The nutritive value of laboratory ensiled lablab
(*Lablab purpureus*) and pearl millet (*Pennisetum americanum*)

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Abstract

A laboratory study was conducted with field-grown pearl millet (*Pennisetum americanum*) and lablab (*Lablab purpureus*) to examine the effects of addition of lablab in varying amounts on the quality of millet silage. Combinations compared were: 0:100, 15:85, 30:70 and 50:50 mixtures of lablab and millet, respectively. All silage treatments contained similar concentrations of dry matter, organic matter and ether extract. Incorporation of lablab led to a small increase in crude protein, crude fibre and nitrogen–free extract. All silages showed low crude protein concentrations and would barely supply N requirements for maintenance of cattle. The lactic acid content of the silage increased as the proportion of lablab in the mixture increased. The silage pH values, which ranged from 4.1–4.5, showed that all lablab — millet mixtures were adequately fermented with favourable aroma and colour. The Ca and P concentrations increased with higher incorporation of lablab, while the converse was the case with Mg, Na, K and S. Mineral supplements, in particular S and Na, would need to be fed if these silages constituted a high proportion of the diet of cattle, especially lactating cows. Field studies are required to determine if these results can be duplicated on a practical scale, while feeding studies with ruminants will determine the acceptability of the silages and animal performance.

Introduction

In the northern part of Nigeria, where the grazing season is limited and pasture production fluctuates widely, silage making offers a means of improving the utilisation of pastures. As reported by Cowan *et al.* (1993), forage growth on tropical and subtropical perennial pastures often exceeds the feed requirements of dairy herds during summer and early autumn. These authors estimated that the level of utilisation of the available pasture was 30–50%, leading to considerable wastage.

There has been considerable debate on whether the surplus forage in summer can be conserved and used to partly fill the winter-spring feed gap (Kaiser *et al.* 1993). Ensiling has been suggested as the preferred conservation option as climatic conditions during the period when the surplus exists are considered unsuitable for haymaking.

Given the generally poor preservation of tropical pasture as silage, various compounds such as formaldehyde and acids have been used as additives in making silages from grasses (Morrison 1979; Thompson *et al.* 1981). These compounds have been a primary mechanism for improving the feeding value of silage. Pearl millet (*Pennisetum americanum*) and lablab (*Lablab purpureus*) are promising forage crops with high potential for integration into Nigerian livestock production systems. The crops are highly adapted to a range of agronomic conditions with fodder yields of 2.7–7.7t/ha in locations varying from the semi-arid to the subhumid zone, where rainfall varies between 600–1100mm (Agishi 1985). Both crops have the characteristics of easy establishment under local conditions, rapid growth and high yields. Umoh *et al.* (1981) showed incremental benefits in milk, beef and small ruminant production from using maize (*Zea mays*), millet, sorghum straws, gamba (*Andropogon gayanus*) and elephant grass (*Pennisetum purpureum*)

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silage as a means of enriching fodder and its optimum conservation. Legume forages have been found to provide large responses in milk production, while milk production from *L. purpureus* has been found to be higher than from grasses (Hamilton *et al.* 1970). In a different trial, Catchpoole and Henzell (1971) observed that silage made from *L. purpureus* provided only maintenance requirements of stock although DM digestibility was 56 percent and crude protein digestibility 67 percent.

Production responses would be expected from incorporating *Lablab purpureus* when making silage from millet. Umoh (1975), in a comparison of maize-mucuna (*Mucuna pruriens*) silage and elephant grass silage for milk production, found that cows on the maize-mucuna silage produced significantly more milk than cows on elephant grass silage. In studies to measure milk yields of cows fed on diets based on maize silage or sorghum-soyabean silage, Baxter *et al.* (1984) found higher milk yields on the maize silage while Harbers *et al.* (1992a) found similar yields on the two silages. Morris and Levitt (1968) examined the intake and digestibility of lablab ensiled immediately after harvesting, or following wilting for 2 or 3 days with and without 3% molasses. All silages were satisfactory and were readily eaten by sheep.

To obtain preliminary data on the quality of silage made from mixtures of millet and lablab, a laboratory study was conducted.

**Materials and methods**

The study was conducted at the National Animal Production Research Institute experimental farm at Shika located within the grid (11°–11°13′N, 6°55′–7°33′E) in the subhumid zone of Nigeria. Mean annual rainfall varies from 700–1300mm with a long-term average of 1050mm. Approximately 95 percent of the rainfall occurs during May–October. The highest mean maximum temperature of 36°C is recorded in April while the lowest mean minimum temperature of about 11.5°C occurs in December–January (Kowal and Knabe 1972).

