knowledge	Feeding	Wants	Wants

	of silage techn.	experience	to make	commercially prepared silage
AUGII	90	70	20	60
FAD	10	5	-	20

It was noted that farmers living in AUGII, because they have more knowledge about silage feeding, want to continue with this practice, but due to high production and labor costs are not able to do so. However, they showed a positive response for use of silage if it is commercially made and available at reasonable prices as in the case of poultry rations. The impact of government and other international agencies was restricted near to government institutes and in peri-urban areas.

Table 2: Constraints Related with Silage Making

	Cost	Time	Small area or animal unit	Quality of silage	Cost: Benefit
AUGII	80	60	90	70	80
FAD	NI	80	70	NI	NI

NI: No idea

Small area of land and small animal units were other major factors that affected silage production (Table 2). A majority of the farmers owns only few acres of land (3-5 acres/family) and their major concern was cash crop production; and they owned small animal units comprising 1-2 animals to meet their daily household needs. For such a small unit farmers can easily get fodder from barren lands, roadsides and canal sides or by working in big farmers' fields.

Conclusions

1. **High production cost, small land and animal units are major constraints that do not permit farmers to go for silage production.**
2. **The cost:benefit ratio is not impressive due to small animal units.**
3. **To reduce the production cost mass scale commercial production of silage should be started.**
4. **Effective extension work and feedback is required.**

The Use of Silage in Year-Round Feeding System: The Case in Sarangani Agricultural Company, Inc. cattle operation in Southern Philippines

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1. Introduction

Sarangani Agricultural Co., Inc.(SACI) is a diversified all-Filipino company offering a diverse range of agricultural products with base office in Maribulan, Alabel, Sarangani Province, Philippines. Over the years, it has distinguished itself as the premier cattle producer in the country, maintaining a herd of 5,000 purebred and graded American Brahman cattle with upgraded horses raised in General Santos City, Malungon and Alabel, all located in Southern Mindanao. From Sarangani Brahman, SACI has expanded into production of banana, pummelo and bangus, tilapia, prawn and specialty fishes. It has initiated vegetable production and tree planting for industrial uses.

Along with the breeding of quality Brahman cattle, SACI has continuously developed feeding technologies using farm byproducts such as banana rejects, pineapple pulp, corn (maize) stover and cobs, rice straw, Ipil-ipil and silage among others. This paper gives special reference to our experience with corn silage in Alabel farm.

2. Cattle Feeding Management in the Farm

Two systems of feeding, grazing and confinement or feedlot, are used in the farm. The breeding herd which at present is composed of 230 cows and 24 bulls along with 140 calves and 96 yearlings are grazed in 186 ha and 223 ha of Para grass (*Brachiaria mutica*)/Leucaena and native pastures, respectively. Other groups of animals (marketable bulls, marketable heifers, culled cows from ranch operation, fattening bulls and fattening steers) are kept in the feedlot.

3. Planting and preparation of corn for silage

Corn is planted in 25 ha throughout the year where four crops are harvested with irrigation. Following each crop of corn in a particular area, land is prepared and planted with new crop after 15 days and 22 days, respectively, from harvesting. Each crop is harvested at 75 days after planting by tractor mounted harvester-chopper machine, dumped and piled in stack in an area near the feedlot. The area for the

stack pile is lined with plastic sheets before dumping the chopped corn plants. The stack pile in a day's harvest is immediately covered with special and strong plastic sheets after compacting by several passings of a tractor over the pile.

Recovery of ensiled materials ranges from 80 to 92 percent. The variation is related to age of corn at the time of harvest. Corn harvested at 80 days from planting has higher recovery compared to those harvested at 70 days. However, ensiled younger corn is more palatable and has less wastage during feeding.

4. Utilization of corn silage

Ensiled corn is generally kept from 90 to 100 days during the rainy season (July to October) but shorter in the dry season, sometimes for only 18 days when severe drought occurs, like during the *el ni�o* months in 1997/1998. One time we experienced shortage of corn silage for 14 days, thus we harvested 38 ha of Para grass as green-chop in the farm (at the expense of our breeder herd) and purchased 65 tons of green-chop corn to support the animals in the feedlot.

4.1. Feeding of corn silage

Corn silage is the principal feed given to cattle kept in SACI feedlot. Below are the general feeding schemes used for different groups of animals per head per day.

Group	Corn Silage (kg)	Concentrate (kg)	Molasses with 10% urea (kg)
Marketable bulls	18	2	-
Marketable heifers	17	2	-
Fattening bulls (rejects)	20	4	1
Fattening steers	20	4	1

Culled cows	20	-	1

Corn silage is important in maintaining well-conditioned and uniform breeder heifers and bulls that we offer for sale to customers. It is also an important tool for conditioning culled thin cows (with average liveweight of 280 kg) from the ranch. If these cows are sold immediately to butchers, the price will only be 30 pesos per kg liveweight (US$1=PhP39.8 current exchange rate) but if we passed them to the feedlot on corn silage-based ration, these cows gain 1.6 kg/hd/day in 2 months and are sold at 36 pesos/kg.

For fattening steers and bulls, feeding of concentrates is done by mixing them with the silage to obtain uniform daily gain. Earlier observation showed that if they are top-dressed over the silage the more aggressive animals get more access to the concentrate and perform better. Our concentrate mixture is composed of rice bran, palm kernel cake and Ipil-ipil plus mineral supplements.

Corn silage is crucial to our Alabel cattle operation, allowing us to maintain a population of 410 head of two-year old bulls and heifers, culled cows and fattening bulls and steers at any given time in the feedlot in conjunction with the breeding

herd raised in pasture.

Silages from Tropical Forages: Nutritional Quality and Milk Production

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Introduction

There is a need for silage making technology under local conditions, especially in those areas experiencing drier months or where monsoonal conditions restrict the routine cutting of forages. The need for silage making is even more significant in dairy cattle feeding, where the demand for uniform and high quality feed is of great importance. The tedious daily harvesting of green forages throughout the year also posed problems with smallholders, particulary when family labour is not sufficient.

The objective of this paper is to evaluate the performance and suitability of six tropical grasses and three forage crop for silage making and a feeding trial for milk production.

Methods

Six grasses viz. setaria (*Setaria sphacelata* var. splendida), signal (*Brachiaria decumbens*), humidicola (*B.humidicola*), MARDI Digit (*Digitaria setivalva*), Napier (*Pennisetum purpureum)* and three crops viz. (*Zea mays*) forage sorghum (*Sorghum vulgare* x *S. bicolor*) and *S. almum* were planted. The grasses were cut at 6 weekly intervals. Corn was harvested at 75 days, forage sorghum at 70 days and *S. almum* at 63 days after planting.

Fresh samples were taken for DM% and water-soluble carbohydrates (WSC) (Dubois *et al.* 1956) and for silage making in the laboratory. The silage samples were analysed for pH, lactic acid analysis (MAFF 1973) and physical characteristics. In the second experiment, six multi-parous Sahiwal-Friesian cows in mid-lactation were used to test three dietary treatments in a double switch over experiment (Cochran *et al.* 1941). Treatments were levels of silage in the diet in direct substitution for cut

fodder as follows a) fodder *ad libitum*, b) fodder+silage (50:50) *ad libitum* and c) silage *ad libitum*. In addition each animal received six kg of concentrate once daily. Feed samples were taken once weekly and composited by cow-period. Feed intake and milk production were recorded daily.

Results and Discussion

The mean value of the WSC and the DM% in the crops and quality of silage produced (pH and lactic acid content) are shown in Table 1. Corn and forage sorghum produced good silage with pH <4.0 and lactic acid level with the values of 2.72 and 3.7%, respectively (Table 1). For the grasses, it was found that without additives, setaria and Napier can be turned into acceptable silage with pH of 4.07 and 3.96, respectively. The pH of the grass silage was reduced with the addition of 4% molasses (Table 1).

The nutritional composition of sorghum silage and guinea grass used in the second experiment are shown in Table 2. Treatment means for feed DMI, milk yield and feed efficiency are in Table 3. Intake of DM from roughage was higher ($P<0.05$) on treatment B than either A or C. The higher roughage intake of treatment B appears

to be attributable to a stimulatory effect of silage on intake. The difference in the total DMI reflects differences in roughage DMI. Expressed as percent body weight, total DMI on the respective treatments were within the range 2.0 to 2.4%. Average daily milk yield was higher (P<0.5) for cows fed sorghum silage compared with control. The difference in milk yield was 13% between treatments C and A. Mean feed efficiency value of cows on the silage-based diet was nearly twice as good as either treatment B or the control group A (Table 3).

Of the crops, forage sorghum and corn can be made into excellent silage without additives. Grasses are suggested to be cut at about 6 weeks regrowth. Napier and setaria can be ensiled into reasonable silage, but the quality can be improved with the addition of 4% molasses before ensiling. As for the second experiment, sorghum silage appears to be a better feed than the average guinea grass commonly fed to lactating cows in this country. This is reflected in its effect on milk yield and feed efficiency.

Table 1. Silage Made from Tropical Grasses and Forage Crops

	Silage	Silage 4 %	Quality

			molasses				
Crop Species	**DM%**	**WSC %**	**pH**	**lactic acid (%)**		**pH**	**lactic acid (%)**
Grasses							
S. splendida	15.30	6.17	4.07	2.47	Good	3.64	1.96
B. decumbens	20.37	8.64	5.07	1.08	Poor	3.37	1.87
B. humidicola	20.85	2.35	5.32	1.26	Poor	3.31	2.03
D. setivalva	18.21	1.26	4.32	1.46	Poor	3.31	2.83
P. purpureum	15.77	9.88	3.96	2.53	Good	2.98	nd
P. maximum	19.35	3.03	4.71	1.84	Moderate	3.27	2.74
Crops							
Z. mays	21.20	22.99	3.72	2.72	Very good		
S. vulgare x *S. bicolor*	21.35	11.69	3.68	3.75	Very good		

S. almum	18.40	nd	4.40	nd	Moderate		

nd – not done

Table 2. Chemical composition of feedstuffs (%)

Feedstuff	DM	CP	TDN	CF	EE	NFE	Ash	Ca	P
Guinea grass	24.1	11.7	61.6	33.6	2.4	46.1	6.2	0.57	0.27
Sorghum silage	29.4	8.7	60.1	33.4	2.6	51.0	4.2	0.47	0.17
Concentrate	91.2	23.5	77.2	5.5	11.6	54.7	4.7	0.57	0.36

Table 3. Feed intake and efficiency and milk yield for the different treatments

Variables	A	B	C

Feed DM Intake (kg/d)			
Roughage	4.95b	6.22a	4.50b
Concentrate	5.40	5.40	5.40
Total	10.35b	11.63a	9.90b
DMI Per 100 kg BW	2.1	2.4	2.0
Milk Yield (kg/d)	7.01c	7.54ab	7.93a
Feed Efficiency (kg total DMI/kg milk)	2.16b	2.65b	1.37a

The values within rows with different letters are significantly different (P<0.05)

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Silage quality and losses due to ensiling of Napier grass, Columbus grass and maize stover under small holder conditions in Kenya

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Introduction

On behalf of the National Dairy Development Project, several ensiling experiments were conducted at the National Animal Husbandry Research Centre (NAHRC) at Naivasha, Kenya, in the period 1983-1989. The aim of the experiments was to develop methods and techniques suitable for smallholders for the ensiling of Napier grass, Columbus grass and maize stover to overcome feed shortages during the dry season.

Materials and methods

The following six series of ensilage experiments were conducted:

> **Series A: 2 silages of chopped, wilted Napier grass with or without addition of molasses, ensiled in an number of netted nylon bags and placed inside a larger silage clamp**
>
> **Series B: 6 pits of wet long or chopped Napier grass with addition of 3.5% or 6% or without molasses**

Series C: 4 pits of wet long or chopped Napier grass with addition of 3.5% molasses or MUM (molasses/urea mixture)

Series D: 6 pits of wet long or chopped Napier grass with addition of 3% molasses

Series E: 4 pits of wet long or chopped Columbus grass with addition of 3% molasses

Series F: 3 pits of chopped maize stover or maize stover mixed with lablab, without additive.

Silages were made in small earthen pits in quantities varying from 1000 to 2000 kg fresh material, thus more or less representing conditions for small-scale farmers. Sides and top of the pit were covered with 2 m wide polyethylene plastic sheets covered with a layer of about 50 cm of sand on top and sides

Results

Percentage non-edible silage (mouldy and rotten silage) varied from 0 to 2.5%, indicating that sealing with polyethylene sheet and soil cover was good. Levels of butyric acid and contents of ammonia nitrogen often were below 0.3% and 12 respectively for silages of wilted Napier grass and wet chopped Columbus grass with the addition of molasses and for silage of maize stover. These fermentation characteristics indicate good silage quality. Smell was good as well. For some wet Napier grass silage and for silages made with addition of MUM of unchopped Columbus grass, results were less good.

Long, unchopped Napier grass wilted for one or two days to about 30% dry mater and with the addition of molasses and with proper compaction, often resulted in good silage as well.

Dry matter losses due to ensiling of Napier grass averaged 15.2 � 4.2%. Losses were lower for silages made of grass wilted for one or two days and higher for silages made of wet unchopped grass and grass with the addition of MUM. For wet Columbus grass, there was also a clear positive effect of chopping. Average dry matter losses for ensiled maize stover were 8.1%.

Losses of crude protein averaged 16.9%, but variation was large, partly due to

sampling errors. Losses were lower for wilted silages and much higher for silages with the addition of MUM.

In vitro organic matter digestibility decreased due to ensiling and was more than 10 units lower in case of poor quality silages. For well-preserved silages, the decrease in digestibility was often limited to 5 units or less. Losses of digestible organic matter for Napier silages averaged 28.5� 7.9%. Losses were lower for wilted silages and much higher for wet silages of series D and silages made with the addition of MUM.

Results show that under smallholders' conditions, good silage can be made. Poor quality silages of poorly digestible Napier grass however, will not meet maintenance requirements of animals.

Conclusions and practical recommendations

1. **Under small farmer's conditions, good silage can be made, provided that air-tight sealing with plastic polyethylene sheets is applied, with at least a cover of 50 cm of soil on top and sides of the pit, and with good drainage of rain water.**

Ensiling and covering has to be completed within one day.

2. **As shown by good fermentation characteristics and smell, wilting one or two days to reach a dry matter content of 30% often results in good silage, especially when molasses is added. Wilting to a dry matter content of more than 30%, or wilting of old stemmy material is not recommended, because of the higher weather risks and difficulties with compaction.**

3. **Dry matter losses due to ensiling of wilted or wet, chopped Napier grass with the addition of molasses could be limited to 15%.**

4. **Dry matter losses of silages made of wilted, un-chopped long Napier grass are probably slightly higher than from chopped Napier grass. Provided proper compaction, addition of molasses, air-tight sealing and covering with at least 50 cm soil, making silage of long, wilted Napier grass may be a good alternative for smallholder conditions.**

5. **Although it is not very clear from the limited experience provided by these experiments, addition of 3% molasses to wet and long wilted Napier grass will probably be sufficient to obtain good quality silage, especially when hand-**

mixed through chopped silage. To increase chances for good quality silages addition rates of up to 6% are suggested when molasses is applied in the silage pit on layers of grass. For chopped, wilted Napier grass and for chopped Columbus grass, addition of molasses can be lower.

6. **MUM as an alternative additive for molasses does not produce good silages.**

7. **Silages of chopped Columbus grass with molasses and chopped maize stover without molasses made good silage. Dry matter losses appeared to be lower compared to Napier grass.**

8. **Because of a higher risk for leaching, dilution of molasses with water in order to ease application should not exceed a 1-to-1 ratio. A relatively small quantity of molasses should be used at the bottom layers of the pit, and more to be added to the middle and top layers.**

9. **Losses of crude protein and digestible organic matter were not accurately measured in these experiments, because of the limited number of samples and because of sampling errors. Based on good quality silages in these experiments, losses are about 15% and 25% for crude protein and digestible organic matter**

respectively.

10. **Poor silages of overgrown Napier grass will at best supply sufficient energy for maintenance. Feeding overgrown Napier grass as standing hay, or mulching might be a better alternative then. Proper storage and utilisation of crop residues like maize stover and preserving feeds like sweet potato vines, fodder beets, cassava or fodder trees may prove better in those situations.**

Wet Season Silage Production at Taminmin High School

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1. Feed Resources in the Wet Tropics

The main limiting factor for ruminant production in the Tropical Top End of Australia is the lack of good quality feed throughout the year. Seasonal rainfall provides a period of abundant herbage at its peak nutritional value during the wet season, followed by a period of lower quality mature herbage in the dry season. It makes sense to try and conserve the abundance of good quality vegetation when it is available in the wet, and use it later in the dry season when plant growth is severely restricted, natural feed is in short supply, and commercially available feed is relatively expensive.

This is exactly what has been done at Taminmin High School, which is located near Humpty Doo, approximately 40 km South East of Darwin, Northern Territory, Australia. The precise location is 12� 24' S, 131� 15' E.

2. Taminmin's Silage Program

As a regular part of their farm management strategy, Taminmin makes baled silage during late January or early February each year. Making hay at this time is not an option because it is too difficult to dry the plant matter to the required 85%DM or

more.

Fig 1. Baled Silage being transported on the Taminmin Trailer

On the other hand, wet season pasture can be baled at lower dry matter (DM) content and higher moisture than hay, wrapped in plastic film and allowed to ferment into silage.

Almost any pasture can be made into silage, but the best silage is made from the

best pasture. At Taminmin, silage is regularly made from Pangola grass, Cavalcade legume, and Wynn Cassia legume.

The trick is to watch the weather, then cut only enough pasture that you can comfortably wilt, bale, wrap and stack in a single day without any rainfall.

3. A Typical Day of Making Silage

As long as we are confident of getting a rain free day we go ahead. Trial and error has taught us to process no more than 1.5 hectares.

Check with the Weather Bureau. They regularly track tropical storms by radar and are very competent predictors of storm incidence, arrival times, and intensity/duration. We have found their accuracy decreases as distance inland increases, but for the cost of a phone call they are a terrific advisory service.

Pasture is cut at 0900 hours. Sunrise is usually just after 0700, and the two hours is enough time to get most of the free water evaporated from the pasture.

