# EFFECT OF FEEDING *Hordeum jabatum* HAY SUPPLEMENTED WITH *Leucaena leucocephala* ON NUTRIENT DIGESTIBILITY IN SHEEP

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## ABSTRACT

***The fermentation profiles and nutrient digestibility of Leucaena leucocephala as a supplement to Hordeum jabatum hay was investigated using twelve castrated sheep averaging 24.4 ± 2.2 kg body weight (BW). Six of the sheep were fistulated at the rumen and used for ruminal pH, ammonia and volatile fatty acid determination in rumen fluid. Dried leaves of Leucaena leucocephala were offered as supplement at two levels, 25% (diet 2) and 50% (diet 3) of dry matter intake (DMI), replacing Hordeum jabatum hay diet. The basal hay diet without supplementation was diet 1. Rumen liquor was sampled one hour before, and one, three and five hours after the morning feeding. The sheep were subjected to digestibility trial. Sheep on diet 3 had higher (P<0.05) ruminal pH than sheep on diets 1 and 2, respectively. The ruminal ammonia concentration of sheep on diet 2 was superior (P<0.05) to those on diet 1 but not with diet 3. Diet 1 had superior (P<0.05) volatile fatty acid concentration than diets 2 and 3, respectively. There were no differences (P>0.05) in the dry matter, organic matter, neutral detergent fibre, acid detergent fibre and hemicellulose intake among treatments. There were however, significant (P<0.05) differences in the digestibility of nutrients among treatments. It was concluded that dried leaves of Leucaena leucocephala has a forage potential for livestock farmers. It can be classified as a plant of moderate fodder value.***

**Keywords:** *Leucaena leucocephala,* Rumen parameter, Nutrient digestibility, Wethers

## INTRODUCTION

Browses, in the form of fodder trees and shrubs, form an integral part of farming systems in humid West Africa (Atta-Krah *et al.*, 1986). As their establishment and management require little effort, labour, time, technical know-how and resources, it should be easy to promote and intensify their use as animal feed. The multipurpose nature of browses as fuel wood, shade, food (fruits), poles, etc, as well as their potential to improve soil fertility and conservation, are added incentives. In terms of utilisation as animal feed, browses currently play an important albeit non-strategic, role, as animals under confinement often receive one type or another of browse, from fallow lands or around homesteads (Reynolds and Adediran, 1988). Efficient utilisation in a complementary way with grass forages and crop residues is what needs to be worked out through research, in order to exploit their potential nutritive value. Data in the literature (Reynolds, 1989; Ademosun, 1988) demonstrated the potential complementary roles between browses and grass forages. Although the nutrient contents of some common browses indicate on the average that browses contain more crude protein and organic matter, but less fibre than tropical grasses, they nevertheless contain anti nutritional factors that limit their utilisation (Osakwe *et al.*, 1999; Osakwe, 2003). This study was therefore designed to examine the effect of *Leucaena leucocephala* supplementation with *Hordeum jabatum* hay on nutrient digestibility in wethers.

## MATERIALS AND METHODS

The study was conducted at the Institute of Animal Nutrition, (450), University of Hohenheim, Germany.

***Leucaena leucocephala:*** This leguminous tree of the Mimosaceae family, grows up to 15 metres tall and has its origin in the tropical regions of America. It is a classical fodder tree and as a legume plant, serves to improve soil fertility. Its use as a fodder plant is restricted by its content of anti nutritional factors particularly mimosine. Leaves from mature *Leucaena leucocephala* from the humid zone of Cotonou (Benin) Republic were collected during the dry season, sun dried on a raised wooden platform at the experimental station of "Direction de la Recheche Agronomique", Cotonou. The dried leaves were then packed in plastic containers and transported to the University of Hohenheim, Germany for analysis and feeding trial.