**Crop establishment**

The millet and lablab seeds were sown on June 1 and July 30, 1999, respectively. Seeds of millet were drilled into a clean seedbed following single ploughing and harrowing at a seeding rate of 20 kg/ha and fertilised with NPK fertiliser (27:13:13) at the rate of 50kg/ha. Lablab was also drilled into a clean seedbed at the rate of 20 kg/ha. Prior to planting of lablab, single superphosphate fertiliser was applied at the rate of 20 kg/ha. Plots of both lablab and millet were weeded twice after planting, with hand hoes. The common weeds found in the plots were *Elusine indica*, *Cassia tora*, *Tephrosia* spp. and *Amaranthus spinosa*.

**Silage preparation**

Samples of forage were cut for chemical analysis when lablab was at 50% flowering and millet at the milk stage. On October 15, 1999, 3 weeks later, when millet was at the soft dough stage of maturity and lablab at the podding stage, both crops were cut and wilted in the field for 24 h. Samples of the wilted material were taken for dry matter determination. The harvested material was chopped to 2cm with a forage chopper and ensiled in 1.5-litre glass jars (Weck, Wehr-Olfingen, Germany), equipped with lids, which allowed only the exit of gas. All treatment mixtures were ensiled on the same day and the jars were stored at ambient temperature (25–27°C) for 60 days to allow complete fermentation to occur.

**Sampling**

Following the 60-day fermentation period, each glass jar was opened and the contents were visually examined for colour and the aroma was recorded. Composite samples (450g) of silage were obtained by selecting material (150g) from the top, middle and bottom of each glass jar, which was bulked immediately and mixed thoroughly. The pH of samples of the silages was measured immediately after removal from the jars. The composite samples were placed in air-tight sealed jars and stored in a deep-freeze (−5°C) until required for analysis.
Chemical analysis

Dry matter concentration in the fresh material cut 3 weeks before ensiling was determined by oven-drying for 48h at 60°C. Ash concentration was obtained by ashing the dried samples in a Gallenkamp Muffle furnace at 600°C for 30 min. Dry matter levels in the silage samples were determined by the toluene distillation method as described by Dewar and McDonald (1961). Organic matter (OM) was obtained by difference between dry matter and ash concentrations of the silage.

Lactic acid was determined by the spectrophotometric method of Baker and Summerson (1941). AOAC (1984) procedures were used for determination of proximate constituents in the silage samples. Total-N was determined in fresh silage by macro-Kjeldahl procedures (AOAC 1984).

Statistical analysis

Analysis of variance and Duncan’s Multiple Range test (Snedecor and Cochran 1976) were performed to test differences.

Results

The chemical composition of the fresh pearl millet and lablab forages cut 3 weeks before ensiling is shown in Table 1. Millet and lablab had CP percentages of 10.2 and 17.5%, respectively.

Addition of lablab to millet led to an increase (P < 0.05) in crude fibre (CF) and nitrogen-free extract (NFE) concentrations in the pre-ensiled mixtures. Concentrations of all components increased progressively with each increment of lablab, although differences were not always significant.

The chemical composition of the silages is shown in Table 2. The only chemical component that varied markedly between fresh fodder and silage was crude protein (CP), which was much lower in the silage. The corrected values for dry matter obtained in the silages (range 25.4–26.8%) (toluene distillation method) were slightly higher than those obtained by oven-drying of the fresh samples. As with the fresh material, inclusion of lablab resulted in an increase (P < 0.05) in organic matter (OM), CP

Table 1. Chemical composition of fresh pearl millet and lablab forages and their mixtures cut 3 weeks before ensiling.

<table>
<thead>
<tr>
<th>Lablab</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>50</th>
<th>100</th>
<th>s e m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet</td>
<td>100</td>
<td>85</td>
<td>70</td>
<td>50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter (%)</td>
<td>23.0a</td>
<td>24.1a</td>
<td>24.7a</td>
<td>25.4a</td>
<td>23.4a</td>
<td>±2.41</td>
</tr>
<tr>
<td>Silica-free ash (% DM)</td>
<td>1.7a</td>
<td>2.0a</td>
<td>2.1a</td>
<td>2.5a</td>
<td>1.8a</td>
<td>±0.35</td>
</tr>
<tr>
<td>Crude protein (% DM)</td>
<td>10.2a</td>
<td>10.4a</td>
<td>11.0a</td>
<td>11.8a</td>
<td>17.5b</td>
<td>±0.51</td>
</tr>
<tr>
<td>Ether extract (% DM)</td>
<td>1.0a</td>
<td>1.2a</td>
<td>1.3a</td>
<td>1.5a</td>
<td>1.4a</td>
<td>±0.24</td>
</tr>
<tr>
<td>Crude fibre (% DM)</td>
<td>27.8b</td>
<td>28.0b</td>
<td>29.5a</td>
<td>30.7a</td>
<td>29.8a</td>
<td>±1.17</td>
</tr>
<tr>
<td>Nitrogen-free extract (% DM)</td>
<td>48.5a</td>
<td>50.3b</td>
<td>51.5b</td>
<td>52.3b</td>
<td>46.3a</td>
<td>±0.54</td>
</tr>
</tbody>
</table>

1 Within rows, values followed by different letters are significantly (P < 0.05) different.

Table 2. Chemical composition of silages made from pearl millet and lablab mixtures.