A second tractor forms up the windrows almost immediately. This is usually done by 10.30. We turn the windrows over just once, starting at 11.00. This is usually done by 12.30. We sample the windrows and estimate the dry DM content. This is easily done in 10 mins using a microwave oven, but we are lucky enough to have a probe (Farmscan 2180) to do this in the field. We start baling as soon as the DM content is 40% or more. (Actually, the last two seasons the contractor has made this process much more efficient: he has used a mower/conditioner to cut, condition, and windrow in one operation. This has also allowed the cut pasture to dry out quicker.)

We get about 60 bales, and baling is normally finished by 1730. We start wrapping as soon as the bales are formed. This takes longer than baling, but is completed just before 1900.

We do not provide any additives such as molasses, urea, or lactic acid bacteria inoculant. Our research has shown that the cost of the additive cannot be justified. Weight increases of stock being fed silage with or without additives are not significantly different. However, it is extremely important to wilt the material to about 40%DM before baling. Ensiling wet material (e.g. less than 30% DM) will almost certainly result in production of poor quality silage, high amounts of wastage, and a high degree of stock rejection.

It is a very busy day that we usually repeat, weather permitting, two or three times in 7-10 days. The end result is a harvest of between 70-80 tonnes of reasonable quality feed stored away for use later in the dry season.

After baling, we spread fertiliser. Late wet season rains give us a good regrowth which can be grazed or harvested a second time. The second harvest is usually made into hay as per normal practice for our area.

4. The Benefits

- **Fodder conservation from our improved pastures has increased by more than 40%.**
- **We get two harvests instead of one (and a grazing period).**
- **The same small areas previously were only lightly grazed and turned into hay during May: although it was good quality hay, it is nutritionally lower than the silage made in February.**
- **Weed control is improved. Small amounts of weed that are present are ensiled before they head out. Consequently we spend less time and money on weed**

control, whilst continually giving our pastures a competitive advantage.

- **The process manages Wynn Cassia really well. Wynn Cassia makes good silage, but very poor hay (see section below).**
- **Our feed costs during the dry season are dramatically reduced. We still buy supplements, but the vast bulk of the feed is provided by the conserved silage.**
- **Conserved forage is a cash crop: we have always sold our excess hay, but also having baled silage for sale improves our management options as well as our annual income.**

5. The Disadvantage

The major difficulty with the program is the need to use a contractor. The making of silage is not difficult, but the program depends on having the equipment readily available. Although late January / early February is a time of inactivity for baling contractors, most do not have wrapping machines, and anyhow it is costly to move the equipment about in order to process a relatively small amount of forage.

Hopefully, as more people try this management strategy, costs will reduce, and

efficiencies due to processing larger amounts of forages can improve.

6. Special Benefit: Wynn Cassia

This vigorously growing tropical legume has a positive benefit for soil nitrogen content, and is an excellent ground cover for weed control. However,

- **cattle and buffalo only eat Wynn Cassia reluctantly under normal grazing conditions, and**
- **it is extremely difficult to make into hay. This is because the plant is very leafy. The leaves shatter easily as they dry out. They also shatter and drop off when moving through a baler. If you are successful at all in making a bale of Wynn Cassia hay, it will be nearly all stem.**

The positive benefit is that Wynn Cassia silage is easy to make: the higher moisture leaves do not shatter, and the bale is much easier to form. Silage made from a mixed Wynn Cassia / grass pasture is even easier to make, and usually better quality. Secondly, stock love Wynn Cassia silage: they accept it immediately, and eat

it all when it is presented.

7. For the Technically Minded

A summary for the silage quality, including nutrition data is shown in the table.

Table 1. Harvest Summary: Baled Silage

	Pangola	*Cavalcade*
Dry Matter (%)	42	45
Digestibility (%DM)	57	55
Metabolisable	8.5	9.0

Energy (MJ kg^{-1}DM)		
Crude Protein (%DM)		

Kikuyu Grass Composition and Imp Production

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Introduction

Kikuyu grass (*Pennisetum clandestinum*), often top-dresse an important summer growing pasture along the east coa and south east Queensland. Cutting surplus summer and

improve forage utilisation and the management of the
Strategic silage cuts could be integrated with grazing to
vegetative, higher quality stage of growth for dairy and
kikuyu grass with an organic matter digestibility of 0.60 t
to 50 days would be required. This interval would va
conditions. There are few data on the ensiling characteri
this stage of growth.

Materials and Methods

Fresh kikuyu grass samples were collected at silage cutting
the Nowra district of coastal NSW. Regrowth intervals v
fertiliser was applied at 50 or 100 kg N/ha at the commen
Samples were dried in a forced-air oven at 80�C for 24 h
were then ground prior to analysis for water soluble carb
N content. Buffering capacities were determined on fre
Playne and McDonald (1966). A summary of the data
presented in Table 1.

Table 1. Composition of kikuyu grass at the time of cutting from 11 experiments

	DM content (g/kg)	Water-soluble carbohydrates (g/kg DM)	Starch* (g/kg DM)	Total N (g/kg DM)	Buffe capac (m eq DM
Mean	195.9	44.5	38.9	25.6	350
Range	108.5-323.0	23.4-68.4	14.2-57.8	17.4-35.1	224.7-

*** Starch data available from 4 experiments, a experiments**

Results and Discussion

Although there was some variation in kikuyu grass comp content, low WSC content, high N concentration and inte DM content in the range 100 to 160 g/kg is common, an when kikuyu grass is moisture stressed that DM conten The mean buffering capacity, an indicator of the ability o was similar to published values for temperate grasses (Mc

The results from four experiments indicate that kikuyu quantity of starch. While starch will not contribute direct silage bacteria cannot ferment starch, hydrolysis of star prior to the establishment of anaerobic conditions in th sugars available for fermentation, provided there are respiration.

The low WSC content, low DM content and intermediate there is a significant risk of a poor fermentation if kiku with only a minimal wilt (<300 g/kg DM content). D temperate grasses have shown that the critical sugar lev production is 25-30 g/kg fresh crop (Wilkinson 1990). In c content of kikuyu grass on a fresh crop basis was only 8

level.

Conclusion

Because of its low DM content, low WSC content and farmers ensiling kikuyu grass will need to rely on wilting c probability of achieving a satisfactory lactic acid fermenta

Acknowledgments

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Silage of Cratylia argentea as a dr alternative in Costa I

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Introduction

The legume *Cratylia argentea* (syn. *C. floribunda, Dio* naturally south of the Amazon river through the area ea Bolivia and Argentina, is a shrub that branches from the b to 3.0 m height (de Queiroz and Coradin 1995). It is wel with a 5-6 month dry season and infertile acid soils v tropical areas below 1200 masl.

Germplasm of *Cratylia* has shown good regrowth capacity biotic and abiotic constraints in several lowland sites in La Ceiba in Honduras, and several sites in Costa Rica, Co Africa (CIAT 1995). CIAT and NARS have carried out stu value of *Cratylia* in the region. Results indicate that yi increased when plant density is at least 20,000 plants/h 60%) and crude protein (20- 25%) vary with plant par material is increased when *Cratylia* is cut and wilted, gi

freshly harvested immature *Cratylia* forage is low (Raaflau

The value of *Cratylia* as a cut and carry protein suppleme during the dry season to lactating dairy cows is being purpose cattle farms in Costa Rica (Argel and Lascano currently evaluating the option of utilizing excess *Craty* season for ensiling.

In this paper we present results from the on-station and when used as silage to supplement milking cows in the dr

Method of making silage with Cratylia

Ensiling *Cratylia* is a farmer-based initiative and as a co Rica are now in the process of producing information for to make good quality silage with this legume. Farmers tes have developed their own system of harvesting and ens and stem material from 3-4 month regrowth is cut fresh a 5 cm fine pieces. Harvested material is then placed in h

plastic after good compaction is achieved. Molasses is ad (10-15 % dry matter bases), while a silage inoculum is ad of silage when mixed with King grass (30:70 proportion of

Use of Cratylia silage as a supplement for lactati

In areas with 5-6 month dry season in Costa Rica, there cows with concentrates or chicken manure to main production. However, farmers are looking for alternative too expensive and milk prices are decreasing. An altern reduce supplementation costs is to replace concentrates or ensiled *Cratylia* fed in combination with sugarcane or k

An initial experiment was carried out in the Escuela (ECAG), Atenas, Costa Rica (460 masl, annual mean t precipitation of 1600 mm). Six mature Jersey cows (50 d assigned to the following treatments arranged in a 3 x 3 T1=sugarcane (1.0% BW) + rice polishing (0.5% BW) + (0,02% BW) ; T2=sugarcane (1.3% BW) + concentrate (0.5

(1.2% BW) ; T3=sugarcane (0.1% BW) + concentrate (0.5
(2.4% BW)

Each treatment period comprised 12 days of which 7
measurement. Concentrate (0.5 % BW) was fed with the (
in the experiment were accustomed to receiving some cor

Results shown in Table 1, indicate that milk yield was sin
concentrate as those supplemented with *Cratylia* fres
interesting to observe that milk fat was greater in cows fe
and lower benefit: cost ratio of feeding *Cratylia* silage
ECAG for harvesting and separating edible portions of
which is not the case in farms as indicated in a subsequer

Table 1. Dry matter intake and milk production of Jersey
the dry season in Costa Rica (F. Romero and J. Gonzalez, u

Treatments	DM intake	Milk yield (kg/cow/d)	Fat (%)	Protein (%)	Solids (%)	*C supp

	(kg/cow)					($/
T1. Concentrate	10.8	11.1	3.5	3.4	12.4	
T2. Fresh *Cratylia*	10.7	10.9	3.7	3.2	12.5	
T3. Silage of *Cratylia*	10.4	10.7	3.8	3.2	12.5	
Sig. Difference	Ns	Ns	P< 0.06	P< 0.01	Ns	

*** Includes the cost of all ingredients in the supplement ex**

One farmer in the Central Pacific subhumid coast area of (assistance of researchers the use of *Cratylia* as silage. Six (Brahman dual-purpose cows in the third month of lactati(following treatments arranged in a 3 x 3 cross-over Latin S sugarcane + 6 kg *C. argentea* silage + 0.6 kg rice polishing; *argentea* fed fresh + 0.6 kg rice polishing; T3=12 kg sugarc

kg rice polishing

The results shown in Table 2 corroborate on-station re yield, but higher milk fat when chicken manure was rep also indicate that the cost of supplementation was lowe ensiled, which resulted in higher economical benefit fo chicken manure.

Table 2. Average milk yield of dual-purpose cows supplen or as silage and with chicken manure. (M. Lobo, V. Acu data)

Treatments	Milk yield (kg/ cow/d)	Total solids (%)	Fat (%)	Cost of supplement ($/kg DM)	Benefit to cost ratio
T1. *Cratylia* as silage	5.1 b	12.3	3.6	0.17	1.58

T2. Fresh *Cratylia*	5.5 a	12.2	3.4	0.11	2.37
T3. Chicken manure	5.3 a b	11.7	3.0	0.22	1.14

Conclusions

The use of *Cratylia argentea* for making silage has beer purpose cattle farms in hillsides of Costa Rica. On-fa supplement to milking cows has been shown to be a viab given that it economically replaces expensive concentrat Research is underway to better define ways of produ silage.

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A Comparison of the Nutritive Value pasture and Pangola grass pasture p

hay

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Experiment Location

This small study was conducted at Humpty Doo, appr Darwin, Northern Territory, Australia (12� 24' S, 131� : annual rainfall between 1500-2000mm, 80% of which fa December 1st and March 31st.

Description of the Experiment

The nutritive values of Cavalcade legume (*Centrosema* (*Digitaria eriantha*) pastures were compared with the pastures preserved as 7 month old hays and silages. (Cavalcade by slashing and Pangola using a disc mower) a

to obtain forage with dry matter contents ranging fro pastures were made into small cylindrical bales (800mm either wrapped in plastic film for preservation as silage, bale was sampled and analysed for nutritive content (DM the Cavalcade and Pangola pastures were 125 days and 4

The results are given in Table 1 and Table 2 (This data is t and hays after 7 months storage. This corresponded to a is available on request showing the nutritive values of th formation (ie at the beginning of the storage period)

Table 1. A Comparison of the Nutritive Value of Cavalca wilted silage or hay

Cavalcade legume

	Pasture	Silage		H
		Wilted	Heavily Wilted	
DM (%)	23.3	41.4	61.8	9
Digestibility (%DM)	55.1	53.4	50.1	4
ME (MJ/kg DM)	8.2	7.8	7.3	6
CP (%DM)	20.4	16.1	16.1	1
Bale Weight (kg)		25.7	15.9	9
pH		4.50	4.60	
Ethanol		2.49	1.44	
Acetic acid		13.99	5.10	
Butyric acid		1.79	0.34	
Lactic acid		16.61	13.44	
		52.30	32.20	

Ammonia N (g/kg TN)				

Units for ethanol, and Acetic, Butyric, and Lactic acids are

The nutritive values of the Cavalcade forage and the content increased, but nutritive contents during storag better nutritive value than hays. Silage quality was good lactic acid contents, lower acetic and minor butyric acid p low pH. Spoilage was generally low (11.5 %). In the fermentation product was ethanol, but the silage qualit contents higher than acetic acid content, minor butyric a with high pH (4.95). Spoilage was consistently low (2.82% was always less than 60 g kg^{-1} Total N, was highest for l species.

Table 2. A Comparison of the Nutritive Value of Pangola g silage or hay

Pangola grass					
	Pasture	Silage			I
		Minimum Wilt	Wilted	Heavily Wilted	
DM (%)	22.1	44.3	55.4	63.7	9
Digestibility (%DM)	59.8	60.8	57.0	55.5	4
ME (MJ/kg DM)	9.0	9.0	8.4	8.1	
CP (%DM)	13.0	10.7	10.8	11.3	
Bale Weight (kg)		24.8	22.3	18.4	1
pH		4.50	4.90	5.40	
Ethanol		16.27	12.52	7.38	
Acetic acid		4.12	1.87	1.30	
Butyric acid					
		0.45	0.06	0.04	

Lactic acid					
Ammonia N (g/kg TN)		40.00	30.70	28.90	

Units for ethanol, and Acetic, Butyric, and Lactic acids are

Tomato Pomace-Rice Straw Silage a Cattle

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1. Introduction

1. Introduction

In Ilocos Norte (Philippines), there are very distinct dry (O (June to September) and the average landholding of farm from grasses, weeds, and crop residues on the farm are work animals throughout the year. Hence, the need to crop residues and agro-industrial by-products.

Rice straw is available after the harvest season (Septem quality roughage (92% DM, 3.3% CP, 1.5% ether extract when dry and has very low voluntary intake when fed as i

Tomato pomace is a by-product from the processing of from January to April when the only thing that can be use mature grass, containing 15% DM, 14.5% crude protein, 2 30.2% nitrogen-free extract, 0.43% calcium and 0.30% pho

Fresh tomato pomace would spoil in two days if expose preserve this material by ensiling it with rice straw to pc and feeding value of these materials and also come up

later.

2. Methodology

Rice straw was chopped (2-3 cm) and mixed thoroughly w a proportion that would give a mixture containing 35% DI tightly in a 200 l drum lined with foil (bags rejected fron storage for the duration of the study, although feeding days. After the feeding trial, extra silage was kept for furtl

The roughage ration was supplemented with a concentrat bran, 23% copra meal, 1% salt and 1% lime at the rate of :

3. Results and Discussion

Table 1 shows that the quality of the silage deteriorate

This could be due to poor storage conditions, i.e., cracks/
and exposure to the heavy rains that occurred in the 3rd r

Table 1. Quality of the tomato pomace-rice straw silage o

CRITERIA	TIME OF OPENING AFTE			
	14 days	**1 month**	**2 months**	**3 mo**
Colour	Greenish yellow	Greenish yellow	Greenish yellow	Gree yell
pH	3.98	4.20	4.22	4.
Acceptability	Very acceptable	Very acceptable	Very acceptable	accep
Presence/absence of moulds	absent	absent	absent	On or

Table 2 presents the performance of animals fed with v

days of feeding, the animals fed with 50% TPRSS, had t those fed with 75% TPRSS had the lowest. In terms of fee that the intake increased with decreasing level of TPRSS with 25% TPRSS taking in the highest amount and animal lowest.

Table 2. Performance of growing cattle fed with varyin straw silage.

treatment	total gain in weight, kg	average daily gain, kg	total feed consumption	feed efficiency
75% roughage + 25% TPRSS	49.33	0.55	469.09	10.79
50% roughage	54.00	0.60	424.31	8.56

+ 50% TPRSS				
25% roughage + 75% TPRSS	33.17	0.37	408.71	17.57
cv %	22.76	21.81	12.81	5.30

From this, we can see that animals fed with 50% TPRSS w
8.56 kg of feed for 1 kg weight gain. In terms of cost of f
fed with50% TPRSS incurred the least cost.

We could see the potential of ensiling rice straw or n
tomato pomace, producing feed for growing cattle, es
scarcity. This type of silage could also be fed to other rum
goats. However, the kind of silo and storage should be i
silage over a longer period of time.

4. Conclusion

Ensiling may offer a way of preserving highly perishable f feeding value of poor quality roughage in a place like I additional feed resource for the smallholder livestocl opportunity to provide a better quality feed for ruminant these animals.

5. Reference

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Rumen Metabolism of Sheep Fed Silag Litter

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1. Introduction

The use of molasses not only improves the energy conte pH and prevents proteolysis. The nitrogen (N) concent silages, which is generally low, can however, be improved its fermentation characteristics, by the addition of poult Ensiling poultry waste with cereal forages and grasses their inherent low N concentration but also provide man calcium, phosphorus and unidentified nutrients. In this

recycled as feed for livestock with no undesirable effects of this study was to determine the effect of feeding silag rumen metabolites of sheep.

2. Materials and Methods

Commercial broiler house litter was sun dried, ground representative sample of litter was analysed for total-N, fractions, silica (Van Soest and Robertson 1982) and broiler litter (30 % DM) and cane molasses (60% of DM fodder[1] (SPL-Silage) for silage making. Control silage with determine chemical changes during ensiling, triplicate analysed at the start and on 40th day, when opened. matter (DM), total-N, protein-N, ammonia-N and lactic ac high silica concentration, which dissolves in neutral dete adding the difference in silica between ADF and NDF to th made a correction. Lignin was determined as acid deterg lignin free ADF.

Three adult rumen cannulated mature sheep were ra following rations in an experiment run according to experiment.

