The effects of feeding mixed cereal-tree forage legume silages on milk yield and composition in lactating dairy cows.

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Abstract

Mixed legume silages in the sub-tropics can play an important role in providing good quality supplementary feed to lactating animals during the dry season. The objective of this study was to assess the nutritive value of *A. boliviana* and *L. leucocephala*-maize silages as partial substitutes for commercial dairy meal in lactating Holstein dairy cows. The coppice growth of tree forage legumes were ensiled together with maize harvested at medium-dough stage in a 50:50 ratio (w/w). The crude protein content of the maize-legume silages ranged from 176 to 209 g/kg DM and was greater than that of maize silage, 71 g/kg DM. The neutral detergent fibre content of the silages was not significantly different with values of 608, 658 and 603 g/kg DM for bagged maize, maize-leucaena and maize-acacia silages, respectively. The milk yield was significantly higher in cows fed maize-acacia, 15.7 kg/d, and maize silages, 17.0 kg/d, compared to animals on mixed maize-leucaena silage, 14.1 kg/d. However the milk composition in terms of butterfat, lactose, protein and total solids was not significantly different across the treatment diets. The content of butterfat, protein, lactose and total solids were 3.57 to 3.72 %, 3.36 to 3.45 %, 4.48 to 4.58 % and 12.47 to 12.74 %, respectively. It is concluded that mixed silages can be used to partially replace commercial feed supplements without loss in milk yield or quality.

Keywords: *Acacia boliviana, Leucaena leucocephala,* milk composition, silage.

Introduction

In the tropics and sub-tropics there is a general shortage of natural grazing during the dry season resulting in high use of commercial feeds in livestock production during this period. Panditharatne et al (1986) highlighted this phenomenon of lack of all year round supply of good quality on-farm forages and indicated that it was one of the major limiting factors to improved milk yield in the tropics. In the smallholder dairy sector of Zimbabwe commercial feeds account for over 60 % of the total production costs (ARDA, 1999). In this regard dairy producers would benefit if the amounts of commercial feeds were reduced in their feeding systems without a decline in yield and quality of milk.

Traditionally silage has been made from cereals and grasses whilst legume silages have some potential (Belibasakis et al, 1997). The cereal

silages are rich in energy but low in protein. Silages prepared from tropical legumes alone are of low quality and are characterised by high pH, ammonia and acetic acid (Moss et al., 1984). Titterton et al, (1997) found that the protein content of the maize silage could be improved significantly by ensiling it together with tree forage legumes. The objective of this study was to assess the effect of *A. boliviana* and *L. leucocephala*-maize silages as partial substitutes for commercial dairy meal on milk yield and composition in lactating dairy cows.

Materials and Methods

Crops and harvesting

The forage-tree legumes (FTLs) used in this experiment were *Acacia boliviana* (Acacia) and *Leucaena leucocephala* (Leucaena) and the material used came from coppices of the 1999 harvests. The coppices were cut 0.7 m high when more than 25 % of the coppices were at flowering stage. The leaves were stripped by hand from the branches and twigs. A long season white maize variety, SC709, was used. The crop was managed in line with a commercial maize crop in terms of fertilizer application and weeding as well as pest and disease control. The maize was harvested a medium-dough stage. Hand harvesting was used and a motorised chuff cutter was used to chop the maize into pieces of 15 cm long.

Ensilage process

Ensilage was done in 50 kg plastic bag silos (Titterton et al, 1997). Five kilograms of freshly chopped maize was thoroughly hand mixed with five kilograms of the respective freshly cut leaves of the forage tree legume (FTL). The mixed forages were then packed in the plastic bags and compacted by hand to exclude as much air as possible and then tied by a string ensuring air-tightness. The material was left to incubate in a room for seven weeks before samples were taken for laboratory analyses. At the same time, maize from the same crop was ensiled in a bunker silo. The maize silage provided the basal diet for the trial animals.

Samples preparation

Samples of freshly milled maize and mixed maize-legume material were taken for laboratory analyses. After a seven-week incubation period three bags of each of the respective silages were randomly selected, opened and thoroughly mixed before three two-kilogram samples were taken for laboratory analyses.

Ration formulation

Individual animal rations were formulated to give an overall CP content of 130 g/kg DM and energy concentration of 11.0 MJ/kg ME. The bunker silage provided the basal diet for the experimental animals. A commercial lactating meal (19.6 % CP and 13 MJ/kg ME) was used to balance the rations for overall CP and energy content. The diets consisted of 10 kg treatment silage, 20 kg of basal maize silage (from the bunker) and 6.5 to 10.5 kg of a commercial lactating meal.