<table>
<thead>
<tr>
<th>Lablab</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>50</th>
<th>s e m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Millet</td>
<td>100</td>
<td>85</td>
<td>70</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>Corrected DM (%)</td>
<td>26.5a</td>
<td>26.3a</td>
<td>26.8a</td>
<td>25.4a</td>
<td>±1.41</td>
</tr>
<tr>
<td>Organic matter (% DM)</td>
<td>87.4b</td>
<td>88.5a</td>
<td>88.8a</td>
<td>89.4a</td>
<td>±1.10</td>
</tr>
<tr>
<td>Crude protein (% DM)</td>
<td>5.2b</td>
<td>5.5b</td>
<td>6.3a</td>
<td>6.5a</td>
<td>±0.74</td>
</tr>
<tr>
<td>Ether extract (% DM)</td>
<td>1.2a</td>
<td>1.3a</td>
<td>1.5a</td>
<td>1.7a</td>
<td>±0.37</td>
</tr>
<tr>
<td>Crude fibre (% DM)</td>
<td>27.7b</td>
<td>31.3a</td>
<td>33.3a</td>
<td>35.2a</td>
<td>±2.10</td>
</tr>
<tr>
<td>Nitrogen-free extract (% DM)</td>
<td>48.2c</td>
<td>50.1b</td>
<td>52.4a</td>
<td>53.2a</td>
<td>±0.73</td>
</tr>
<tr>
<td>Lactic acid (% DM)</td>
<td>4.3c</td>
<td>4.5b</td>
<td>4.6b</td>
<td>5.8a</td>
<td>±0.03</td>
</tr>
<tr>
<td>pH</td>
<td>4.3a</td>
<td>4.4a</td>
<td>4.5a</td>
<td>4.1a</td>
<td>±0.40</td>
</tr>
</tbody>
</table>

1 Within rows, values followed by different letters are significantly (P < 0.05) different.
and CF of the silages. The pH levels in all silage samples were similar (range 4.1–4.5). Lactic acid levels in the silages increased from 4.3% in the straight millet (Treatment A) to 5.8% in Treatment D (50:50 mixture).

Table 3 shows the mineral composition of the silages. Levels of calcium and P increased (P < 0.05) as level of lablab in the mixture increased, while levels of magnesium, sodium, potassium and sulphur decreased (P < 0.05).

Silages from Treatments A, B and C were similar, having a sweet aroma and pale yellow colour. Silage from Treatment D with 50 percent legume incorporation was yellowish-green and had a very sweet aroma (Table 4).

Discussion

The quality of our silage samples was comparable with that obtained with grain sorghum-soybean mixtures by Harbers et al. (1992b) and maize-soyabean (*Glycine max*) mixtures by Kaiser et al. (2001). The former authors observed that the CP content of mixed silage was higher than that of sorghum silage even though there were only minor changes in digestibility. In a similar trial, Morris and Levitt (1968) worked with *Dolichos lablab* and produced silages with a CP content of approximately 190 g/kg DM, but the digestibility in sheep was found to be low (OMD < 60%). Our results are also comparable with those of Awolumate and Olubajo (1982) for silages made from mixtures of citrus wastes and elephant grass.

All silages appeared acceptable on the basis of colour and aroma but the quality, as indicated by chemical analyses, was disappointing. This applied particularly to crude protein concentrations.

The low protein concentrations (5.2–6.5%) would not provide the maintenance protein requirements for cattle (NRC 1976) and were well below the 10.8% crude protein recommended for production in beef cattle. While analyses of fresh material cut 3 weeks before ensiling suggested a much higher protein concentration in lablab than in millet, this was not reflected in the crude protein levels in the silages, which were produced. The substantial loss of crude protein during the ensiling process could be linked to protein degradation, which has been documented during fermentation of many legumes (McKersie 1985; Charmley and Thomas 1987; Albrecht and Muck 1991), or to low DM concentration in the crop at ensiling (Muck 1980).
Kallah et al. (1999) examined hay and silage made from Colombus grass (*Sorghum almum*) and found much lower CP concentrations in the silage than in hay made at the same stage of growth. They attributed the lower CP levels to proteolysis before full fermentation occurred during the ensiling process. It is also likely that the interval of three weeks which elapsed between cutting of the fresh sample of lablab at 50% flowering and the ensiling operation at podding contributed to the decline in CP levels. If cattle were to be fed predominantly on these silages, it would be necessary to provide protein supplements. Even those silages, which contained 50% lablab, would barely provide a maintenance level of protein.