1. **Ration A: Complete farm ration.**
2. **Ration B: SPL-silage.**
3. **Ration C: Sudax silage + 30% concentrate mixture**

All rations were formulated at 14% crude protein (CP) ar (TDN). Each ration was fed to a rumen cannulated sh adjustment period. In the following three days, the rume at 0, 3 and 6 hr post-feeding. The pH of rumen liquor collection with Beckman pH meter. The rumen liquor sam layers of cheesecloth and the filtrate was collected in 50 drops of N H_2SO_4. After adding a few drops of chlorofo deep freezer till analysis after thawing, for total-N, protei

The data on chemical analysis of rumen liquor were analy variance technique in a factorial model (3� 3 with intera (Steel and Torrie 1981).

3. Results

Data on average pH and different N fractions in rumen rations is shown in Table 1. Significantly ($P<0.05$) higher p of sheep fed the ration containing SPL-silage as compared concentrate mixture. The changes in pH of rumen liquor feeding were found to be non-significant ($P>0.05$).

Sheep fed on complete farm ration had significantly (P<0. SPL-silage or Sudax silage plus concentrate mixture. Th lowest total-N concentration, and was significantly higher supplemented with concentrate mixture (Table 1). Signi also observed in total-N concentration of rumen liquor c feeding. At zero hours post-feeding the total-N concentra complete farm ration was significantly higher ($P<0.05$) tha ruminal total-N concentration of sheep on SPL-silage an mixture rations were similar at 0 hours post- feeding. At concentration of rumen liquor of sheep on Sudax silage

increased and was higher (P<0.05) than that on SPL-silage

The protein-N concentration of rumen liquor was s complete farm ration followed by regime Sudax silage pl silage. The protein-N concentration of rumen liquor of times post-feeding followed a similar pattern as in case of

Table 2. Average pH and different N fractions in rume rations

Ration *	**Time post feeding (hr)**	**pH**	**Total-N (mg %)**	**Protein-N (mg %)**	**Am (**
A	0	6.39^{c}	127.8^{b}	89.13	
	3	6.24^{c}	120.3^{bc}	83.31	
	6	6.50^{c}	148.0^{a}	105.36	
	Average	*6.357^{c}*	*132.0^{a}*	*92.60^{a}*	*2*
B	0	6.01^{a}	[illegible]	46.53	

B	0	6.91^{a}	89.4^{f}	[illegible]	
	3	6.80^{a}	96.5^{def}	58.76	
	6	6.76^{a}	92.1^{ef}	55.99	
	Average	*6.826^{a}*	*92.66^{c}*	*53.76^{c}*	*3*
C	0	6.66^{b}	88.4^{f}	56.22	
	3	6.58^{b}	109.2^{dc}	72.38	
	6	6.59^{b}	104.5^{de}	71.33	
	Average	*6.608^{b}*	*100.7^{b}*	*66.64^{b}*	*2*

***Ration A: complete farm concentrate, B: SPL-silage, mixture.**

abcdef Means within column with different superscripts d

The ammonia-N of rumen fluid of sheep fed SPL-silage wa compared to complete farm ration or Sudax silage plus c

ammonia-N concentration of rumen fluid was the low significantly (P <0.05) at 3 hours post-feeding and then c feeding. Following this pattern the final ammonia-N cor not significantly different from that determined at zero hc

4. Discussion

The results as shown in Table 1 indicate that the c significant (P< 0.05). It has been observed that when 3.1 t cattle in a daily ration, ammonia concentration in rume than the optimal level of 10 mg/dl for maximum ferm protein synthesis (Silanikove and Tiomkin 1992) It was requirements for N in the rumen are met, there should b of fermentation. Excessive consumption of poultry litter burdens, as reflected in ammonia (> 2O mg/dl) concent span (Visck 1984).

Ammonia concentration in rumen fluid had direct relati

and the parallel increase with pH would encourage the a gut (Harmeyer and Martens 1980). Excessive ammonia microbes, is absorbed in the blood circulation and conv consequent metabolic burden on liver.

Rumen pH, concentration of total-N, protein-N and amm the physiological status of the animal as happened in ou fed on SPL-silage. When Sudax silage was fed with supple concentration of total-N and protein-N increased and compared with SPL-silage, yet it was less (P<0.0l) than increased DM intake, reduced cell wall or structural ca increase in cell contents and thus increased rate of

Voluntary Intake and Digestibility o Fronds

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1. Introduction

Oil palm frond (OPF) is one of the most abundant agric
Almost all pruned fronds are discarded in the plantation,
soil conservation. It has great potential to be utilised
component in compound feed for ruminants. Much res
MARDI and JIRCAS to use OPF for animal feeding either
Hassan *et al.* 1995). Detailed studies on the fermentatio
of OPF silage as well as on animal performance have bee
Ishida 1991; Ishida and Abu Hassan 1997; Oshio *et al.* 1
was to study the effect of processing methods of OPF c
intake.

2. Materials and Methods

Four processing methods of OPF (pelleting, dry choppin were compared for *in vivo* digestibility and intake usin yearling heifers (mean live-weight 160 kg). The fresh OPF Serdang, Selangor, Peninsular Malaysia, was chopped uniformly. A portion of the chopped OPF was dir (approximately 100 l) for making silage. The material w feeding to the animals.

Simultaneously, a portion of the chopped OPF was mixed ratio of 15 kg to 100 kg of fresh OPF. The material was pa kept for one month until feeding. For making dry choppe OPF was chopped again using the same machine, dried then completely dried in an oven. OPF pellets were pr pelletiser after being dried the same way as chopped OP mm screen grinder.

These four types of OPF were mixed with a basal ration c (PKC), 20% palm oil mill effluents (POME), 16% tapioca w

and vitamin mixture, 1% salt, and 1% urea at various ratic 60% OPF pellets, 40% chopped OPF, 40% OPF silage an measure the apparent digestibility of each form of treate 3-4 animals for each ration. Each ration was fed for 14 da were collected for measuring the digestibility throughout chopped OPF were mixed at the ratio of 25, 40, 60 and basis with the basal ration as mentioned above. Each di heifers, respectively. OPF silage and NaOH-treated OPF ration and were fed to the animals in the same ratios, exc was fed to the animals daily at 10-20% above the satura and DM content of the remainder were measured in th was carried out for the last 3 days to measure the digestik

3. Results and Discussion

Table 1 outlines the voluntary intake and digestibility maintenance level, the digestibility of OPF pellets was pellets mixed with the basal ration was maintained even

9.1

chopped OPF and OPF silage did not reveal much differ
higher for the chopped OPF ration than for OPF silage.
level of chopped OPS was depressed to 58% of that at the

Table 1. Voluntary intake and digestibility of treated OPF

Ratio of OPF	OPF pellets		Chopped OPF		OPF silag
	DM intake $g.DM/kg^{0.75}$	DM dig. %	DM intake $g.DM/kg^{0.75}$	DM dig. %	DM intake $g.DM/kg^{0.75}$
Voluntary intake level					
25%	104.5	63.7	97.8	61.8	89.7
40%	101.7	56.1	83.0	57.6	74.6
60%	107.9	47.4	65.4	56.2	59.0
75%	87.6	35.8	57.2	51.0	
DM digestibility (%) of each treated OPF at mai					
Basal					

ration 69.5		33.3		38.6	

The digestibility and intake of NaOH-treated OPF were th pelletising lowered the digestibility due to the faster rate these processes were more effective for enhancing the ir treatment improved not only the digestibility but also the

Therefore, this treatment has great potential for improvi NaOH is caustic and dangerous, a safer and more cost-eff needed. Ammonia treatment, an alternative to NaOH tr this experiment. Although ammonia treatment could be a quality, there is a high possibility that reaction betw ammonia will produce toxic substances such as 4-met treatment is adopted for improving the quality, it is impo of the toxic materials.

3. Conclusion

The digestibility and intake of NaOH-treated OPF was hi
or OPF-silage were. More studies are needed to determir
or can be replaced with ammonia, for improving the OI
OPF silage than the chopped OPF but the digestibility wa
fresh-chopped OPF, OPF silage has advantages for anin
handling, storage, less labour usage, easy to be transporte
to processed daily. This is not only time consuming but in
not cost-effective.

Although pelletising of OPF is effective for improving inta
Therefore, an alternative processing method such as cul
same level of digestibility as chopped OPF and simultanec

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Sweet Corn Stover Silage P

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Department of Veterinary Services,

Introduction

In Malaysia, livestock production is mainly in the hands dependent on forages for their feed resources. With the Veterinary Services (DVS), more farmers are now cultivati are involved in the milk collecting centre (MCC) dairy pr droughts and floods, fodder conservation is likely to pla production among smallholders in certain areas of the co

Sweet corn is a popular crop in Malaysia. After its cobs still contains a good source of nutrients suitable for c protein concentration we found in an earlier study, it harvested at 75 days of age (Yacob *et.al.* 1992). The meta 7.82 MJ/kg of fresh stover is comparable to or in some grass species being used in Malaysia. Although this by- itself in the fresh state, at harvesting time the quantity w in a short time before they decompose. This material nee adverse seasons. Ensiling the stover is thought to be th

present the production of sweet corn silage is carried out
an estimated production of 120 t annually. Since the inc
ensilage programme in 1996, an estimated 400 t have bee
cattle.

Materials and Methods

The stover of sweet corn harvested after 75 days was c
lengths, using a portable forage chopper. The chopped st
l plastic drums, taking care to exclude as much air as
conditions for successful ensilation.

The ensiled materials were opened after 30 days and sam
for analyses using AOAC (1984) methods. Calcium concen
atomic absorption spectrophotometer, phosphorus usin
complex, metabolisable energy by the gas test procedu
(1975) and the fibre components using the method of Go

Result and Discussion

Yacob *et al.* (1992) estimated a production of 10 t of dry ı corn and this figure is close to the average of 12 t ach evident that a substantial quantity of forage can be obta sweet corn is ensiled and utilised by dairy smallholders.

At the normal harvesting age of 75 days, the protein and 9.6% and 7.82 MJ/Kg respectively. In the silage product decreased to 8.2% and ME value to 5.86MJ/kg. Very neg the drums during the project.

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Successful Smallholder Silage
A Case Study from Northeas

Ganda Nakamanee

Pakchong Animal Nutrition Research Ce

In Thailand, a major limitation in raising dairy cattle is in the dry season. Farmers are very familiar with the use of but less familiar with forage conservation. Despite r production at research centres and Universities in Thaila low. There are many reasons for this, including

- **a lack of herbage,**
- **silage making is deemed complicated,**
- **a lack of investment capital for new machinery.**

This paper discusses the potential for adoption of smallholder Thai dairy farms and the factors affecting t Sung Nuen District, Nakornratchasima in Northeast T latitude 14�30’ - 15�15’ N, longtitude 101�43’ - 101� 805 mm and the principal crops grown are rice, maize ,cas

Participatory diagnosis of livestock feeding problems was

1997. The major problem was a lack of good quality ro other feed resources the farmers have been commonly u crop residues (especially rice straw) and sugar cane top available free of charge, but rising demand has resulte residues becoming increasingly scarce. Also, the low prot not adequate for productive cattle during the dry sea become interested in testing forage conservation method:

Silage Making Demonstration

The Animal Nutrition Research Centre at Pakchong colla officer to conduct a silage making demonstration in th participating. Three different techniques of silage making

- **Bunker silos**
- **Black polythene bags of 40-kg capacity**
- **Plastic bags of about 800-kg capacity**

Because they were in a maize growing area, corn silage w Farmers provided chopped corn leaves and their labo provided labour, materials (plastic bags) and technica conducted to check for problems and discuss with farme making. All 53 farmers were interested in trying to make s modified the technique to make silage in plastic buckets for sale.

Table 1. Preference ranking of various types of silo.

Silage technique	Farmer's preference (%)
Bunker silo	38
Plastic bucket	31
Black polythene bag	23
Plastic bag (800kg)	8

Farmers' Comments

Black polythene bag:

cheap and easy to feed animals

Plastic bag (800kg):

can make a large amount at one time

Plastic bucket:

even if it is more expensive than plastic bags at the b
times and also protect the silage from insects and ro

Bunker silo:

Large initial capital investment for construction but l

Factors Affecting the Potential for Adoption of Si

- **Farmers realised that the lack of good quality rougha main constraint.**
- **Learning by doing: farmers found that in fact, silage r complicated as they had heard and read.**
- **The development workers know the needs of farmer alternatives for them to observe, compare and evalu possible solutions.**
- **Farmers must have sufficient material available locall**
- **As they are smallholder farmers, not all ensiling tech cost of the ensiling technology needs to be balanced on-farm.**

Conclusions

There is some potential for broader application of silag farms in Thailand. However, the particular methods u adapted by farmers to fit their own situations. We are farmers to monitor adoption and discuss their needs so of which silage technologies have the best potential unde

Grain Corn Silage and Forage Corn Sila Nelore and Canchim Cattle Perfor

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An experiment was carried out to evaluate corn grain and and nutritive value of silage based on the performance of randomised design was used with a 2 x 2 factorial arra (Nelore and Canchim) and two corn varieties (grain and f 120 days after sowing, when plants showed more than 2 in the dough stage. The silage was stored in 400 t silos. Th grain or forage corn silage, 7.2 liters of liquid yeast (1.5 kg kg of ground corn (1.0 kg of dry matter/head/day). Th days, with a 20 days adaptation period and 90 days fo weighed every 28 days. It was concluded that corn grain than corn forage, because at the same stage of growth it with a higher dry matter content and a 41.3% higher grai gain and better feed/gain ratio in the feedlot beef cattle.

Table 1: Forage corn variety: Yield characteristics and com

Parameters	Forage Corn Variety	
	Forage Corn	Grain Corn
As fed yield [1] (ton/ha)	45.00	27.20
Dry matter (%)	32.00	44.00
Yield DM [2] (ton/ha)	14.40	12.00
Grain yield (ton/ha)	5.40	6.40
Remainder [3] (ton/ha)	9.00	5.60
Grains in DM (%)	37.50	53.00

1. As fed matter
2. Dry matter
3. Remainder of the plant

Table 2: Corn silage: Chemical characteristics and pH.

Parameters	Corn variety	
	Forage Corn	Grain Corn
Dry matter (%)	34.80*	45.60*
Crude protein (%)	7.37	8.32
Acid detergent fiber (%)	26.10*	23.80*
Lignin (%)	4.10*	2.80*
Ammoniacal nitrogen [1] (mg)	8.73*	6.52*
Acid detergent insoluble nitrogen (mg)	8.02*	6.12*
PH	3.96	3.20
Cellulose (%)	19.53	18.62

1. Ammoniacal nitrogen as a percent of total nitrogen.
*** Significant at the level of 5% of probability.**

Table 3: Animal performance during 90 days in feedlot.

Breed	Corn variety					
	Forage Corn			Grain Corn		
	DG[1]	DFI[2]	FG[3]	DG	DFI	F
Nelore	0.79	10.09	12.77	1.17	10.23	8.7
Canchim	1.29	9.39	7.28	1.38	9.63	6.9
Mean	1.04	9.74	10.03	1.28	9.93	7.8

DG: Daily weight gain (kg/day)
DFI: Dry matter intake (kg/day)
FG: Feed/gain ratio (kg DM/kg DG)
1. CV = 16.0%
2. CV = 6.9%
3. CV = 7.3

Table 4: Dry matter intake.

Intake (kg/day)	Corn variety	
	Grain Corn	Forage
Dry matter	9.93	9.7
Concentrate	2.50	2.5
Ground corn	1.00	1.0
Yeast	1.50	1.5
Silage	7.43	7.2
Grains corn from the silage	3.94	2.7
Remainder of the plant	3.49	4.5
Total intake of corn		
(Concentrate + silage)	4.94	3.7
Total of concentrate		
(Concentrate + grains from the	6.64	5.2

silage) Total forage	3.49	4.5
Forage: concentrate ratio	35:65	46:
Daily gain	1.28	1.0

Development of Ensiling Technology Cattle Owners in Zimb

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1. Introduction

Commercial dairy farming is keenly desired by many small arid areas of Zimbabwe. However, it is not feasible unless productivity in their cows is overcome and that is, the v feed in the dry season. Rain-fed forages are being grown conservation as high quality hay is difficult due to leachi material. Ensilage of forage, can, if done correctly, maint dry season. However, storage in a pit or bunker rec chopping and compaction. Experience has shown, furth frequent exposure, suffers large spoilage losses. We technology to produce silage from semi-arid adapted cr case, an easily portable plastic bag. In order to produce mix of either sweet forage sorghum or Napier (*Pennisei*

dolichos bean (*Lablab purpureus*).

2. Methods

2.1 The crops

Two forage crops: Sweet forage sorghum (FS) (var. Sugarg SDBN3[b]). One legume: Dolichos bean (DB).

Ensilage was carried out in each plastic bag with either o a 50:50 by fresh weight basis with legume to produce 8 k of the forage crops alone, also at 8 kg fresh weight. The FS/DB; FS; PS/DB; PS

2.2 Treatments

1. **<u>Chopping</u>: Chopping was done by one of two ways:**

- **with the use of a petrol motor driven chaffer, produc length of about 2.5 cm.;**

- **manually, with the use of pangas, producing a chop v 7.5 cm.**

2. **<u>Compression</u>: Compression was done by one of two**

- **with the use of a manual tobacco press which compr on to a metal plate sitting on the bag of crop materia**

- **by leaning as hard as possible on the bag, using hand possible.**

2.3 The silos

The silos were black bags which were recycled plastic b size which could carry up to 50 kg material.

Upon filling and evacuating the bags of air, they were tigh

a closed storeroom.

3. Results

The fermentation quality of all silages were good, showi total nitrogen ratio of less than 10%, dry matter loss of l from 2 to 7%, acetic acid ranging from 1-2.5% and buty Table 1. Visual and sensory evaluation of the silage However, while treatments of chopping method and co on fermentation, crop variety showed significant differen volatile fatty acids. Sorghum silages had better fermen silages, with or without legume. This is probably due to carbohydrates in sweet forage sorghum (av. 220 g/kg) co g/kg) at ensiling.