Animals and treatment allocation

Twelve Holstein cows with a mean of 610 71 Kg live weight and all in mid-lactation (days in milk 166 27) were used in the study. The animals were arranged into four groups of three animals each according to parity. The three cows in each group were randomly allocated to one of the three treatment silages namely maize (control), maize-leucaena and maize-acacia. All the experimental animals were then randomly allocated to individual feeding troughs in the feeding shed.

Feeding management

The cows were given three meals per day at 06:00, 12:00 and 17:00 hours for a period of 21 days of which 14 days were for adaptation followed by seven days of data collection. The meal was mixed with the silage to prevent excessive selection against the roughages.

The apparent intake was calculated as the difference between the amount offered and the refusals for each meal. The animals were given access to water in-between meals every day. Daily milk yields were recorded during the morning and evening milking sessions.

Milk samples

Milk sampling was done twice per week during morning and afternoon milking sessions. Twenty millilitre samples were collected into sample bottles with a Bromopol (2-bromo, 2-nitropraine, 1,3 Diol + Natamycine) preservative tablet to prevent any spoilage before chemical analysis.

Laboratory analyses

All forage samples were milled through 1.5 mm screen before analysis. The parameters analysed on the fresh material and the silages included oven dry matter (DM), neutral detergent fibre (NDF), modified acid detergent fibre (MADF), crude protein (CP) and ash. All analyses were done in duplicate. The DM in fresh forages and silages were determined in a forced air oven at 60 C for 48 h. The CP content was determined by the Kjeldahl method (AOAC, 1984). The NDF and MADF were assessed using the procedures outlined by AOAC (1984). Energy in the forages was estimated from the MADF values according to the following formula: ME (MJ/kg) = 0.16D (where D is the estimated digestibility of the forage calculated from the MADF value from the formula; Digestibility (D) = 99.43 - 1.17*MADF). The milk samples were analysed for butter fat (BF), lactose, protein, and total solids by a Bently 2000 infrared milk analyser.

Statistical analysis

The data on parameters for nutrient content was analysed using the Statistical Analysis Systems (SAS, 1990) analysis of variance (ANOVA) procedures for a completely randomised design as represented by the model below. Tukeys method was used to separate the means.

$$R_{ij} = \ + T_i + e_{ij}$$

Where: R_{ij} = response variable (e.g. dry matter, crude protein),

= Overall mean,

T_i = treatment effect (i = 1, 2, 3),

e_{ij} = random error.

In the feeding trial the general linear model procedure of SAS (1990), for repeated measurements in a completely randomized block design was used for the analyses of DMI, milk yield and milk composition data. The following model was used:

$$R_{ijk} = + P_i + T_j + e_{ijk}$$

Where: R_{ijk} = response variable (DMI, milk yield, protein, butterfat, lactose etc)
= overall mean,
P_i = effect due to parity (i = 1, 2, etc),
T_j = treatment effect (j = 1, 2 or 3),
e_{ijk} = random error.

The differences among the means were assessed by Tukeys method.

Results

Nutritional composition of the silages

The NDF content of the silages were not different but they were all significantly different from that of the meal ($P < 0.05$) as indicated in Table 1. Bagged maize silage and mixed maize-acacia silage had statistically similar MADF values of 304.4 and 318.6 g/kg DM, respectively. The bunker maize silage and the maize-leucaena silage had significantly higher ($P<0.05$) MADF values of 353.5 and 357.4 g/kg DM, respectively, compared to the other silages. The bagged maize silage had the highest D-value followed by the mixed maize-acacia silage, bunker maize silage and the mixed maize-leucaena silage. The estimated D-value of the bagged maize silage was significantly different from that of the maize-leucaena and the bunker maize silage ($P < 0.05$) but similar to that of the maize-acacia silage. The maize-acacia silage was not significantly ($P > 0.05$) different from that of the bunker silage and the mixed maize-leucaena silage. The same trend was found with the estimated metabolizable energy values.

The CP content of maize- acacia was the highest whilst the bunker maize silage had the lowest. The ash content was highest ($P < 0.05$) in the mixed maize-leucaena silage followed by the bagged maize silage and then the lactating meal with similar levels to those of the bunker silage and the mixed maize-acacia silage.

Table 1: The mean proximate composition of the silages

Feed Type	Bunker maize silage	Bagged maize silage	Maize--Leucaena silage	Maize--Acacia silage	Standard Error of means
DM (g/kg)	309^{a}	271^{a}	276^{a}	339^{a}	12.3
CP (g/kg)	65.0^{c}	71.2^{c}	176.0^{b}	208.7^{a}	0.5
NDF (g/kg)	665.0^{a}	608.2^{a}	658.4^{a}	602.6^{a}	17.5
MADF (g/kg)	353.5^{a}	304.4^{b}	357.4^{a}	318.6^{b}	4.4
ME (MJ/kg)	9.29^{c}	10.21^{b}	9.22^{c}	9.95^{bc}	0.1
Ash (g/kg)	56^{b}	66^{ab}	74^{a}	56^{b}	2.0
Digestibility (%)	57.9^{c}	63.8^{b}	57.6^{c}	62.2^{bc}	1.5

^{abc}Values with different superscripts in a row are significantly different ($P<0.05$)

Dry matter intake

The dry matter intake (DMI) levels of the silages are shown in Table 2. The cows given mixed maize-acacia and maize silage had higher intake levels than those fed the mixed maize-leucaena silage ($P < 0.05$).