**Hay:** The hay consisted of grasses harvested in mid-October at the Hohenheim University. Grass species composition was predominantly foxtail barley (*Hordeum jabatum*).
Dried leaves of *Leucaena leucocephala* were offered as supplements at two levels, 25% and 50% of dry matter intake, replacing *Hordeum jabatum* hay in the basal hay diet. The experimental diets were as follows:
Diet 1 (100% *Hordeum jabatum*), diet 2 (25% *Leucaena leucocephala* leaves + 75% *Hordeum jabatum*) and diet 3 (50% *Leucaena leucocephala* leaves + 50% *Hordeum jabatum*)
In addition to the experimental diet, animals received a mineral premix supplement (10 g $d^{-1}$). Feed was offered twice a day at 0800 and 1600 hr. Water was provided *ad libitum.*

**Rumen pH:** Rumen liquor was taken one hour prior to feeding and one, three and five hours after feeding directly by means of a vacuum pump with plastic tube thrust into the rumen compartment. Immediately after collection, pH was measured with Schott CG 840-pH Meter. The samples were then immediately freed of coarse particles by filtration through cheese-cloth and centrifuged at 2500*g* for 20 min under refrigeration.

**Rumen Ammonia:** Ruminal ammonia was determined using 5 ml of the rumen filtrate that was diluted with 45 ml of de-ionised water and then 0.5 ml of 10 mol/l NaOH added. The gas released was measured immediately using a gas sensitive electrode. A standard solution was used for the calibration curve for an ammonia electrode as described by Cammann (1979).

**Ruminal VFA Determination:** Volatile fatty acid pattern in ruminal fluid was determined in duplicate using 5 ml of the rumen filtrate that was vacuum distilated according to Zijlstra *et al.* (1977). Thereafter, gas-chromatography analysis was made using HP 5880A series gas-chromatograph with hp 7671A automatic sampler

**Animal Trial:** Twelve castrated sheep (average body weight 24.4 ± 2.20 kg) were used in a completely randomised design to determine nutrient digestibility of sheep fed *Hordeum jabatum* supplemented with *Leucaena leucocephala*. In trial 1, four sheep each (two fistulated and two non fistulated) were randomly assigned to diets 1, 2 and 3, respectively. The animals were adapted for 10 days to the experimental diets. This was followed by an 8 day collection period in which animals were kept in individual metabolism crates to measure food intake, and to collect faeces and urine outputs.

**Analytical Methods:** Feed samples were ground in a hammer mill to pass a 1mm mesh sieve for chemical analysis. Feed and faecal samples were analysed for moisture (934.01), ash (942.05), crude protein (988.05), fat (920.39), by procedures of AOAC, (1990). Neutral detergent fibre (NDF), Acid detergent fibre (ADF), and Acid detergent lignin (ADL) were determined as described by Van Soest *et al.* (1991). The difference between NDF and ADF was designated as hemicellulose, and between ADF and ADL as cellulose. Gross energy of feed and faeces was measured by bomb calorimeter using benzoic acid as a standard (26437 J/g). Analyses of extractable condensed tannins were carried out by the method described by Markkar *et al.* (1993). Ruminal ammonia was determined as described by Camman, (1979) and volatile fatty acid as described by Zijlstra *et al.* (1977).

**Statistical Analysis:** Analysis of Variance (ANOVA) was used to analyse the data using the General Linear Modelling Procedure (SAS, 1985). Significant treatment means were separated using Duncan's Multiple Range Test (Duncan,1955).

## RESULTS

The chemical composition and gross energy content of the experimental diets and *Leucaena leucocephala* is presented in Table 1. *Leucaena leucocephala* has a high CP (30.1 %) and a relatively high GE content (21.4 kJ/g DM).

The effect of *Leucaena leucocephala* supplementation on ruminal pH is shown in Figure 1. There were significant ($P < 0.05$) differences on the mean values of ruminal pH of sheep on the different diets. Sheep on diet 3 had higher ($P < 0.05$) ruminal pH than sheep on diets 1 and 2, respectively.

**Table 1: Composition of experimental diets and *Leucaena leucocephala* (% of DM)**

| Item | Diet 1 | Diet 2 | Diet 3 | *Leucaena leucocephala* |
|---|---|---|---|---|
| CP | 13.1 | 17.4 | 21.6 | 30.1 |
| Ash | 10.5 | 10.0 | 9.5 | 8.5 |
| Ether extract | 2.0 | 2.7 | 3.3 | 4.6 |
| NDF | 61.0 | 58.2 | 55.5 | 49.9 |
| ADF | 35.4 | 34.2 | 33.0 | 30.6 |
| ADL | 3.7 | 6.8 | 9.8 | 15.9 |
| Cellulose | 31.7 | 27.5 | 23.2 | 14.7 |
| Hemicellulose | 25.6 | 24.0 | 28.9 | 19.3 |
| Condensed tannins [1] | n.a. | 0.3 | 0.6 | 1.2 |
| GE ($kJg^{-1}$ DM) | 17.9 | 18.8 | 19.7 | 21.4 |
| Mineral premix [2] | 10.0 | 10.0 | 10.0 | n.a. |