Nutrition quality of silages showed that addition of significantly higher crude protein content (range 13-14%) and improved digestibility (range 52-56%) over pennisetu

Table 1. Fermentation quality of different forage crops en

Crop material	DM loss %	pH	NH_3:N %	Lactic acid %	Bu ac
All sorghum (FS)	9.36	3.70	4.07	5.63	0
All pennisetum (PS)	18.0	4.3	4.99	4.25	1
FS/DB	12.3	3.78	4.37	6.55	
FS only	7.15	3.63	3.85	4.76	0
PS/DB	16.46	4.25	5.26	2.32	
PS only	19.79	4.4	4.71	1.92	0
All materials fine-chopped	12.43	3.84	4.4	4.65	0
All materials coarse-chop	15.31	4.20	4.7	4.62	0
All materials tobacco-press	15.04	4.05	4.5	4.18	

All materials hand - press	12.88	4.01	5.2	3.59	(

Table 2. Nutritional quality of silages made from different

Crop	DM%	Digestibility g/kg	Crude Protein g/kg
PS SE	30.55 0.41	471.05 10.76	66.5 1.66
PS/DB SE	27.5 0.76	523.17 8.92	133.23 9.22
FS SE	32.8 1.34	544.15 16.2	64.98 7.90
FS/DB SE	30.1 0.94	536.29 11.55	144.88 12.13

4. Conclusion

Mixed forages and legumes adapted to semi-arid conditic plastic bags with only manual chopping and compressior have subsequently shown the same success.

Forty farmers are presently participating in farmer-cor trials in Gulathi communal area in the semi-arid region of

Sweet Sorghum - A fine forage crop f China

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Sweet sorghum (*Sorghum bicolor* (L.) Moench) is a C4 plar m. It is not only known as a "high energy crop" for having it is also called "the camel among crops" with its resistance, tolerance to water logging and saline-alkali adaptability. Sweet sorghum is a versatile crop that can b production and as a grain crop.

Since 1974, a large number of quality varieties of sweet s the Beijing Botanical Garden. Comparative experimentat green forage of the varieties 'M-81E' and 'Theis' reachec (Table 1). Sweet sorghum is an excellent crop for silage ma

The sown area of sweet sorghum cv 'Rio' in the Nanjia increased from 10 ha in 1979 to 400 ha in 1982. The avera sorghum per unit area was 76.8% more than that of maiz the statistics of the Beijing Administrative Bureau of Farm 'M-81E' reached over 1333 ha in the outskirts of Beijing area of 'M-81E' has occupied 84% of the total harveste region. Because of the high yield of 'M-81E', an area of a sowing winter wheat and other grain crops. Most sw

making.

There are similar situations in many other provinces and
Worker-Peasant Alliance Agriculture-Livestock Farm, fo
forage of sweet sorghum was 149% compared with m
barley. The Institute of Agricultural Science of Changde
that the biomass yield of 'M-81E' reached 125 t/ha, which

Sweet sorghum can be grown not only in North China bu
accumulative harvested area in recent years has been
Shenzhen City.

Table 1 shows the yields of different fractions of the cro
in China.

It will be of great significance through popularisation of s
change the livestock farming structure by devoting great
grazing-livestock farming (cattle, sheep, rabbits, geese, et
output of meat and reduce the pressure on grain used fo

Harvesting sweet sorghum for silage making

Table 1. Mean yield of stalk, fermentable sugar, alcohol, f

sorghum in experiments at the Beijing Botanical Garden

	CULTIVAR			
	Theis	**M-81E**	**Wray**	**Keller**
Stalk (kg/ha)	95	89	76	76
Fermentable sugar (t/ha)	10.6	9.6	10.3	10.5
Alcohol (l/ha)	6159	5607	5981	6131
Fresh material (t/ha)	125	128	106	107
Seed (kg/ha)	6674	6213	1426	1960

Tropical Maize Silage in Ce

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Introduction

The long (5-7 months) dry season of the savanna region ((imperative the conservation of forage for the continuous

Surveys conducted in the late 1970's and early 1980's ind Gerais the conservation of maize, sorghum, elephant gr these species were extremely common among dairy prod samples (Paiva *et al*. 1978) showed that the resulting sila value, with a mean in vitro organic matter digestibility (protein (CP). A parallel survey (unpublished) also showed slow and in small dairies it was frequently carried out ma

It was therefore hypothesised that the low resulting nutr part to the slow process of cutting, chopping and ensiling

was carried out to determine maize growth curves, nu vegetative period, various measurements of the efficien which field operations can be carried out, material loss conservation, and the resulting nutritional value of m model of the whole process and various alternatives w 1979; Vera and Pizarro 1981).

What follows is a brief summary of results, with emph value of maize, and of the resulting silage, when the conditions and on low fertility oxisols.

Results and Discussion

Locally bred and widely available maize varieties were u Agroceres 259, Dentado Composto, BR103 and Maia 1 released by the National Center for Maize and Sorghum R

The growth curve of the last two varieties was studied f

regular samples were collected between days 23 and 170 components of the biomass were quantified.

The maize crops were fertilised as per then current recom 40 P and 40 K. A typical soil analysis (0-20 cm) is as follow 2 ppm, OM 2.6%

Analysis of the growth curves showed that for all pra differences were accounted for by differences in accum and rainfall (ACCRAIN), and these two variables togethe provided a good prediction of dry matter (DM) yields:

YIELD = 8.22 ACCRAIN + 0.00080 ACCRAIN^2 + 4.803 ACCTE 2659 (r=0.96)

DM percentage of the whole plant (DMPC) did not vary was largely accounted for by AGE:

DMPC= 7.66 exp(0.0120 AGE) (r=0.95)

The most striking result in terms of nutritional value w
content of the crop, regardless of year and variety. CP t
the 100th day of growth, as follows:

$$CP = 22.56 \exp(-0.0285\ AGE) + 6.09 \exp(-0.003085\ AGE)$$

Dry matter digestibility (DMD) of the standing crop was ev
first one determined the in vitro DMD of samples collecte
as explained above. The second set of data was derived
trial carried out with penned sheep between days 49 a
should be noted that over the period 140-77 days, the cr
dried.

Up until 140 days of age, digestibility decreased linearly:

$$DMD = 73.98 - 0.172\ AGE\ (r = 0.84)$$

This implies that over the period of 100-120 days
approximately 30% DM (stage generally recommended
roughly 50-55% and CP 5%.

At approximately this stage of maturity, the contribut unexpectedly low despite being reasonably high in absolu

Table 1. Total dry matter and grain yields in two tropical r

	BR 105	**Maia 13**
Dry matter yield, kg/ha	11626	18078
Grain yield, kg/ha	3288	4237
Grain yield, % of total yield	28.3	23.4

As shown in Table 2, soluble carbohydrates and starch in forage. The low starch content in the fresh forage, rel almost certainly due to a laboratory artefact since later laboratory found that at a comparable stage of growth, ranged between 18 and 19% (Neto, *et al.* 1984). Nevertl the latter case were even lower than above.

It is worth noting that Neto *et al.* (1984) analysed sam (Bailey1967, 1973) and were able to account for 85-90% ash and possibly minor fractions unaccounted for.

Table 2. Chemical composition of the fresh material and t BR 105

	Green forage	Silage
Dry matter, %	30.43	30.68
Ethanol soluble CHOs, % dm	12.37	1.81
Starch,% dm	5.93	16.28
Cellulose, % dm	22.37	22.12
Hemicellulose, % dm	20.01	22.12
Lignin, % dm	6.67	4.94
Crude protein, % dm	5.35	5.88

		For purpose of comparison, it should be noted that temperate maize is generally as follows: water soluble CH

Contrary to our initial hypothesis, it is clear that the low nutritional value of farm silages cannot be attributed to the speed with which field operations are carried out, since the crop is of low quality throughout a relatively long vegetative period, including stages earlier than those most appropriate for ensilage.

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Evaluation of Different Harvest Times of Four Genotypes of Sunflower (Helianthus annuus L.) for Ensiling

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1. Introduction

In recent years, the sowing of fodder crops during the rainy season (January to March) has become very popular. Generally, corn and sorghum are used, because they produce a well-preserved silage of good nutritive value. However, their dry matter (DM) yields and quality are uncertain from year to year, because of frequent drought stress.

Sunflower stands out as an alternative for forage production and conservation as silage because of its drought tolerance, its high DM yields, its resistance to cold and heat, its adaptability to different edafoclimatic conditions and its relative independence of latitude, altitude and photoper�od (Cotte 1959, Tomich, 1999).

To obtain silage of good quality and of high nutritive value, the material should be cut at the right point of maturity. Tan and Tumer (1996) ensiled sunflower at several stages of maturity and concluded that the final flowering stage was the best for silage making.

The present study was carried out at the EMBRAPA-National Center of Research in

Corn and Sorghum. The objectives were to evaluate the sunflower genotypes V2000, DK180, M734 and Rumbossol-91 grown in a completely randomised block with 3 replications and cut and ensiled 30, 37, 44 and 51 days after flowering.

2. Results

Table 1 shows that many of the plots had inferior stands compared to those recommended by CASTRO *et al.* (1996) of 40 to 50 thousand plants per hectare. Rumbosol-91 was significantly taller than the other cultivars, but had the lowest percentage heads and the highest percentage stem. Dry matter (DM) yield of V2000 was inferior to the others, except for the first harvest time (Table 2). The DM concentration of the material is the most important factor for the quality of the ensiling process (McDonald *et al.* 1991) and it is recommended to be between 30 to 35%.

Laboratory silos of PVC with 40 cm of length and 10 cm diameter were used and the silos were opened after 56 days.

Table 1. Stand (plants/ha), height of the plants (cm), diameter of the heads (cm) and percentages of heads, stems and leaves at 30 , 37, 44 and 51 days after flowering

	Stand	Height	Diameter	Head%	Stem%	Leaf%
			V2000			
30	39.59ABa	195.00Ba	16.84Aa	46.34Aa	35.56Ba	18.12Aab
37	26.74Ba	190.00Ba	20.44Aa	42.17Aa	37.34Aba	20.49Aa
44	33.34Aa	178.33Ba	17.56Aa	47.22Aa	37.16Aba	15.61Bab
51	19.44Aa	176.67Ba	15.55Aa	51.85Aa	37.68Ba	10.47Ab
			DK180			
30	31.60Ba	205.00Ba	17.56Aa	44.38Aa	35.46Ba	20.16Aa
37	39.58Aba	190.00Ba	15.56Aba	52.00Aa	35.03Ba	12.97Ba
44	25.35Aa	200.00Ba	17.67Aa	45.63Aa	38.32Ba	16.05Ba
51	38.19Aa	203.33Ba	12.22Aa	41.16Ba	42.41Ba	16.43Aa
			M734			
30	30.56Ba	193.33Ba	19.67Aa	48.83Aa	32.68Ba	18.49Aa

37	42.71ABa	181.78Ba	14.78ABa	48.99Aa	33.30Ba	17.71ABa
44	46.53Aa	198.33Ba	15.11Aa	50.67Aa	31.25Ba	18.08ABa
51	39.58Aa	191.67Ba	13.22Aa	48.58ABa	35.62Ba	15.79Aa
RUMBOSOL 91						
30	58.33Aa	235.00Aa	16.67Aa	26.52Ba	50.27Aab	23.21Aa
37	57.64Aa	226.67Aa	13.68Ba	33.38Ba	44.20Ab	22.43Aa
44	25.35Ab	228.33Aa	17.78Aa	29.95Ba	46.05Ab	24.01Aa
51	42.36Aab	228.33Aa	15.00Aa	24.78Ca	57.20Aa	18.01Aa
CV	32.80	6.616	18.42	11.90	11.23	20.01

Capital letters compare harvest times among genotypes
Small letters compare harvest times within of each genotype

The largest densities were observed for V2000, which may be explained because of its lowest DM concentration. Within each genotype, the densities decreased with

time, due to the higher DM concentrations as plants matured, with the exception of V2000. These results are superior to those reported by Tomich (1999) who studied 13 genotypes with an average density of 677.4 kg/m^3 and they are also above those found for farm silos, with values of around 600 to 800 kg/m^3 for a good compression (Nussio 1992). The quality of the preservation decreased with age of the plants as shown by increasing pH, particularly for V2000, which also had high ammonia-nitrogen (N - NH_3) levels. In another experiment done at our lab with 13 genotypes (Tomich, 1999) the mean values of ether extract and in vitro DM digestibility of the silages were 13,7 % and 50 %, respectively, and showed normal profiles of lactic acid and AGV production.

Table 2. Production of fresh matter (FM t/ha), DM (t/ha), DM (%) of plants, heads, leaves and stems at 30, 37, 44 and 51 days after flowering.

	FM/ha	DM yld	Plants	Heads	Leaves	Stems
			V2000			
30	30.94Aa	5.63Aa	17.85Aa	23.45Aa	20.35Ab	22.45Aa
37	16.31Ab	3.05Bb	19.13Ba	6.23Aa	29.27Bb	16.17Ba

44	10.28Ab	3.27Bb	32.80Ba	26.77Aa	48.43Aab	21.37Ba
51	7.57Ab	2.73Bb	35.17Ba	30.30Ba	58.13Aa	22.73Ba
DK180						
30	24.58Aa	6.03Aa	24.53Ab	24.20Ab	31.77Ab	21.00Aa
37	21.49Aa	6.22Aa	29.30ABb	27.43Ab	46.30Bab	26.47Aba
44	12.85Ab	5.50Aa	42.57ABa	32.10Ab	60.70Aa	24.80ABa
51	11.39Ab	6.40Aa	59.60Aa	51.30ABa	71.97Aa	31.00Ba
M734						
30	29.93Aa	6.53Aa	22.10Ab	21.70Ab	22.27Ab	19.20Aa
37	20.21Ab	6.24Aa	32.27ABb	25.73Ab	31.30Bb	20.80ABa
44	13.51Abc	7.49Aa	55.43Aa	37.30Aab	68.43Aa	25.70Ba
51	10.35Ac	6.57Aa	67.33Aa	49.73ABa	78.10Aa	32.30Ba
RUMBOSOL 91						
30	24.38Aa	6.15Aa	25.70Ac	24.77Ab	38.43Ab	31.60Ab
37	12.57Ab	5.32Aa	43.20Ab	39.83Ab	70.10Aa	37.90Aab
44	15.77Ab	6.95Aa	49.23ABb	42.40Ab	76.43Aa	41.80Aab
51	7.43Ab	4.79Aa	68.57Aa	68.97Aa	84.50Aa	55.13Aa

CV	26.50	19.97	26.60	32.62	24.59	31.88

Capital letters compare cutting times among genotypes
Small letter compare cutting times within each genotypes

Table 3. Density (kg/m^3), DM (%), CP (%) of the silages cut and ensiled at 30; 37; 44 and 51 days after flowering.

	Density	**DM**	**CP**	**pH**	**N - NH_3**
		V2000			
30	2092,50^{A}a	18,60Aa	13,09 Aa	4,43	14,76
37	1821,33^{A}a	22,28Aa	13,37Aa	5,26	24,27
44	1559,00Aa	31,10Ba	13,18Aa	5,28	12,52
51	1494,33Aa	32,79Ba	12,66Aa	5,24	21,59

DK180					
30	1673,67Aa	23,06Ab	11,17Aba	4,42	11,00
37	1570,67Abab	28,70Ab	10,31Ba	4,18	9,72
44	1261,00Aab	39,40Abb	11,40Ba	5,14	9,51
51	1050,33Bb	56,56Aa	10,69Ba	*	*
M734					
30	1921,00Aa	21,06Ab	11,25Ba	4,42	8,46
37	1575,00Aba	31,83Ab	10,62Ba	4,17	14,38
44	1240,33Ab	52,05Aa	11,25Ba	5,14	7,75
51	914,67Bb	61,30Aa	12,06Aba	*	*
RUMBOSOL91					
30	1615,67Aa	25,70Ac	9,18Ca	4,07	8,64
37	1189,33Ba	41,24Ab	9,94Ba	4,84	7,48
44	1084,00Aa	44,90Abb	9,44Ca	5,25	9,35
51	666,00Bb	64,57Aa	7,00Cb	*	*
CV	18,87	24,49	8,45		

Capital letters compare harvest times among genotypes
Small letters compare harvest time within each genotype
***Not determined**

3. Conclusions

1. **The best harvest time for ensiling varied according to genotype, and was 37 days after flowering for DK180 and M734, more than 51 days for V2000 and about 30 days for Rambosol-91.**

2. **V2000 had the highest CP concentrations, but even though with 35% DM at ensiling provided silages with undesirable pH and N-NH_3. Within each genotype there were no differences between harvest times in the CP concentration, with the exception of Rumbosol-91, which had lower values at 51days.**

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Sila-wrapped Grass Silage Production Using the Small Bale System (SBS) for Feeding of Goats and Sheep

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Silage making involving mechanised sila-wrapping of small round bales has been introduced in Malaysia in 1991. This method of silage production, which involves mainly grasses, has been undertaken on three ruminant farms as well as on grazing reserves. However, regular production using this method is now primarily carried out on two farms, the Sheep Multiplication Centres in the states of Kedah and Trengganu, which normally suffer from drought during part of the year.

Fresh grass is cut using a mower conditioner and then baled to produce small round

bales averaging about 30 kg per bale. These bales are then collected from the field and delivered to the storage shed where the sila-wrapping machine is located, wrapped mechanically and stored. In some cases, sila-wrapping and storage are done in the field.

Annually, about 500 bales of sila-wrapped silage, equivalent to 15 tonnes, are being produced to feed cattle and sheep during the dry season. In the first 8 months of this year, a record of 2000 sila-wrapped bales have been produced. Up-to-date, a production of about 290 tonnes of sila-wrapped silage has been achieved.

Grasses used are *Brachiaria humidicola*, *B. ruziziensis*, *B. decumbens*, *Panicum maximum* and *Setaria sphacelata* cv Kazungula. Crude protein determined in the silages produced ranges between 5% to 13.4% in the grasses cut between 21 days to 2 months of maturity.

The sila-wrapping system is considered a very convenient means of silage production. However, the main problem is in the high cost of sila-wrap film which has to be imported. Another problem is rats chewing through the sila-wrap film to get at the silage causing spoilage.

Little Bag Silage

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1. Introduction

This paper summarises the development of "Little Bag Silage" (LBS) during 1988 – 92, while the author was fodder and livestock consultant on development projects in northern Pakistan and in Nepal. It relates to the mechanics of ensiling on a small scale, and how this fits within the overall livestock and farming system. While working in northern Pakistan, the problem was how to improve the nutrition of farmers' milking animals when each family keeps only one dairy cow or buffalo? During the cold continental winter the major fodders available were maize stover

and wheat or rice straw, together with very poor quality hay made from mature summer hillside pastures after the rains have ended. Although loans were made to farmers for the purchase of high yielding improved buffaloes from the lowlands, farmers were disappointed that yields soon fell to those of local stock as a result of feeding the same rations as before. As a minimum it was essential to provide a green fodder supplement to enhance rumen function for these animals. One course was to develop winter fodder crops, but this still left 3 months without green feed. Strong plastic shopping bags were available in the lowlands, and it was found that these had a minimum capacity of 5 kg of fresh chopped green fodder sorghum. If these were used for silage, it would mean that one buffalo could be fed one bag of silage a day, providing the minimum of 5 kg green fodder needed as a supplement. This was the birth of the concept of "Shopping Bag Silage", or "Little Bag Silage" as it became known.