Milk yield and quality

The milk yield (Table 2) was higher ($P < 0.05$) in cows fed mixed maize-acacia and maize silages compared to animals on mixed maize-leucaena silage. However, the milk composition in terms of butterfat, lactose, protein and total solids was not different ($P > 0.05$) across the treatment diets.

Table 2: Dry matter intake, milk yield and composition from animals fed cereal-legume silages.

Parameter	Maize silage (control)	Maize-Leucaena silage	Maize-acacia silage	Standard error of means
DMI (kg/100 kg live weight)	3.30[a]	3.11[b]	3.31[a]	-
Daily milk yield (kg)	17.02[a]	14.06[b]	15.7[a]	0.69
Butterfat (%)	3.59[a]	3.72[a]	3.57[a]	0.11
Protein (%)	3.36[a]	3.44[a]	3.45[a]	0.05
Lactose (%)	4.58[a]	4.57[a]	4.48[a]	0.04
Total solids (%)	12.47[a]	12.74[a]	12.48[a]	0.16

[ab]Values with different superscripts across the rows are significantly different at $P<0.05$

Discussion
Nutritional composition of the silages

The CP of the mixed silages that ranged from 170 to 210 g/kg DM is comparable to that of commercial dairy feeds and this gives them the advantage over the maize silage that had a CP content of 68 g/kg DM. These findings are similar to what Titterton et al. (1997) found although the values in this study were slightly higher. The CP content of maize-leucaena of 176 g/kg DM and maize-acacia of 208 g/kg DM were well above the proposed minimum requirement for lactation of 120 g/kg DM as reported by ARC (1984). This means that the crude protein of the mixed silages was sufficient to meet the animal's protein requirements for maintenance and lactation. However, the efficiency of utilisation of the CP in the mixed silages is not guaranteed due to the perceived interference from the polyphenolic compounds on protein utilisation.

The NDF levels of the mixed maize-FTLs are within the range for some forage silages that have been reported in the tropics. For example, *Panicum maximum* silage in Sri-Lanka was reported to have NDF content of 699 - 719 g/kgDM (Panditharatne et al., 1986), while *Pennisetum purpureum* silage in Thailand had an NDF content of 642 - 702 g/kg DM (Shinoda et

Al., 1996). The NDF content of the silages in this study were within the maximum acceptable and desirable range for ruminant animals of 600 to 650 g/kg DM (Mahanna, 1994). However, the values for bunker maize and maize-leucaena silages were slightly higher than the maximum acceptable levels and this could be attributed to differences in the stem to leaf ratio. The MADF content of the silages in this study were within the 220 500 g/kg DM range as suggested by Slater (1991). The lower the MADF the higher the energy level in the silage. The levels found in this study indicates that the mixed maize-FTL silages have a potential to replace the silage from traditional crops such as maize and sorghum if other factors are ideal. It is important to note though that the NDF and MADF levels are dependent on the maturity stage of any given forage since they are essentially indicating the levels of cell wall components mainly the cellulose, hemicellulose and lignin (for NDF) and cellulose and lignin (for MADF).

Similarly the DM and CP of silage all depend on the type and stage of maturity of the crops at the time of ensiling in addition to the methodology of harvesting and technique of ensiling. It is generally known that feeds with high fibre content have low digestibility and hence are of poor quality. The MADF of the bagged maize silage and that of the mixed maize-acacia were similar and so were those of the bunker maize silage and that of the mixed maize-leucaena silage but they were all within the 22-50 % range suggesting that the quality is acceptable. If NDF is considered, the picture is different, with all the four silages having similar content. In this regard MADF seems a better parameter to indicate the potential digestibility of a given silage than NDF. The MADF was used to calculate the estimated digestibility values (D-value) for each silage. The digestibilities of all the silages are slightly higher than those reported in literature. The variation could be due to the differences in maturity of the various crops at the time of ensiling, with better digestibilities being found in young forage material. After the laboratory work there is need to confirm the estimated feeding value (the D-value) of the mixed silages through proper feeding trials.