Attempts have been made in the past to raise protein concentrations in grass silages by incorporating various legumes. In a review of feeding systems for dairy cattle in northern Australia, Kaiser et al. (1993) examined the production of mixed crops such as maize-soyabean and grain sorghum (*Sorghum* sp.)-soyabean for silage production. However, the published literature indicated that DM yields of soyabean crops were considerably lower than those of the maize/sorghum crops, leading the authors to conclude that there was little evidence that incorporating soyabean with maize or grain sorghum will increase animal production from the crop. They also suggested that attempts to raise the protein concentration in high energy silages such as maize or grain sorghum by intercropping with soyabeans do not appear to be successful in terms of yield, silage quality (CP and digestibility) and milk production.

While both crops in our study have high growth rate and yield per unit area of land, the yield of the legume is lower than that of millet. Amodu et al. (2001) documented yields of 5.6, 7.4 and 7.7 t/ha DM for millet cut at flowering, milk and dough stages, respectively. In the same environment, Amodu et al. (2002) reported lower yields (range of 2.7–3.8 t/ha DM) for lablab planted in July. If these species are grown separately or as a mixture there will be some trade-off in yield compared with growing pure stands of millet. This will need to be weighed up against the limited improvement in quality of the resulting forage. Since a marked reduction in yield will result if lablab is substituted for millet, benefits like N addition to the system through biological nitrogen fixation by the legume would need to be significant.

Crude fibre concentration in the silages was significantly higher when the mixtures were ensiled (Tables 1 and 2). With the exception of silage from Treatment A, which showed a decrease of about 0.4% CF, when compared with the fresh sample, increases of 10.5, 11.4 and 12.8% crude fibre were observed in Treatments B, C and D, respectively.

Mineral concentrations in the silages were variable. Sodium concentrations (0.10–0.15%) were similar to the levels recommended for beef cattle (0.06–0.10%; NRC 1984), below those for dairy cattle (0.18%; NRC 1978) and above those for sheep (0.04–0.10%; NRC 1976). Lactating dairy cows would certainly require a salt supplement if fed a ration containing high levels of these silages.

Concentrations of Ca and P in the silages were acceptable. The critical level of Ca in the diet has been set at 0.30% Ca (NRC 1976), and Ca concentrations in our silages approached this level (0.25–0.30%), with the higher levels where more lablab was included. Phosphorus concentrations ranged from 0.27–0.41% P (Table 3), which exceeded the critical values of 0.25% P, suggested by Bourn and Milligan (1984), and 0.18% (NRC 1976) for cattle and far exceeded the recommendation of 0.12% P of Little (1980). The Ca:P ratios in these silages fell in the range 1:2 to 2:1 suggested as desirable by Underwood (1966) for ruminants.

All silages would supply adequate K to meet the requirements of the various classes of ruminants (0.05–0.12% K). However, sulphur concentrations were quite low and sulphur supplements should be fed if these silages constituted a high percentage of the diet.

There is evidence that fermentation patterns in silages from tropical pastures may be different from those in temperate species. Acetate fermentation, often associated with high ammonia-N concentrations, appears to be more prevalent with tropical forages than the desired lactate fermentation (Kaiser 1984). The concentration of water-soluble carbohydrates in the crops could be a contributing factor (Kaiser 1984; McDonald et al. 1991). These authors have recorded lower concentrations of water-soluble carbohydrates in tropical forage crops, and levels may be inadequate for a lactate fermentation, especially when unwilted forage is ensiled. A good way of
combating this loss is to use technologies such as rapid wilting of the crops and silage additives to improve the fermentation process. Rapid wilting to a DM content of 300–450 g/kg has been suggested by Kaiser et al. (1993) as desirable for successful ensiling of tropical pastures. Although the dry matter concentration in the material we ensiled was only 250 g/kg following wilting, the appearance and aroma of the silage samples were quite acceptable. However, the lactic acid concentrations in our silages were only 43–58 g/kgDM, compared with the 62–80 g/kgDM in various sorghum silages cited by Kaiser et al. (1993).

This study has shown that silages, which appear satisfactory, can be made under laboratory conditions from mixtures of millet and lablab. However, the protein concentrations in the silage were low despite moderate levels in the forage prior to harvesting. Silage of this quality is useful only as a roughage source and not as a protein supplement. Further studies are warranted to see if these results can be repeated under field conditions and to endeavour to minimise the loss in protein concentration that occurs during the ensiling process, as losses of the magnitude reported in this study are unacceptable. The effective utilisation of these silages in feeding systems in the region, in terms of acceptability to livestock and animal performance, requires further research.

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