2. Methods

The same basic method for making LBS was used in both N. Pakistan and Nepal:

- **Strong high density plastic shopping bags with a capacity of 5 kg chopped green fodder and with no obvious holes in the seams were purchased in packs of a hundred;**

- **At least 100 kg of summer fodder crop such as multi-cut fodder sorghum was cut and carried to the chopping floor. The fodder was either hand chopped with a large knife against a wooden chopping block, or chopped through a chaff cutter with a rotating blade;**

- **5 kg of chopped green fodder was carefully packed into one of the shopping bags so as to avoid making any holes in the bag;**

- **The bag was gently but firmly squeezed by hand to expel air, and while compressed the neck of the bag was twisted then turned over and tied with twine [it is possible to close bags by tying the two handles in a knot, but this does NOT result in an air-tight closure];**

- **The bag of silage was then inverted into a second empty shopping bag, which was also closed and tied;**

- **The bag of silage was then inverted into a third empty shopping bag and sealed. Each bag of silage was therefore triple wrapped, and seams which might be expected to leak air were doubly protected;**

- **The bags were carefully stacked in a room protected against rats, mice and other pests;**

- **After a minimum period of one months LBS was fed to buffaloes at a rate of one bag per head per day.**

- **The outer two plastic bags of each LBS were kept for re-use.**

3. Results

In N Pakistan the method was initially developed with a farmer/store-keeper who had a couple of Nili-Ravi dairy buffalo and who had planted 0.1 ha to Sadabahar, a local multi-cut Sorghum x Sudan grass hybrid. 120 kg of fodder chopped with a chaff

cutter made as LBS and stored under the farmer's bed was compared with 120 kg of fodder conserved in a single bag made from heavy gauge plastic. Both lots of fodder ensiled well, and the farmer was pleased with milk yields from the buffalo fed silage, although no records were kept. He was especially pleased with the LBS, since it was much easier to feed individual bags, instead of having to untie and re-tie the large bag of thick plastic. His practice was to feed half of each Little Bag in the morning and the remainder in the evening. Neighbouring farmers were impressed that at a time when they had only dry fodders this farmer had green fodder. In response, our entrepreneur was planning to plant up much of his land with Sadabahar, so that he could make sufficient LBS to sell it to his neighbours in the following winter!

The first trial of LBS in Nepal was on-station. Leafy Paspalum grass was harvested at Kathmandu, chopped and ensiled. Bags were well conserved, although the fermentation was not strongly lactic acid. Results were good enough to proceed.

In the second station trial in Nepal LBS was made from Napier grass in the Terai (100 m.a.s.l.), and from maize grown for fodder harvested at the soft dough stage with chopped cobs included at Kathmandu (1,250 m.a.s.l.) and at Jiri (1,800 m.a.s.l.).

After two months excellent lactic acid fermentation resulted from all lots of LBS, and undamaged bags kept well for six months with little fungal spoilage. However LBS from fodder maize appeared to attract every mouse from a km radius, and when the door to the store was opened to remove a bag mice were seen to leap in. Once in, mice could easily hide between the bags. Mice then chewed through the plastic bags, and most of the bags were lost as aerobic spoilage ruined the silage.

The third trial in Nepal was an extension trial with Livestock Development Groups at three locations. In Kathmandu there was a small factory making bags, using machinery from Thailand and plastic prills from the Gulf; special bags of thicker gauge and without loops cut out to make handles were ordered. At each site kits were issued to 20 farmers. Each kit included a pack of 100 high strength plastic bags, an illustrated guide to making LBS, and a record sheet. The making of LBS was demonstrated to each Group by project staff, and the local livestock technician assisted farmers during the trial. Details on the crop to be conserved, the look and smell of the silage, and the milk yield of the selected cow or buffalo before and during a thirty day feeding period were recorded by each farmer.

At Pokhara (800 m.a.s.l.) the farmers were delighted with the bags for a hundred and one uses, but since they were already growing irrigated winter fodder oats

making LBS was not one of them! At Jiri (1,800 m.a.s.l.) farmers used wet mature summer grasses, which unfortunately turned to compost! Within Kathmandu Valley, however, there were peri-urban milk producers who stall-fed buffaloes and who had to purchase all their feeds, including padi straw. In the Valley there was also a tradition of threshing padi while it was still green, with the production of a cooked beaten rice which was sold as a snack food. These milk producers made LBS from the green padi straw, and found their traditional buffalo could eat one bag of silage a day in addition to their normal ration of dry straw and bran. As a result milk yield increased by fifty percent, from 2 l per day to 3 l. The extra litre of milk, sold in Kathmandu diluted with water, was worth Rs 20. It had cost Rs 3 to produce, being the cost of 3 plastic bags @ Rs1 per bag, plus the minimal cost of 5 kg of green padi straw. With care, two of the three bags could be re-used, reducing the total cost for the extra litre of milk to little more than Rs 1.

4. Discussion

Making LBS is labour intensive, and does need care and attention for success. It has

to fit the local livestock and farming systems, and having expenses has to be linked to semi-commercialisation of production. The place of LBS within the overall strategy for fodder development in N Pakistan and Nepal has been described elsewhere (Lane, 1999).

The quality of bags for LBS is important. High rather than low density plastic reduces potential for tearing. The seal must be without holes, and this may relate to factory practice. If holes are present along the seal, sticky tape or tar/mastic may be used to repair seals as the bags are tied. Inner bags do tend to get damaged, but the thicker gauge bags used for the extension trial in Nepal were less damaged to an extent where two rather than three layers of bags may have been sufficient. Initially commercially available shopping bags were used. These happened to be strong enough for the purpose. Some bags are thin and flimsy, as found in China, and these would not be suitable. As in Nepal, discussions with local plastic bag makers will be useful. It happened in Pakistan and Nepal that shopping bags could readily hold 5 kg of chopped green fodder; if larger bags are available, or if handles are omitted, larger quantities could be made per bag. This will reduce the costs of bags per kg silage stored, and reduce losses from damage and surface moulds. However the amount stored per bag should relate to feeding practices, although it is easy to reseal little bags so that feeding of silage from individual bags could readily be

spread over 1-2 days even in hot climates.

Fermentation characteristics of LBS depend on the fodder being conserved, and the old saying "Rubbish in, Rubbish out" applies equally to silage made in little bags. Fodder with high sugar content, whether from specialised temperate or tropical fodder crops or from temperate leafy pasture, will conserve well. Fodder with low sugar content is more likely to rot than ferment, and this has led to a bad reputation for silage in general in the tropics, LBS included. Problem fodders include mature C4 pasture grasses harvested in the rains, legumes in general, and possibly tree fodder. Wet grasses must be partially dried before ensiling, under shelter if it is still raining, and legumes should also be wilted.

The example of peri-urban dairy farmers making good LBS from green padi straw is important, since many crop residues loose much of their soluble carbohydrates during the final stages of grain ripening, and while the residue is left to dry in the field. Under smallholder systems padi is frequently harvested comparatively green, and the crop sun-dried in the field with loss of nutrients from the straw; heating in the stack before threshing completes the loss of sugars. In the Sudan, M. Wade encouraged the ensiling of maize stover in trench silos on commercial dairy farms to improve fodder value of the stover when fed to cows; while maize with stay-green

fodder characteristics has been widely adopted by farmers in N Pakistan. Improved utilisation of crop residues through ensiling needs further attention.

A key feature of LBS is that it allows conservation of available fodder in small quantities over a long period of time. This strongly contrasts with traditional silage making techniques where large amounts of fodder must be harvested and chopped at one time. Thus a small-holder family might be able to conserve a couple of bags of LBS a day over a 100 day growing season, which would allow their milking animal to be fed one bag of LBS a day over a 200 day dry season. This fodder might include leafy grass weeds harvested from the crop fields, terraces and bunds, which could readily be partly air-dried under shelter a little at a time before chopping and ensiling. In Nepal, leaves were progressively removed from maize plants as they commenced to senesce, and these would make excellent LBS.

Although summer fodder crops were frequently used in the trials above, they take land away from food production and would only be financially attractive to families in commercial animal production. Lane (1999) allocated them to high cost systems likely to be adopted by only 25 per cent of farmers. A range of fodder sorghums and millets were, however, grown in trials in both N. Pakistan and Nepal at three sites in each country, and fodder yields were doubled by application of 200 kg N per ha. In

the Mediterranean countries conservation of temperate fodder crops for feeding in the dry summer is relevant, and this also applies to countries in monsoonal zones. In 1976 the author working in Tanzania carried out small scale ensiling trials with cassava, and produced silages from chopped cassava root, leaves, and root + leaf mixtures. Although the fermentation characteristics differed between the silages, they were all edible by sheep. These feeds could easily be ensiled as LBS, and allow cassava to be fed throughout the dry season when harvesting is difficult due to hard ground and when leaves have been lost.

In common with silage making in general, there is interest in the use of additives to assist conservation of the problem crops outlined above. A small station trial was made with sodium bisulphate, but as maize fodder was used no benefit resulted. Any compound for smallholder use must be cheap, non-toxic, non-corrosive and easy to apply. While various additives used in industrialised countries might be reduced in scale and packed in individual sachets for use on individual 5 – 100 kg lots of fodder, they do not meet the above criteria. Even molasses, which does, is not widely available. It was concluded that sugar, in the cheaper less refined brown lump form, would be most applicable. However, it would still be relevant to partly dry the fodder to reduce the amount of sugar required for effective conservation, and to reduce the quantity required relative to the actual quantity of fodder being

preserved. Where very difficult crops are to be ensiled, the use of common salt (NaCl) as a straight preservative also needs evaluation, as many livestock are also deficient in salt as a nutrient.

Essential for success with LBS is protection of the bags, for up to 4-6 months. This has been a major weakness, but may be related to the crop being ensiled. As noted, maize fodder with chopped cobs was a major problem, but green crop residues may be less attractive. Fodder sorghums do still produce HCN in LBS, which may be a deterrent to pests, and no problems of damage by mice was reported in N. Pakistan. Otherwise some form of construction may be required. This might be within an existing store such as large cement or clay storage jars with strong lids. Alternatively, specialised buildings might be constructed, with legs to keep the store off the ground and shaped to prevent rats and mice climbing in, such as the mushroom shaped stones traditionally used in England for grain stores, or protected with metal horizontal discs or downward facing cones. In Nepal a relish for human consumption known as "Gundruk" is made by fermenting wilted cabbage leaves in air-proof clay pots. Thus the actual nature of the vessel used for making small quantities of silage is open to local variation and adaptation of available items and materials.

For harvesting pastures, rather than fodder crops, the Swiss scythe has been successfully introduced into the hills of Nepal, and is used by contractors for making hay along with the hay fence technique. Unfortunately the grass is cut when over-mature but while the rainy season continues, so that the hay is moist when stored and is of little fodder value. Swiss farmers now use a system of a two-wheeled mechanical mower with a tedder and hay rake, and this range has now been extended to a mini-round baler and a bale wrapper for making silage. In hay the bales weigh about 20 kg, in silage following wilting about 50 – 60 kg. Many of the benefits of LBS would result from use of this equipment with young leafy wilted pasture crops, and it would be relevant for commercial dairy farmers with 5 – 20 cows, such as in the highlands of Kenya.

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Further details and a copy of the reference are available on request from the author.

Effect of Time of Day on the Water Soluble Carbohydrate Content of Kikuyu Grass

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1. Introduction

In studies with temperate forage species water soluble carbohydrate (WSC) content has been observed to increase during the day due to photosynthetic activity within the plant. With warm and sunny conditions the content of WSC in the plant is higher in the afternoon than early morning. It has been suggested that cutting of forages for silage should be delayed until the afternoon to maximise the amount of WSC available for fermentation. There are few data available on variation in WSC content of tropical grasses, so the current study was conducted to monitor changes during the day in the composition of kikuyu grass (*Pennisetum clandestinum*).

2. Materials and Methods

Two studies were conducted in which nitrogen (N) fertilised kikuyu grass was sampled to monitor changes in WSC during the day. The first study was conducted over 3 days in March with 30 day kikuyu regrowth and in adjoining plots over 3 days in April with 30 and 45 day kikuyu regrowths. A second study in April investigated the change in WSC content of 30 and 45 day regrowth kikuyu mown for silage production at three times during one day. The two studies were conducted at different sites within the same paddock. The forage samples were analysed for DM, N, WSC, and starch content, and for *in vitro* organic matter digestibility.

3. Results and Discussion

In the first study weather conditions over the three days during the March sampling ranged from warm and sunny through to overcast. Warm and sunny weather was experienced on all days during the April sampling. No significant differences were observed between days in forage composition at either sampling. Composition of

the kikuyu grass from this study is presented in Table 1.

Table 1. Effect of time of day on the composition of kikuyu grass in study 1

Sampling time (Australian Eastern Standard Time)	DM content (g/kg)	N content (g/kg DM)	Water-soluble carbohydrate (g/kg DM)	Starch (g/kg DM)	OMD
March - 30 day regrowth					
7.35 h	167	34.6	50.2	42.3	0.698
11.45 h	167	34.9	68.4	51.4	0.710
15.55 h	171	33.6	66.1	57.8	0.726
Time of day	ns	$P< 0.10$	$P< 0.01$	$P< 0.01$	$P< 0.01$
s.e.d.	5.5	1.07	2.66	4.17	0.0073
April - 30 day regrowth					
8.20 h	191	24.4	48.1	40.4	0.668
14.00 h	203	23.6	60.2	50.6	0.674

17.00 h	202	23.2	63.2	53.3	0.673
April - 45 day regrowth					
8.20 h	193	24.4	48.0	39.0	0.672
14.00 h	196	23.6	61.0	52.0	0.681
17.00 h	202	22.9	63.8	51.7	0.674
Regrowth	ns	ns	ns	ns	ns
Time of day	P< 0.01	P< 0.01	P< 0.01	P< 0.01	ns
Regrowth � time	P< 0.10	ns	ns	ns	ns

During the second study warm and sunny weather conditions prevailed " align="center">

14.15 h

231

20.4

59.2

53.7

0.675

16.15 h

204

19.9

53.6

45.4

0.714

45 day regrowth

10.30 h

208

19.8

46.0

37.6

0.640

14.15 h

214

18.6

55.3

54.9

0.647

16.15 h

191

17.4

54.7

49.4

0.621

Regrowth

P<0.05

P<0.10

ns

ns

P<0.10

Time of day

P<0.01

ns

P<0.01

P<0.05

P<0.05

Interaction

ns

ns

ns

ns

P<0.01

s.e.d.

7.3

0.86

1.92

5.20

0.0197

The results from this study confirms that sugar levels are higher in kikuyu grass in

the middle of the day and in the afternoon (60.6 g/kg DM), than in the morning (47.2 g/kg DM). Despite this increase in sugar content (to 12.0 g/kg fresh forage) the level was still well below the critical value (25-30 g/kg fresh forage) for low risk preservation of unwilted forage (Wilkinson, 1990). Other effects of changing the time of cut to the afternoon were a small increase in forage DM content, a small reduction in N concentration, an increase in starch content but no effect on digestibility.

4. Conclusions

The benefits of higher WSC content obtained by delaying cutting to the afternoon are small, as WSC levels were still well below the critical value required to ensure a good silage fermentation. In addition, cutting in the afternoon could have a negative effect on the ensiling process by slowing wilting. A slow wilt has been shown to adversely affect the fermentation quality of kikuyu grass.

5. Acknowledgements

We are greatly indebted to the Australian Dairy Research and Development Corporation and NSW Agriculture for funding this research, and for assistance from local dairy producers who provided access to land and equipment.

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Evaluation of Quality and Nutritive Value of Napier Grass Silage with Different Growth Stages Either Chopped or Unchopped in Northeast Thailand

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1. Introduction

Stable supply of forage throughout the year is the key constraint for further development in cattle production in Northeast Thailand. Although Napier grass (*Pennisetum purpureum)* is not popular in the region, it may have high possibility under an intensive management with high manure input. The present study aimed at identifying nutritive value and fermentative quality of silages made of Napier

grass with different growth stages either chopped or unchopped, and physiological changes in cattle given the silages.

2. Materials and Methods

The following three kinds of Napier grass were ensiled in cylindrical concrete tanks (0.75m diameter and 0.5m height), pressed by foot and covered by plastic sheet with sand weight on top.

1. **Chopped silage of 1m grass height (about 30 days after cut)**
2. **Unchopped silage of 1 m grass height (about 30 days after cut)**
3. **Chopped silage of 1.5 m grass height (about 80 days after transplanting)**

Aliquot of silage sample from each silo was placed into a bottle with water and kept in a refrigerator for overnight. The extracted fluid was subjected to the analyses of VFAs with gas chromatography, lactic acid with diagnostic kit, volatile basic nitrogen

(VBN) and total nitrogen content.

Two castrated male native cattle (average body weight 166kg) were used for digestion trials with the above-mentioned three feeding treatments, which were conducted in this order. Silage was given to the animals *ad libitum* to measure maximum intake. Nutrient digestibility was examined by total collection method. Blood samples were collected from the jugular vein into heparinised tube at the end of each collection period before feeding and 3hr post feeding, and subjected to the analysis.

3. Results and discussion

Although the original grass used in the treatments of 1 and 2 were the same, CP and NFE contents were lower in unchopped silage, which would be owing to the difference in the fermentation process during being ensiled (Table 1). CP content in the treatment 3 was lower than the others, which would be due to the difference in the maturity. Fermentative quality of unchopped silage was also worse than that of chopped silage of treatment 1 (Table 2). The unchopped silage showed higher pH

and the ratio of volatile basic nitrogen to total nitrogen (VBN/TN), and lower lactic acid concentration. If grass was ensiled without chopping, there was considerable space between the pieces of grass, which made anaerobic fermentation difficult. V-score was calculated from VBN/TN, total content of acetate and propionate, and butyrate content (Masaki, 1996), which is one of methods to evaluate silage quality and used in Japan to evaluate low moisture silage and high moisture silage at the same criterion. It clearly showed the difference in the fermentative quality in spite of not using the value of lactic acid contents for the calculation. It would be a useful method for the evaluation of silage quality especially in developing countries where the analysis of lactic acid is not practical in terms of cost and facilities. The value of pH itself may also be a useful and very simple indicator for the evaluation of silage quality.