The ash content of the mixed silages was comparable to that of the maize silage. Mixed maize-leucaena silage had a significantly higher level of the ash than the lactating meal and other silages used in this study. This suggests that there may be no need to add commercial mineral supplements if the mixed silages are used. However there is need to analyse the ash for the quantities of calcium, phosphorus, iron, magnesium and other minerals required by lactating cows in order to ascertain the sufficiency from the silages.

Dry Matter Intake

There was no significant difference between the DMI of maize-acacia (3.31 kg/100 kg liveweight) and the maize silage (3.30 gkg/100 kg liveweight). This demonstrates the potential of the mixed maize-acacia silage as a source of protein in dairy cattle feeding. DMI is an important parameter in assessing the nutritive value of a feed or forage. The CP content of a feed influences the DMI of that feed because it tends to improve the palatability and efficiency of utilization due to the synergistic supply of CP and energy. However the CP content alone can not be responsible for high DMI because the energy content of the feed also plays an important role since animals eat to satisfy energy requirements (Seyd and Leaver, 1999). The DMI reflected the influence of NDF, MADF and digestibility levels in the experimental treatment silages. The low DMI of the maize-leucaena silage could have been due to high fibre levels resulting in the rumen fill effect.

It is quite interesting to note that the DMI seems to have been influenced by the fermentation quality of the silages. Generally, it is believed that if a forage has high levels of total phenolics its intake may be low. In this study mixed maize-acacia had the highest levels of total phenolics but its dry matter intake was similar to the control that had the lowest levels of phenolics. The reason could be that even the levels detected in the maize-acacia silage might not have been enough to exert significant negative effects on DMI. This is supported by the reports made by Barry et al. (1986) and Wang et al. (1994), that low levels of tannins (20 40 g extractable CTs/kg DM) may in fact be beneficial by reducing protein degradation in the rumen and increase amino acid absorption from the small intestines without depressing fibre digestion and voluntary food intake (VFI). The different picture given by the DMI values seem to suggest that ensilage has an effect on tannin levels and or action of the respective tannins in FTLs. Mixed maize-leucaena silage had significantly high levels of CTs that could have just been above the threshold level for depressing VFI. These findings indicate that ensilage may result in varied responses by the different chemical constituents in the respective forages. This needs further investigation.

Milk yield and quality

Milk yield and quality are influenced by stage of lactation, parity, animal size and the body condition at calving within the same breed in addition to the type of feed and level of feeding. It is a fact that rations that stimulate high milk yield will depress butterfat and increase total solids content. Good levels of feeding tend to stimulate high milk yields and lactose but depress BF, protein and minerals. Conversely under feeding results in high BF, protein and minerals and low milk yield and lactose (Slater, 1991). In this study maize silage had milk yields similar to that of the maize-acacia silage and this indicates that the mixed silage has the potential to replace the maize silage without affecting yields. However the potential of the mixed silages cannot be guaranteed as this depends on the prevailing economic situation. Low DMI levels seem to have affected the milk yield from the maize-leucaena silage. Milk yields from animals supplemented with *L. leucocephala* hay were higher than those from animals fed *Acacia angustissima* and *Calliandra calothyrsus* supplements (Hove, 1999). These findings seem to suggest that the processing done prior to feeding the animals influence the performance of forages. In any case it has been found that sun or oven or freeze-drying have varying effects on tannin levels (Ahn et al., 1989; Hove, 1999) and this has an effect on dry matter intake and subsequently the milk output.

There were no differences in the quality of milk across the treatments although Kumagai et al. (1993) suggested that milk yield and composition in dairy cows might be influenced by the source of roughage. The data generated in the present study seem to be in agreement with the conclusions made by Khorasani et al. (1996) that the dairy cow can maintain similar milk yield despite marked differences in the type of end products arising from carbohydrate and protein digestion. Chenais et al. (1993) carried out similar studies using mixed maize-red clover silage and lucerne silage and found that the mixed silage increased milk yield compared to the maize silage alone (control) but lucerne silage was out performed by the control. The same authors also reported that the legumes compared to the maize silage lowered milk fat and protein levels. Bequette et al. (1993) reported that protein supplementation did result in increased milk output although there was a significant proportion of protein channelled to the mammary gland for tissue growth. The varying results indicate that there is need for more research into the subject of mixed silages and their influences on milk yield and composition in given environments. This is important since the quality of milk has an influence on processing milk into milk products.

The advantages of the mixed silage could be translated in terms of the savings on costs of commercial feeds while the disadvantages would be on the lowered milk yields. The substitution of commercial feeds by the FTLs would be ideal within the smallholder dairy production system as long as the ingredients of the commercial feeds are highly priced.

Conclusion

Mixed silages of good quality can be produced and used to partially replace commercial feed supplements without loss in milk yield or quality. However, there is need to ascertain the trend with low yielding dairy cows especially crossbreeds cows where there is potential to completely replace the commercial feeds with mixed FTLs and increase profits.

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