The TDN content of the silage in treatment 1 was significantly higher than that in treatment 2 (Table 3). It was considered, therefore, that large amounts of nutrients, especially NFE, were lost during the fermentation process in treatment 2. The voluntary intake of silage also decreased in treatment 2. Consequently, TDN intake in treatment 2 was about 68% of treatment 1.

There was no difference in D-3-hydroxybutyric acid (BHBA) level between at 0hr and

at 3hr after feeding in cattle fed chopped silage (treatment 1). On the other hand, BHBA level in cattle fed unchopped silage became higher after feeding (Table 4). It was considered that the difference of butyrate concentration in the silage influenced BHBA level in blood. However, the physiological effects of butyrate on animals would be minimum even if cattle received such low quality silage for longer period, as the values of BHBA and NEFA in blood were within normal range and there was no change in glucose content.

Chopping of original grass before ensiling is highly recommended not only for making better quality silage but also for making better use of silo capacity. Proper preparation of silage minimises the loss of nutrients during the fermentation process and increases voluntary intake, which results in higher TDN intake.

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Japanese).

Table 1. Chemical composition of silage

Treat.	Height of grass	Chopping	DM[1]	OM	CP	EE	NFE	CF	ADF	NDF
			%	% of DM						
1	1m	Chopped	16.9	89.3	11.9	3.9	42.7	30.7	37.7	64.2
2	1m	Unchopped	16.1	86.9	10.2	3.6	39.1	34.0	40.9	64.3
3	1.5m	Chopped	16.6	90.0	7.3	3.1	42.6	37.0	43.9	70.2

1DM, dry matter; OM, organic matter; CP, crude protein; EE, ether extracts; NFE, nitrogen free extracts; CF, crude fibre; ADF, acid detergent fibre; NDF, neutral detergent fibre.

Table 2. Fermentative quality of Napier grass silage

Treatment		1			2			3		
		LSM	SE	No	LSM	SE	No	LSM	SE	No
pH		4.02[b]	0.18	3	5.58[a]	0.15	4	3.87[b]	0.14	5
VBN/TN[1]	%	8.03[b]	2.87	3	17.40[a]	2.49	4	6.88[b]	2.22	5
Acetate	%	0.127	0.178	3	0.460	0.154	4	0.232	0.138	5
Propionate	%	0.007[b]	0.018	3	0.140[a]	0.016	4	0.002[b]	0.014	5
Butyrate	%	0.007	0.096	3	0.243	0.083	4	0.161	0.074	5
V-score		93.2[a]	12.9	3	47.1[b]	11.2	4	82.2[ab]	10.0	5
Lactate	%	1.21[a]	0.09	1	0.06[b]	0.09	1	0.99[a]	0.04	5

1VBN/TN: ratio of volatile basic nitrogen to total nitrogen; LSM, least square means; SE, standard error; No, the number of samples.

[a,b]Means with different superscripts among treatments significantly differ ($p<0.05$).

Table 3. Body weight, feed intake and nutrient digestibilities of native cattle given Napier grass silage

Treatment		**1**	**2**	**3**	**SE**
BW	kg	166	166	166	0.4
DM intake	gDM	4015[a]	3163[b]	3223[b]	48
Digestibilities of					
DM	%	70.5	62.7	66.8	1.4
CP	%	71.7	60.8	62.3	1.8
NFE	%	70.1[a]	55.9[b]	61.8[b]	1.3
CF	%	77.5	74.5	77.1	1.3
TDN	%	71.8[a]	61.6[b]	66.9[ab]	1.3

a,bMeans with different superscripts among treatments significantly differ ($p<0.05$).

Table 4. The Change of NEFA, glucose, total protein and BHBA contents in plasma of cattle given Napier grass silage before and after feeding

	Treatment	NEFA1	Glucose	TP	BHBA
		mEq/l	mg/dl	g/dl	mM
Before feeding	1	0.049	94.5	5.78	0.276
	2	0.129	85	6.05	0.219
	3	0.076	82	5.91	NA
	SE	0.024	3	0.21	0.012
3 hours after feeding	1	0.046	88	6.73	0.291
	2	0.051	96.5	5.84	0.411
	3	0.074	127.5	5.96	NA
	SE	0.01	24	0.12	0.017
	Tr	-	-	-	-
	Ti	-	-	-	-
	T*T	-	-	-	**

1NEFA, non esterified free acid; TP, total protein;
BHBA, D-3-hydroxybutyric acid; Tr, Effect of treatment;
Ti, Effect of time after feeding;
T*T, Interaction between treatment and time after feeding.

The Use of Molasses to Improve the Fermentation of Low-Dry Matter Kikuyu Grass Silages

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1. Introduction

Kikuyu grass (*Pennisetum clandestinum*) is a valuable forage resource for dairy and beef cattle in the coastal areas of eastern Australia. Production of wilted silages is often difficult due to wet weather during summer and autumn, the periods of maximum growth of kikuyu pastures and when surplus material is available for conservation. Kikuyu grass is also low in the water soluble carbohydrates (WSC) required to support a lactic acid fermentation. As a result kikuyu silages produced on farms are often characterised by low dry matter (DM) content, high pH and high ammonia nitrogen (N) levels, which indicate poor fermentation quality. Previous studies have shown that inclusion of molasses as a source of readily fermentable WSC has improved the fermentation of tropical pasture silages (Catchpoole and Henzell 1971).

2. Materials and Methods

Two experiments were conducted to determine if molasses could improve the silage fermentation of low-DM content kikuyu. In each experiment 30-day regrowth

kikuyu pasture was mown using a conventional disc mower. Two field wilting treatments were compared. In the first the mown forage was left without windrowing (at near mower width) and subsequently manually tedded (morning and afternoon) to maximise drying rate (fast wilt). In the second the forage was raked into windrows immediately after mowing (slow wilt) to simulate common farming practice in Australia.

An unwilted control silage was made immediately post-mowing in both experiments. After two wilting intervals mown kikuyu was collected and manually fed through a precision chop forage harvester, and approximately 3-10 kg batches of fresh forage were ensiled in small plastic bag mini-silos (three per silage treatment). Molasses was applied at varying rates (Table 1) to the forage harvested material using a watering can just prior to ensiling after dilution (1:1) with water.

3. Results and Discussion

In both experiments silages differed significantly (P<0.01) in DM content, pH, and ammonia N content (Table 1). Ideal drying conditions in Experiment 1 enabled the

fast wilt silages to be made after 6 hours and the slow wilt material after 28.5 hours. Continual rainfall in Experiment 2 resulted in no drying and silages were made after 48 hours. The differences between silages in DM content in experiments 1 and 2 reflected effects of molasses treatment, initial forage DM (Experiment 1) and wilting treatment (Experiment 2).

In Experiment 2 the slow wilt windrowed treatment seemed to retain more of the rainwater and there appeared to be more discoloration and yellowing of the forage compared to the fast wilt material, which may be indicative of greater deterioration. Many of the silage ammonia N levels were very high (>150 g/kg total N) indicating severe degradation of the protein fraction. In general, silage fermentation characteristics were either poorer or unaffected as a result of the slow wilt treatment compared to the fast wilt. The greater difference in Experiment 1 was attributed to more favourable weather conditions that allowed wilting rate differences to be expressed.

Table 1. Effect of molasses on the fermentation of kikuyu silages

Treatment	Experiment 1	Experiment 2

(kg molasses/t fresh forage)	DM content (g/kg)	pH	Ammonia N (g/kg total N)	DM content (g/kg)	pH	Ammonia N (g/kg total N)
Unwilted control	133	4.34	148.7	109	4.75	220.9
Fast wilt						
0	224	4.45	136.2	92	4.87	453.7
20	-	-	-	116	3.93	171.7
40	-	-	-	116	3.76	189.3
60	246	3.85	93.6	-	-	-
Slow wilt						
0	239	5.51	260.4	91	4.87	436.6
40	-	-	-	120	3.74	158.7
60	257	4.03	137.4	-	-	-

l.s.d (P<0.05)	11	0.10	15.6	9	0.13	58.4

4. Conclusions

Well-preserved silages should have an ammonia N concentration � 100 g/kg total N (Wilkinson 1990). Without additives it is difficult to produce adequately preserved silage from low-DM kikuyu grass, particularly when prolonged and ineffective wilting occurs due to poor weather conditions. Our other research has shown that where weather conditions favour wilting, rapid wilting will produce satisfactory silage. Where low-DM silages are produced from rapidly wilted kikuyu, silage ammonia N can be further reduced by the application of molasses. When unfavourable weather conditions prevail molasses can produce large improvements in silage fermentation, but the level of application will need to be higher than that used in Experiment 2. Apart from improving silage preservation, molasses addition will also increase the metabolisable energy content of the silage.

5. Acknowledgements

We are greatly indebted to the Australian Dairy Research and Development Corporation and NSW Agriculture for funding this research, and for assistance from local dairy producers who provided access to land and equipment.

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Use of Dehydrated Sugar Cane (*Saccharum officinarum*) as an Additive to Napier Grass (*Pennisetum purpureum*)

Ensilage

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1. Introduction

Tropical grass biomass increases with maturity, but decreases in nutritive value. To overcome this problem these grasses are frequently ensiled at an early growing stage. However, young plants have a high moisture content, high buffering capacity and a low level of soluble carbohydrates. According to Woolford (1984), these factors have a negative influence on the fermentatioin process, preventing a rapid lowering of the pH and thus allowing unwanted secondary fermentation, consequently damaging the quality of the final product.

Assuming that the above problems are the main limitations to the ensilage of Napier grass, research was undertaken with the objective to find practical solutions to enable the production of good quality silage from the Napier grass.

Amongst the existing alternatives, the addition of dehydrated sugar cane to the Napier grass to be ensiled appears to be interesting, because it has high contents of dry matter (DM) and water soluble carbohydrates (WSC).

The aim of this study was to evaluate the chemical and fermentation characteristics of the Napier grass silage with different levels of added dehydrated sugar cane.

2. Materials and Methods

This experiment took place at the Forage Section of the Federal University of Cear�. The chemical and fermentation characteristics of Napier grass silage with the addition of 0, 5, 10 and 15% of dehydrated sugar cane on a fresh matterial basis. The Napier grass biomass, aproximately 80 days old, was chopped and mixed with the dehydrated sugar cane. The sugar cane was ground in a mill fitted with 3mm sieves. A replicated, completely randomised design was used.

We used polyethylene laboratory silos with a 100 mm diameter and 340 mm depth.. Sixty days after filling, the silos were opened and homogeneous samples of aproximately 300 g were taken to determine DM, crude protein (CP), pH and $N\text{-}NH_3$. Analyses of variance and regression were used to test the data.

3. Results and Discussion

The DM content of the silage increased linearly with the addition of dehydrated sugar cane (Table 1). Almeida *et al*. (1986) and Tosi *et al*. (1989), studying the addition of sugar cane and sugar cane bagasse, respectively, in the ensilage of Napier grass, also observed a rise in the DM levels.

Table 1: Average value of the levels of DM, CP, ammoniacal nitrogen ($N\text{-}NH_3$), pH and regression equations

Parameter	Sugar cane				Mean	Regression Equations
	0%	5%	10%	15%		Y=25.9465+2.8442x

% DM	21.2	25,2	27,5	29,9	25,9	Y=25,9405+2,8442x R^2 =98,05%
% CP	7,3	5,7	5,6	4,9	5,9	Y=5,8895–0,6954x R^2 = 99,25%
$N\text{-}NH_3$	4,6	3,9	4,9	4,4	4,5	NS
pH	3,6	3,6	3,6	3,7	3,6	NS

CP levels decreased linearly with the addition of dehydrated sugarcane. Similar results were obtain by Almeida *et al.* (1986). Tosi *et al.* (1989), using sugar cane bagasse as an additive in Napier grass ensilage observed that the CP level of the silages fell below 4%. This reduction is explained by the very low CP concentration of sugar cane bagasse (ca 2%)

We have not observed significant differences in $N\text{-}NH_3$ and pH value between the silages. The quality of the silage without sugar cane was as good as that with. Almeida *et al.* (1986) and Tosi *et al.* (1989) also found that wilted Napier grass made well-preserved silage without sugar cane or bagasse.

Conclusions

From the data obtained on this study we can conclude that the addition of dehydrated sugar cane did not change the characteristics of the fermention of the silages, but reduced its CP levels.

As the CP reached very low levels with the addition of the sugar cane, further studies need to take place to test the inclusion of a nitrogen source together with sugar cane.

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Summary of the Discussion

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During the conference there were some welcome comments from participants which can be summarised under three main headings.

Silage making in the tropics, problems of adoption

In the Introductory paper 't Mannetje (Paper 1) raised some doubts about silage making in the tropics, which stirred several participants to agree or to disagree.

Peter Wollesen, writing from experience in Zanzibar, Somalia and Indonesia mentioned that smallholders in these countries have excessive amounts of forage available in the wet season in the form of grass and foliage as well as various crop residues and by-products at the end of growing season. In order to preserve these feedstuffs, ensiling or urea treatment would be necessary, but smallholders are not doing this to any extent because of problems of airtight and watertight storage, with plastic sheeting being too expensive. The use of plastic bags or plastic lined empty oil drums would offer a solution, but these and machinery for chopping are also expensive. Furthermore, the effect of the improved feeding strategy is not readily seen in the production of milk and meat and that discourages the smallholders from continuing. Gilles Stockton (USA), also having worked in Somalia, found that there is a variety of forages during the rainy season, but a shortage during the dry, despite the fact that the price of milk increased substantially at that time. He does not understand why fodder conservation is not practised.

Miguel Velez agreed that silage is the best choice for conserving forage in the tropics, but disagreed on other points regarding the need for silage making in the tropics. He wrote that for the intensification of livestock production in the tropics, forage conservation is a must in most areas. Not only to improve milk production, but also for the fertility of the cows. Without good feeding, livestock improvement is impossible. In tropical regions with an extended dry season, supplementary feeding is necessary. According to him farmers should not only conserve excess forage or crop residues, but they should plan to ensile forage early in the growing season.

't Mannetje advocated ensiling sorghum or maize rather than tropical grasses with their low feeding value and low soluble carbohydrate contents, but Velez remarked that the crops require annual planting, pesticides, heavy machinery for harvesting and chopping and level land to avoid erosion. Boonman agrees with this. He considers the promotion of "special-purpose-fodder-crops" as a major impediment to silage making. These are full-season crops that compete directly with the land needed for cropping. Many farmers find the ensiling of staple food crops objectionable. Most important, however, mechanised maize silage making can be so expensive that it is cheaper at times to harvest and feed the grain.

Wolfgang Bayer (Germany) found that the smallholders he has dealt with (Africa, India, Eastern Europe) make hay quite often even in very laborious ways, such as drying on a roof. Hay can be stored and transported more easily than silage. Boonman also makes a strong plea for haymaking, which he finds, is not as problematic in the tropics as many believe. He considers that conservation of surplus grass provides fodder in the dry season and maintains a young, green sward in periods of excess growth.

Bayer pointed out that animals kept for manure basically have to survive, whilst draft animals, sometimes used only for several weeks or months need not be fat. These types of animals can also afford to lose weight in the dry season. When resources are scarce, silage making may not be a good proposition, because of the costs and losses involved.

Wong Choi Chee from Malaysia agreed with the introductory paper, but pointed out that there is much low-value fodder in the form of rice straw and oil palm fronds (Wan Zahari *et al.* , poster 6P2), which will either be lost or can be ensiled or treated with urea to preserve them for later use and improve their quality. However, there is no adoption of the technology. He wonders whether the technologies generated are not relevant to the livestock farmers, or that the target

group should be the more progressive farmers who are willing to put some investment into it?

Suttie remarked that the technology is available, at least for mechanised farms, so why is tropical silage not more widely used?

The problems of adoption of silage making technology were extensively dealt with in a poster from Pakistan (Syed Hassan Raza, 2P3)and in comments by Rangnekar from India and by Andy Safalaoh, working in Malawi. The main constraints are listed in the closing paper ('t Mannetje, Paper 10).

Boonman reminded us that farmers have done more for the development of new technology in livestock farming than scientists have. He blames the lack of cutting tropical pastures as a management tool in forage production on the reluctance of legume-oriented scientists to cut grass-legume pastures. In his opinion legumes cannot stand either cutting or grazing and therefore the proponents of legumes do not recommend silage making.

Elaine Lanting from the Philippines observed that the benefits of silage cannot be overemphasised. This is particularly true in commercial cattle feedlot operations

and in dairying where it has great economic benefits. However, in smallholder farms where livestock fodder such as crop residues and weeds abound and can be used conveniently without costs involved, silage production/utilisation has not found its place. In some areas, though, where green corn is the major product and farmers raise two or more ruminants or in small-scale dairying, silage may find its niche in smallholder farms.

Poornima Vyasulu working with a farmwomen project in Bangalore presented a very good case in point about the introduction of silage making to smallholders. In the first instance she sought advice from the conference on silage making, as she is not familiar with farming practice. The main activities of the project are training women in agricultural techniques, extension services, organising them into groups to support each other, buy farm inputs and obtain help from other government departments. Most women have holdings of 2-5 acres; most are in rain-fed areas and practise 'complex, diverse and risk-prone' agriculture as a family livelihood. They are economically in the lower stratum, mostly illiterate and vulnerable. She wondered if silage making would have a place in this situation. She received plenty of advice. Wong Choi Chee commented that small holder farmers in Philippines did not adopt silage making because it involves cost and that she should first find out if silage making would be an option for these women. Rangnekar pointed out that she

should see if the level of milk production of the animals was adequate to respond to better feeding and if there is surplus green fodder available. Unless the women have better producing animals they are unlikely to spend time and money on such technology.

Poornima Vyasulu replied that the conference had given her a steady stream of very professionally presented material on silage. She has begun to see some of the issues involved in silage making: the scale of operation, utility, suitable materials, processes, nutritional value, location-specific variations etc. She can now understand why farmwomen of small holdings have not taken to it so readily. Rural women apply very calculative cost-benefit analysis to everything they do and the way they perceive costs and benefits are not so easily discernible to us! She does not believe in 'pushing' any technology on farmwomen. Her approach would be to offer them information on a potential technology, assist them in adoption if needed but let them choose to do so.

Silage from tropical grasses and legumes

Marion Titterton and Felix Bareeba (Paper 4) introduced silage making from tropical grasses and legumes, which also elicited comments by Chris Regan who has had much experience with silage making of mixed legume-grass pastures in northern Australia. His general practice is to wilt to between 40-55% DM before baling and wrapping.

Techniques of silage making for smallholders

Smallholders do not favour pit or trench silos and stacks on top of the ground because it is difficult to cover them so that they are airtight and to keep the water out. To avoid these problems bags, containers and wrapping of small bales are being advocated.

Ian Lane, who worked in northern Pakistan and in Nepal presented a poster on Little Bag Silage (8P2) and Shariffah Noorhani from Malaysia on wrapping 30 kg bales (8P1) of grass for smallholder livestock. Although this "sila-wrapping" is very convenient, the problem is the cost of the machinery, and rats tend to chew the bales, spoiling the silage. Chris Regan commented that this would be a good case for

cooperation between smallholders or for someone to wrap bales at a small cost. In northern Australia the cost came to Aus$ 0.85 per bale. Bales are also handy for selling them to farmers, who do not make silage themselves.

References

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Introduction to the conference on silage making in the tropics

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1. Introduction

Forage, crop residues and by-products products are usually consumed fresh by domestic animals. However, it is possible to conserve them for use during future periods of feed shortages. Conservation can be achieved by sun drying (hay), artificial drying (meal), and addition of acids or fermentation (silage).

Hay making is difficult in tropical regions because at the time when the forage is of acceptable quality (early in the wet season) to conserve it, the weather is likely to be too unreliable for sun drying. Artificial drying is expensive and facilities are not widely available. Addition of acids may be beyond the resources of small holders and can be dangerous. Remains fermentation by silage making, which can be done of fresh or, preferably, wilted material.

Silage is forage, crop residues or agricultural and industrial by-products preserved by acids, either added or produced by natural fermentation. Fresh forage is harvested, or crop residues and by-products are collected, the material may be chopped or conditioned, additives may be added, and it is then stored in the absence of air so that facultative anaerobic bacteria, present on the forage, or added as inoculants, can rapidly convert soluble carbohydrates into acids. The quality of the ensiled

product depends on the feeding value of the material ensiled and on the fermentation products present: the types of acids and the amount of ammonia. The resulting pH of a well-ensiled product becomes so low that all life processes come to a halt and the material will be preserved so long as it remains in airtight storage.

There are three important considerations to take into account before embarking on a silage making program:

- **Is there a need for silage making?**
- **If so: Are there enough good quality forages or other products available to ensile?**
- **If so: Can the conditions for good silage making be met?**

2. Is there a need for ensiled forage?

Silage making is practised widely in intensive animal production systems in temperate regions, mainly for two reasons. Firstly, because during the winter period there is no high quality feed available in the fields and secondly in order to feed

high quality conserved supplements (e.g. maize) at any time of the year to complement grass to improve milk production and/or nitrogen utilization.

Whether silage making is recommendable in the tropics depends on the type of farm system and on the climate. For a start, feed conservation is generally only a proposition for intensive farm systems, such as milk production for a liquid milk market. Secondly, in humid and sub-humid climates with green forage available year-round, forage conservation is generally not profitable. If the quality of forage from permanent sources (pastures, road-sides) is inadequate, it is nearly always possible to grow a fodder crop (Saleem 1985) or harvest stockpiled forage (Andrade *et al.* 1998*)* or use fodder banks (Milera *et al.* 1994, Peters *et al.* 1994).

Materials to be ensiled can be grasses, legumes, fodder crops (sorghum, maize), crop residues or by-products. The storage period, after which the silage is fed, depends on the purpose of the silage making. If silage is made of forage or a fodder crop of exceptional quality that is only available at a certain time of the year, it will most likely be used in a matter of months. It may also be used for an annual recurrence of periods of shortage or for unseasonal droughts that occur every number of years. Silage can also be a standard feed supply in feedlot systems.

3. Is there enough good quality forage to ensile?

Only excess forage, crop residues or by-products for which there is no other economic use should be ensiled. In other words, if rainfall is unreliable, farmers will not know until late in the growing season that there will be excess forage. This points to a conflict between availability of forage to ensile and its quality. The quality is high early in the growing season, but the farmer cannot take the risk to preserve forage if he is not sure there will be excess. Once he can be sure of that, the quality is too low to make it worthwhile to conserve it. To overcome this problem it is possible to grow a fodder crop to be harvested, or crop residues and by-products or other waste materials to be collected for silage making.

4. Can the conditions for good silage making be met?

Silage making is useful only if the ensiled product is of good quality, i.e. well

preserved and of high digestibility and protein concentration. The main prerequisites for ensilable forage are that it should be harvested at a young stage of growth from a feeding value point of view and that it should contain enough sugars for fermentation. The material to be ensiled should be easily compactable and covered to exclude air. If the material is of adequate quality, but lacking in sugars, molasses or another source of sugar may be added. Chopping before ensiling will also help to compact the material. Tropical grasses (C_4) are inherently low in soluble carbohydrates, with the exception of maize and *Sorghum* species. To ensure good quality silage it may be better to grow a crop of maize or sorghum for silage than to ensile tropical grass. Problems with silage can also arise when it is being fed out due to spoilage caused by moulds that grow particularly fast at high temperatures, common in the tropics. Therefore, silage pits or heaps for smallholders should be small, so that they can be fed out in a very short time (1 or 2 days). Poorly made silage can cause health problems in animals and man.

Catchpoole and Henzell (1971) wrote an early review, which clearly sets the scene for silage making from tropical forages.

5. The conference

The aim of the conference is to review the potential of silage making for livestock production in the tropics with special reference to smallholders.

There will be main papers and posters to cover the main issues of silage making under these conditions. The first main paper will deal with the theory of silage making, the fermentation processes, and what problems will be encountered to meet the requirements for good silage making. This will be followed by other main papers and posters on silage making in large and small scale animal production systems, of grass-legume mixtures, of cereals and fodder crops, of agricultural by-products and industrial, non-agricultural, residues, of harvesting and ensiling techniques, on the use of additives to improve the silage making process of tropical forages and case studies.

There will be ample opportunity for discussion.

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The Future of Silage Making in the Tropics

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1. Introduction

Over a period of 3 months (September till early December 1999) the participation in this Electronic Conference on silage Making in the Tropics has been good and sustained. There were 355 participants from 68 countries, 148 of whom were from Latin America, but only a limited number of contributions came from there. Nine invited main papers were supported by 25 submitted posters and several comments have

given a reasonable and sometimes lively discussion. It was an eye-opener to me and probably to many other participants in this conference to what extent silage making in the tropics has been advocated and tried. But a question remains: to what extent is silage production being adopted by small farmers? At this stage we cannot gauge how many small holders are actually practising silage making.

2. Adoption by small farmers

The contents of the papers and the posters show that silage making is generally known by scientists in the tropics, but that actual small holder silage making activity is low, except in Malaysia (Chin and Idris) and China (Li Dajue and Song Guangwei). The reasons for non-adoption of this technology were presented for Pakistan (Hassan Raza), India (Rangnekar) and Thailand (Nakamanee).

The main reasons mentioned were:

- ***lack of know-how***
- ***lack of finance***
- ***silage making was considered cumbersome and labour intensive***
- ***benefits were not commensurate with effort and time***
- ***animals have a low genetic potential for production and cost and trouble of silage making did not provide adequate returns***
- ***lack of farm planning***
- ***lack of available feedstuffs of good quality***

It was also mentioned that farmers might be prepared to buy ready made silage, which indicates willingness to feed it, but lack of time to prepare it.

It is clear that it is necessary to have trained extension staff and in order to involve farmers in any pilot projects of silage making from an

early start. Only a participatory approach will lead to adoption of new technology that fits in with their system of farming and availability of funds and labour. If farmers would like to feed silage but cannot adopt the technology it may then be necessary to modify it in close cooperation with the farmers to suit their needs and resources.

3. Materials to ensile

Anything that has feeding value can be ensiled. What actually is ensiled depends on availability and quality, but only good quality material should be ensiled to ensure that costs will be reimbursed. Materials mentioned in this conference include:

- ***grasses***
- ***legumes (herbaceous and edible material of woody species)***
- ***fodder crops***

- *crop residues*
- *oil palm fronds*
- *tomato pomace*
- *poultry litter*

4. Methods of silage making

For large farms the temperate approach of mechanised methods and the use of large silos is also applied in Australia (Cowan) the Philippines (Montemayor et al.) and Cuba (Ojeda). Small farms use plastic bags, containers or small bale wrapping.

5. Additives

Although a large range of additives is available, there is little evidence *of its use on small farms in the tropics. If anything, molasses is used on low-sugar containing materials.*

6. Conclusions

Silage making is possible and can solve nutritional problems on small as well as larger farms, but as with many innovations to overcome animal production constraints in developing countries, socio-economic problems prevent general adoption. The main exception is Malaysia, where silage making has become part of a scheme of small scale milk production and collection, providing a regular income to farmers. This may be a lesson in its self: Technology of any kind will only be adopted if it can be part of production systems that generate income.

This conference has been useful because it has brought together and made available the knowledge and shown the constraints concerning

silage making in the tropics.

7. Acknowledgements

The readiness of authors for a quick turn-around of edited papers and posters has made it possible to adhere to the time schedule. I thank them for their cooperation and enthusiasm.

Special thanks to H�ctor Osorio, who has given excellent assistance in technical editing and preparing the material for distribution by e-mail and posting on the Website.

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Silage fermentation processes and their manipulation

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1. Introduction.

Fresh forage crops such as maize, grasses, legumes, wheat and lucerne can be preserved by ensiling. In many countries ensiled forages are highly valued as animal feed. In European countries such as The

Netherlands, Germany and Denmark more than 90% of the forages locally produced are stored as silage. Even in countries with generally good weather conditions for hay making such as France and Italy approx. 50% of the forages are ensiled (Wilkinson et al. 1996). It is essential to have a good microbial fermentation process to produce high quality silage. A good fermentation process is not only dependent on the type and quality of the forage crop, but also on the harvesting and ensiling technique. In this paper our current knowledge on general silage microbiology is reviewed with the aim to aid with the choice of the best ensiling strategy to produce high quality silage.

2. The ensiling process.

Ensiling is a forage preservation method based on a spontaneous lactic acid fermentation under anaerobic conditions. The epiphytic lactic acid

bacteria ferment the water-soluble carbohydrates (WSC) in the crop to lactic acid, and to a lesser extent to acetic acid. Due to the production of these acids the pH of the ensiled material decreases and spoilage microorganisms are inhibited. Once the fresh material has been stacked and covered to exclude air, the ensiling process can be divided into 4 stages (Weinberg and Muck 1996; Merry et al. 1997),

Phase 1, aerobic phase. This phase normally only takes a few hours in which the atmospheric oxygen present between the plant particles is reduced, due to the respiration of the plant material and aerobic and facultative aerobic microorganisms such as yeasts and enterobacteria. Furthermore, plant enzymes such as proteases and carbohydrases are active during this phase, provided the pH is still within the normal range for fresh forage juice (pH 6.5-6.0).

Phase 2, fermentation phase. This phase starts when the silage

becomes anaerobic, and it continues for several days to several weeks, depending on the properties of the ensiled forage crop and the ensiling conditions. If the fermentation proceeds successfully lactic acid bacteria develop, and become the predominant population during this phase. Due to the production of lactic and other acids the pH decreases to 3.8-5.0.

Phase 3, stable phase. As long as air is prevented from entering the silo, relatively little occurs. Most microorganisms of phase 2 slowly decrease in numbers. Some acid tolerant microorganisms survive this period in an almost inactive state, others such as clostridia and bacilli survive as spores. Only some acid tolerant proteases and carbohydrases and some specialized microorganisms, such as Lactobacillus buchneri continue to be active at a low level. The activity of this latter organism will be discussed in more detail further on in this paper.

Phase 4, feed-out phase or aerobic spoilage phase. This phase starts as soon as the silage gets exposed to air. During feed-out this is unavoidable, but it can already start earlier due to damage of the silage covering (e.g. by rodents or birds). The process of spoilage can be divided into two stages. The onset of deterioration is due to the degradation of preserving organic acids by yeasts and occasionally acetic acid bacteria. This will cause a rise in pH, and thus the second spoilage stage is started, which is associated with increasing temperature, and activity of spoilage microorganisms such as bacilli. The last stage also includes the activity of many other (facultative) aerobic microorganisms such as moulds and enterobacteria. Aerobic spoilage occurs in almost all silages that are opened and exposed to air. However the rate of spoilage is highly dependent on the numbers and activity of the spoilage organisms in the silage. Spoilage losses of 1.5-4.5 % dry matter loss/day can be observed in affected areas. These losses are in the same range as losses that can occur in airtight silos

during several months of storage (Honig and Woolford 1980).

To avoid failures it is important to control and optimize each phase of the ensiling process. In phase 1 good silo filling techniques will help to minimize the amount of oxygen present between the plant particles in the silo. Good harvesting techniques combined with good silo filling techniques will thus minimize WSC losses through aerobic respiration in the field and in the silo, and in turn will leave more WSC available for lactic acid fermentation in phase 2. During phases 2 and 3 the farmer cannot actively control the ensiling process. Methods to optimize phases 2 and 3 are therefore based on the use of silage additives that are already applied at the time of ensiling as will be discussed in section 4. Phase 4 will start as soon as oxygen is available. To minimize spoilage losses during storage an airtight silo is required, and any damage to the silo covering should be repaired as soon as possible. During feed-out spoilage by air ingress can be minimized by a

sufficiently high feed-out rate. In addition, at the time of ensiling silage additives can be applied that are able to decrease spoilage losses.

3. The silage microflora.

The silage microflora plays a key role in the successful outcome of the conservation process. The flora can basically be divided into two groups namely the desirable and the undesirable microorganisms. The desirable microorganisms are the lactic acid bacteria. The undesirable ones are the organisms that can cause anaerobic spoilage (e.g. clostridia and enterobacteria) or aerobic spoilage (e.g. yeasts, bacilli, listeria and moulds). Many of these spoilage organisms do not only decrease the feed value of the silage, but also have a detrimental effect on animal health and/or milk quality (e.g. listeria, clostridia, moulds and bacilli).

3.1. Desirable microorganisms.

3.1.1. Lactic acid bacteria. (LAB)

Lactic acid bacteria belong to the epiphytic microflora of plant material. Often the population of LAB increases substantially between harvesting and ensiling. This is probably mainly due to the resuscitation of dormant and non-culturable cells, and not by inoculation by the harvesting machinery or growth of the indigenous population. Crop characteristics like sugar content, dry matter content, and sugar composition, combined with lactic acid bacterial properties such as acid and osmotolerance, and substrate utilization will decisively influence the competitiveness of the lactic acid bacterial flora during silage fermentation (Woolford 1984; McDonald et al. 1991).

Lactic acid bacteria that are regularly associated with silage are

members of the genera Lactobacillus, Pediococcus, Leuconostoc, Enterococcus, Lactococcus and Streptococcus. The majority of the silage lactic acid bacteria are mesophilic, i.e. they can grow at temperatures between 5 and 50^{o}C, with an optimum between 25 and 40^{o}C. They are able to decrease the silage pH to pH 4-5, depending on the species and the type of forage crop. All lactic acid bacteria are facultative aerobes, but some have a preference for anaerobic conditions (Holzapfel and Schillinger 1992; Hammes et al. 1992; Devriese et al. 1992; Weiss 1992; Teuber et al. 1992). Based on their sugar metabolism lactic acid bacteria can be classified as obligate homofermenters, facultative heterofermenters or obligate heterofermenters. Obligate homofermenters produce more than 85% lactic acid from hexoses (C-6 sugars) such as glucose, but cannot degrade pentoses (C-5 sugars) such as xylose. Facultative heterofermenters also produce mainly lactic acid from hexoses, but in addition they also at least degrade some pentoses to lactic acid, and

acetic acid and/or ethanol. Obligate heterofermenters degrade both hexoses and pentoses, but unlike homofermenters they degrade hexoses to equimolar mounts of lactic acid, CO_2, and acetic acid and/or ethanol (Hammes et al. 1992; Schleifer and Ludwig 1995). Obligate homofermenters are species such as Pediococcus damnosus and Lactobacillus ruminis. Facultative heterofermenters are for example Lactobacillus plantarum, Lactobacillus pentosus, Pediococcus acidilactici, Pediococcus pentosaceus, and Enterococcus faecium. To the obligate heterofermenters belong members of the genus Leuconostoc, and some Lactobacillus sp. such as Lactobacillus brevis and Lactobacillus buchneri (Devriese et al. 1992; Weiss 1992; Holzapfel and Schillinger 1992; Hammes et al. 1992).

3.2. Undesirable microorganisms.

3.2.1. Yeasts.

Yeasts are eucaryotic, facultative anaerobic, heterotrophic microorganisms. In silages anaerobic as well as aerobic yeast activity is considered undesirable. Under anaerobic silage conditions yeasts ferment sugars to ethanol and CO_2 (Schlegel 1987; McDonald et al. 1991). This ethanol production in silage does not only decrease the amount of sugar available for lactic acid fermentation, but it can also have a negative effect on milk taste (Randby et al. 1998). Under aerobic conditions many yeast species degrade the lactic acid to CO_2 and H_2O. The degradation of lactic acid causes a rise in silage pH, which in turn triggers the growth of many other spoilage organisms (McDonald et al. 1991).

Yeast populations can reach up to 10^7 colony forming units per gram during the first weeks of ensiling, prolonged storage will lead to a gradual decrease in yeast numbers (Jonsson and Pahlow 1984; Middelhoven and Van Balen 1988; Driehuis and Van Wikselaar 1996).

Factors that affect the survival of yeasts during storage are the degree of anaerobiosis, and the concentrations of organic acids. The presence of oxygen enhances survival and growth of yeasts during storage (Jonsson and Pahlow 1984; Donald et al.1995), whereas high levels of formic or acetic acid reduce survival during storage (Driehuis and Van Wikselaar 1996; Oude Elferink et al. 1999). Initial yeast activity appears to be enhanced in crops with a low initial pH (< 5), e.g. due to the addition of acid additives, and in crops with a high sugar content, e.g. potatoes, orange peels or sugar beets. These crops often result in silages high in ethanol and low in lactic acid (Henderson et al. 1972; Ashbell et al. 1987; Weinberg et al. 1988; Driehuis and van Wikselaar 1996). Silage additives developed to inhibit yeast activity are described in section 4.3.

3.2.2. Enterobacteria.

Enterobacteria are facultatively anaerobic. Most silage enterobacteria are regarded to be non-pathogenic. Nevertheless, their growth in silage is undesirable because they compete with the lactic acid bacteria for the available sugars, and in addition they can degrade protein. This protein degradation does not only cause a reduction in feeding value, but also leads to the production of toxic compounds such as biogenic amines and branched fatty acids. Biogenic amines are known to have a negative effect on silage palatability (Woolford 1984; McDonald et al. 1991; van Os and Dulphy 1996), especially in animals that are not yet accustomed to the taste (van Os et al. 1997). Moreover, the ammonia formed through proteolysis increases the buffer capacity of the ensiled crop, thus counteracting a rapid decrease of silage pH. A special characteristic of enterobacteria is their capability to reduce nitrate (NO_3) to nitrite (NO_2) under silage conditions. In silage nitrite can be degraded by enterobacteria to ammonia and nitrous oxide (N_2O), but it can also be chemically degraded to NO and nitrate

(Spoelstra 1985; 1987). With air NO is oxidized into a mixture of gaseous, yellow-brown nitrogen oxides (NO_2, N_2O_3, N_2O_4). Gaseous NO and NO_2 have a damaging effect on lung tissue, and can cause a disease with pneumonia-like symptoms known as "silo filler's disease" (Woolford 1984). To prevent animals from getting in contact with gaseous nitrogen oxides they should not be housed in buildings adjoining silos during silo filling or the first week of silage storage (O'Kiely et al. 1999). Despite the above mentioned problems, a little nitrite reduction is considered positive for silage quality, because the formed nitrite and NO are very effective inhibitors of clostridia (Woods et al. 1981, Spoelstra 1985).

Enterobacteria will not proliferate at low pH. Ensiling methods that induce a rapid and sufficient drop in silage pH will therefore help to decrease enterobacterial growth (McDonald et al. 1991).

3.2.3. Clostridia.

Clostridia are endospore-forming anaerobic bacteria. Many clostridia ferment carbohydrates as well as proteins, thus causing problems such as the reduction in feeding value and the production of biogenic amines, similarly as has been described for enterobacteria. Furthermore, clostridia in silage impair milk quality. This is due to the fact that clostridial spores can survive the passage through the alimentary tract of a dairy cow. Clostridial spores present in silage are transferred to milk, via feces and fecal contamination of the udder. The acid tolerant Clostridium tyrobutyricum is the most relevant species for the dairy industry. In addition to carbohydrate fermentation C. tyrobutyricum can degrade lactic acid to butyric acid, H_2 and CO_2 according to the following overall reaction:

$$2 \text{ lactic acid} \rightarrow 1 \text{ butyric acid} + 2\, H_2 + 2\, CO_2$$

This butyric acid fermentation does not only counteract the lactic acid fermentation in silage and cheeses, but it also is responsible for a significant gas production, causing a cheese defect called "late blowing" in hard and semi-hard cheeses such as Emmental, Grana, Gouda and Parmesan (Gibson 1965; Goudkov and Sharpe 1965, Klijn et al. 1995).

Some clostridia can cause serious health problems. An extremely toxic Clostridium sp. is C. botulinum. This organism can cause botulism, which can be deadly for cattle. Fortunately, C. botulinum has a limited acid tolerance, and does not grow in well-fermented silage. Incidences of animal botulism caused by silage contaminated with C. botulinum could nearly always be attributed to the presence of a cadaver (e.g. mouse, bird, etc.) in the silage (Kehler and Scholz 1996).

A typical "clostridial silage" is characterized by a high butyric acid

content of more than 5 g/kg dry matter, a high pH (over pH 5 in low dry matter silages), and a high ammonia and amine content (Voss 1966; McPherson and Violante 1966). Ensiling methods that cause a rapid and sufficient drop in silage pH will help to prevent the development of a "clostridial silage", because similar to enterobacteria, clostridia are inhibited at low pH. Furthermore, clostridia are more susceptible to a low availability of water (i.e. a low water activity (a_w)) than lactic acid bacteria (Kleter et al. 1982; 1984, Huchet et al. 1995). For this reason decreasing the a_w-value of a crop, e.g. by wilting to a higher dry matter content, can be a way of selectively inhibiting clostridia (Wieringa 1958). Finally, clostridia will also be inhibited by nitrite and NO or compounds that are degraded in silage to nitrite and NO (Spoelstra 1983; 1985).

3.2.4. Acetic acid bacteria.

Acetic acid bacteria are obligate aerobic, acid-tolerant bacteria. Thus far all acetic acid bacteria that have been isolated from silage belonging to the genus Acetobacter (Spoelstra et al. 1988). The activity of Acetobacter ssp. in silage is undesirable because they can initiate aerobic deterioration, due to the fact that they are able to oxidize lactate and acetate to carbon dioxide and water. Generally, yeasts are the main initiators of aerobic spoilage, and acetic acid bacteria are absent, or play only a minor role. However, for whole crop corn silages there is evidence that acetic acid bacteria alone can initiate aerobic deterioration (Spoelstra et al. 1988). Furthermore, selective inhibition of yeast also can increase proliferation of acetic acid bacteria in silage (Driehuis and van Wikselaar 1996).

3.2.5. Bacilli.

Bacilli are like clostridia endospore-forming rod shaped bacteria.

Nevertheless, they can easily be distinguished from clostridia due to the fact that they are (facultative) aerobes, whereas all clostridia are obligate anaerobes (Claus and Berkeley 1986; Cato et al. 1986). Facultative aerobic bacilli ferment a wide range of carbohydrates to compounds such as organic acids (e.g., acetate, lactate, and butyrate) or ethanol, 2,3-butanediol, and glycerol (Claus and Berkely 1986). Some specific Bacillus sp. are able to produce antifungal substances, and have been used to inhibit aerobic spoilage of silage (Phillip and Fellner 1992; Moran et al. 1993). Except for these specific strains, the proliferation of bacilli in silage is generally considered undesirable. Not only are bacilli less efficient lactic and acetic acid producers than lactic acid bacteria (McDonald et al. 1991), they can also enhance (later stages of) aerobic deterioration (Lindgren et al. 1985; Vreman et al, in press). Furthermore, high numbers of Bacillus spores in raw milk have been associated with high spore numbers in fresh cow feces (Waes 1987; te Giffel et al. 1995). In seems very plausible that bacillus spores

are transferred from silage to milk via feces similar to clostridial spores (Vreman et al, in press). Psychrotrophic B. cereus spores are considered to be the most important spoilage organism of pasteurized milk (te Giffel 1997). High numbers of these (psychrotrophic) B. cereus spores have been found in silages (Labots et al. 1965; te Giffel et al. 1995).

To decrease bacillus growth in silage, storage temperatures should not be too high (Gibson et al. 1958) and air ingress should be minimized (Vreman et al, in press). In addition, initial contamination of fresh plant material with soil or manure should be prevented (McDonald et al. 1991; Rammer et al. 1994).

3.2.6. Molds.

Molds are eucaryotic microorganisms. A mold-infested silage is usually easily detected by the large filamentous structures and colored spores that many species produce. Molds develop in parts of the silage were

(a trace of) oxygen is present. During storage, this is usually only in the surface layers of the silage, but during aerobic spoilage (phase 4) the whole silage can become moldy. Mold species that regularly have been isolated from silage belong to the genera Penicillium, Fusarium, Aspergillus, Mucor, Byssochlamys, Absidia, Arthrinium, Geotrichum, Monascus, Scopulariopsis and Trichoderma (Pelhate 1977; Woolford 1984; Frevel et al. 1985; Jonsson et al. 1990; Nout et al. 1993). Molds do not only cause a reduction of feed value and palatability of the silage, but can also have a negative effect on human and animal health. Mold spores are associated with lung damage and allergenic reactions (May 1993). Other health problems are associated with mycotoxins that can be produced by molds (Oldenburg 1991; Auerbach 1996). Depending on the type and amounts of toxin present in the silage heath problems can range from minor digestive upsets, small fertility problems, and reduced immune function, to serious liver or kidney damage, and abortions (Scudamore and Livesey 1998). Some important mycotoxin

producing mold species are Aspergillus fumigatus, Penicillium roqueforti, and Byssochlamys nivea. Especially P. roqueforti, a species which is acid tolerant and can grow at low levels of oxygen and high levels of CO_2, has been detected as the predominant species in different types of silages (Lacey 1989; Nout et al. 1993; Auerbach et al. 1998; Auerbach 1996). There is still uncertainty under which conditions mycotoxins are formed in silage. A heavily infested silage does not necessarily contain high amounts of mycotoxins, and not all types of mycotoxins a mold species can produce have to be present in one silage (Nout et al. 1993; Auerbach 1996). For Aflatoxin B1, a mycotoxin of Aspergillus flavus, it is known that in can be transferred from animal feed to milk. However, thus far it is unknown if a similar transfer can occur with mycotoxins from P. roqueforti, or A. fumigatus (Scudamore and Livesey 1998).

Ensiling methods that minimize air ingress (e.g. good compaction and

covering of the silo), and additives that prevent initiation of aerobic spoilage, will help to prevent or limit mold growth.

3.2.7. Listeria.

Members of the genus Listeria are aerobic or facultatively anaerobic. Regarding silage quality the most important Listeria spp. is the facultative anaerobic L. monocytogenes, because this species is a pathogen to various animals and man. Especially animals with a suppressed immune system (e.g. pregnant females and neonates) are susceptible to L. monocytogenes infections (Jones and Seeliger 1992). Silage contaminated with L. monocytogenes has been associated with fatal cases of listeriosis in sheep and goats (Vazquez-Boland et al. 1992; Wiedmann et al. 1994). In addition, Sanaa et al. (1993) have identified poor quality silage as one of the main sources of contamination of raw milk by L. monocytogenes. Growth and survival

of Listeria in silage are determined by the degree of anaerobiosis, and the silage pH. L. monocytogenes can tolerate a low pH of 3.8-4.2 for long periods of time only if (small amounts) of oxygen are present. Under strictly anaerobic conditions it is rapidly killed at low pH (Donald et al. 1995). Silages that have a higher chance of aerobic surface spoilage, such as big bale silages seem, to be particular liable to Listeria contamination (Fenlon et al. 1989). L. monocytogenes generally does not develop in well fermented silages with a low pH. Thus far the most effective method to prevent growth of L. monocytogenes is to keep the silage anaerobic (McDonald et al. 1991).

4. Silage additives.

In the past decade it has become increasingly common to use silage additives to improve the ensiling process. The choice of additives

appears to be sheer limitless if one looks at the large number of chemical and biological silage additives that are commercially available. The UKASTA Forage Approval Scheme of the UK for example lists more than 80 products (Rider 1997). Fortunately, the choice of a suitable additive is less complicated than it seems, because the modes of action of most additives fall within a few categories (Table 1).

Table 1, Categories of silage additives (adapted from McDonald et al. 1991).

Additive category	**Selection of Active ingredients**	**Remarks**
Fermentation stimulants	Lactic acid bacteria Sugars (molasses) Enzymes	May impair aerobic stability
Fermentation		

inhibitors	Formic acid* Lactic acid* Mineral acids Nitrite salts Sulfite salts Sodium chloride	Formic acid* Lactic acid* Mineral acids Inhibition of clostridia
Aerobic deterioration inhibitors	Lactic acid bacteria Propionic acid* Benzoic acid* Sorbic acid*	
Nutrients	Urea Ammonia Minerals	Can improve aerobic stability Can improve aerobic stability
Absorbents	Dried sugar beet pulp Straw	

or corresponding salt

Between products of one category differences exist in product properties such as general effectiveness, suitability for certain crop type, and ease of handling and application. These factors, together with the price and availability, will determine what product will be the most adequate for a specific silage. A drawback of some of the chemical additives is that they can be corrosive to the equipment used, and/or can be dangerous to handle. The biological additives are non-corrosive and safe to handle, but they can be costly. Furthermore, their effectiveness can be less reliable, since it is based on the activity of living organisms. Proper storage of these biological additives by the manufacturer, retailer and farmer is of vital importance. Despite these disadvantages, in Europe and the USA bacterial inoculants have nowadays become the most commonly used additives for corn, and grasses and legumes that can be wilted to above 300 g DM kg^{-1} (Bolsen

and Heidker 1985; Pahlow and Honig 1986; Bolsen et al. 1995; Kung 1996; Weinberg and Muck 1996). In the Netherlands the absolute as well as the relative amount of silages treated with bacterial inoculants has increased in the past 4 years. Last year 13.7 % of all grass silages in the Netherlands was ensiled with an additive, of these treated silages 31 % was treated with an inoculant, 37% with molasses and 29% with fermentation inhibitors (Hogenkamp 1999).

4.1. Additives improving silage fermentation.

Assuming good harvesting and ensiling techniques initial silage fermentation (phase 2) can still be sub-optimal. This can be due to a lack of sufficient numbers of suitable lactic acid bacteria or a lack of sufficient amounts of suitable water-soluble carbohydrates, or both.

The amount of water-soluble carbohydrates necessary to obtain sufficient fermentation depends on the dry matter content and the

buffer capacity of the crop. Weissbach and Honig (1996) characterized the relation between these factors as follows,

FC = DM (%) + 8 WSC/BC FC = fermentation coefficient

DM = dry matter content

WSC = water-soluble carbohydrates

BC = buffer capacity

Forages with insufficient fermentable substrate or too low a dry matter content have a FC < 35. In these forages sufficient fermentation can only be ding acids.

Silage additives inhibiting silage fermentation can reduce clostridial spore counts. In wilted grass silages a decrease in spore counts by a factor 5 to 20 has been observed. A similar decrease in spore counts could be obtained by adding molasses, a fermentation stimulant. To

inhibit clostridial growth the most effective fermentation inhibitors appear to be additives based on formic acid, hexamethylene and nitrite (Hengeveld 1983; Corporaal et al. 1989; van Schooten et al. 1989; Jonsson et al. 1990; L�ttem�e and Lingvall 1996).

4.3. Additives inhibiting aerobic spoilage.

Is clear that to inhibit aerobic spoilage, spoilage organisms, in particularly the ones causing the onset of deterioration (i.e. yeasts and acetic acid bacteria) have to be inhibited in their activity and growth. Some additives which have proven to be effective in this respect include chemical additives based on volatile fatty acids such as propionic and acetic acid, and biological additives based bacteriocin producing micro-organisms such as lactobacilli and bacilli (Woolford 1975a; McDonald et al 1991; Phillip and Fellner 1992; Moran et al. 1993; Weinberg and Muck 1996).

Furthermore, it is known that sorbic acid and benzoic acid have a strong antimycotic activity (Woolford 1975b; McDonald et al. 1991). Recently, it was discovered that Lactobacillus buchneri is a very effective inhibitor of aerobic spoilage. The inhibition of spoilage appears mainly due to the capability of L. buchneri to anaerobically degrade lactic acid to acetic acid and 1,2-propanediol, which in turn causes a significant reduction in yeast numbers (Driehuis et al. 1997; Oude Elferink et al. 1999; Driehuis et al., in press). This reduction in yeast numbers is in agreement with the finding that volatile fatty acids such as propionic acid and acetic acid are much better inhibitors of yeasts than lactic acid is, and that mixtures of lactic acid and propionic and/or acetic acid have a synergistic inhibitory effect (Moon 1983). The results of Moon (1983) also explain why biological inoculants that promote homofermentative lactic acid fermentation, in most cases do not improve, or even decrease, aerobic stability (Weinberg and Muck 1996; Oude Elferink et al. 1997).

Biological additives based on the propionate producing propionibacteria appear to be less suitable for the improvement of silage aerobic stability, due to the fact that these bacteria are only able to proliferate and produce propionate if the silage pH remains relatively high (Weinberg and Muck 1996).

4.4. Additives used as nutrients or absorbents.

Certain crops are deficient in essential dietary components for ruminants. The nutritional quality of these crops can be improved by supplementation with specific additives at the time of ensiling. Additives that have been used in this respect are ammonia and urea to increase the crude and true protein content of the silage, and limestone and $MgSO_4$ to increase the calcium and magnesium contents. The above mentioned additives generally have no beneficial effect on silage fermentation, but urea and ammonia can improve the

aerobic stability of silage (Glewen and Young 1982; McDonald et al. 1991).

Absorbents are used in crops with a low dry matter content to prevent excessive effluent losses. Good results have been obtained with dried pulps such as sugar beet pulp and citrus pulp. Straw can also be utilized, but has a negative effect on the nutritive value of the silage (McDonald et al. 1991).

4.5. Combined additives.

Most commercial additives contain more than one active ingredient in order to have a high efficacy and a broad range of applicability. Very popular are for example combinations of inoculants stimulating homofermentative lactic acid fermentation together with sugar releasing enzymes, or combinations of fermentation and aerobic deterioration inhibiting chemicals such as formic acid, sulfite salts and

propionic acid (Rider 1997; Arbeitsgemeinschaft der norddeutschen Landwirtschafskammer 1999).

New additives are currently being developed that decrease the negative effect of homofermentative lactic acid fermentation on aerobic stability. Promising results have been obtained by combining homofermentative or facultative heterofermentative lactic acid bacteria with chemicals such as ammonium formate and sodium benzoate (Kalzendorf 1992; Bader 1997), or by combining facultative heterofermentative lactic acid bacteria with the obligate heterofermentative L. buchneri.

5. Silage fermentation in tropical silages.

Ensiling of forage crops or industry by-products could make an

important contribution to the optimization of tropical and sub-tropical animal production systems, but thus far it has not yet been widely applied (Wilkins et al. 1999). This is not only due to the low prices for animal products, the low levels of mechanization, and the high costs of silo sealing materials, but also due to the lack of ensiling experience. More research is needed to address the specific problems associated with tropical silages. Tropical grasses and legumes have for example a relatively high concentration of cell wall components and the low level of fermentable carbohydrates compared to temperate forage crops (Catchpoole and Henzell 1971; Jarrige et al. 1982). Furthermore, on average storage temperatures in tropical climates are higher than in temperate climates, which might give bacilli a competitive advantage over lactic acid bacteria (Gibson et al. 1958). In addition, it has to be taken into account that some silo sealing materials cannot withstand intense sunlight, and thus might impair the aerobic stability of the silage. Nevertheless, it seems likely that ensiling technologies from

temperate climates can be modified for tropical conditions.

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