*[1]As leucocyanidin equivalent; n.a.: Not applicable; [2]Composition/kg: vit A 600,000 IU, vit D3 75,000 IU, vit E 300 mg, Zn 3,000 mg, Mn 480 mg, Co 12 mg, Se 10 mg.*

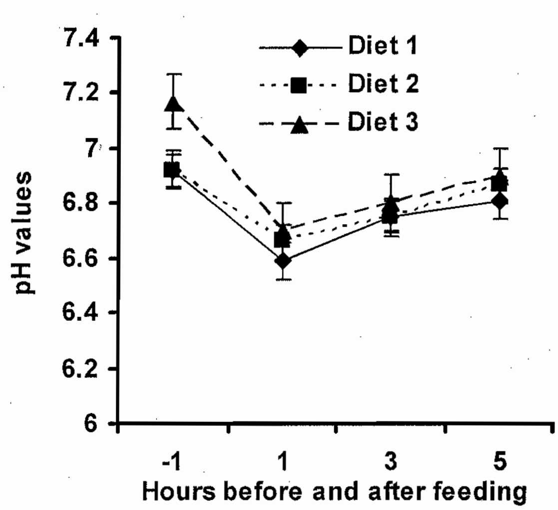


**Figure 1: Effect of *Leucaena leucocephala* supplementation on ruminal pH**

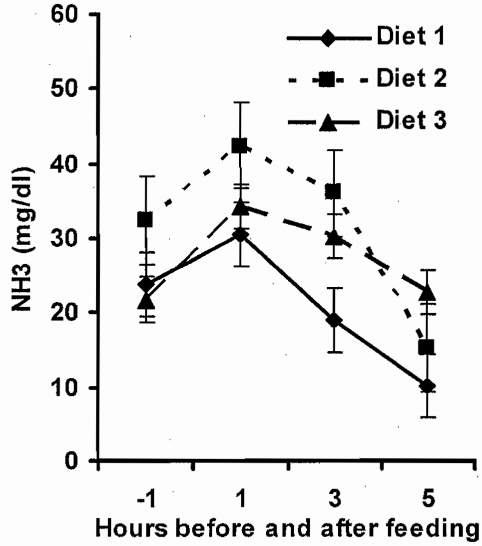


**Figure 2: Effect of *Leucaena leucocephala* supplementation on ruminal ammonia concentration.**

There was no difference in the ruminal pH of sheep on diets 1 and 2.

Mean values of ruminal ammonia concentrations of sheep supplemented with *Leucaena leucocephala* is shown in Figure 2. The ruminal ammonia concentrations of sheep on diet 2 was superior ($P<0.05$) to those of sheep on diet 1 but not with diet 3.

The effect of supplementation with *Leucaena leucocephala* on total volatile fatty acid (VFA) is presented in Figure 3. Diet 1 had superior ($P<0.05$) VFA concentrations than diets 2 and 3, respectively. Diets 2 and 3 are not significantly different in their VFA concentrations.

Total nutrient intake and digestibility coefficients of sheep supplemented with *Leucaena leucocephala* is summarised in Table 2. There were no differences ($P>0.05$) in the dry matter intake, organic matter, NDF, ADF and hemicellulose intake among the treatments. There were however, significant ($P<0.05$) differences in the digestibility of nutrient among treatments.

## DISCUSSION

McLeod (1974) reported the effects of pH on complex formation of tannin and proteins. Condensed tannins (CT) can react and form complexes by H-bonding with carbohydrates and proteins, but at neutral pH form stronger bonds with proteins. Barry and Forss (1983) reported that complexes with low tannin concentration can be deaminated by rumen microorganism in the pH range of 6.5 to 7.0. The lower pH of diets 1 and 2 compared with diet 3 could indicate a higher rumen fermentation. The higher pH of diet 3 compared with diets 1 and 2 would suggest inhibition of fermentation.

The superior ruminal ammonia concentration of diet 2 compared with diet 1 would indicate a positive effect of supplementation with *Leucaena leucocephala* at 25% inclusion level.

**Table 2: Total nutrient intake (g/d) and digestibility coefficients of sheep supplemented with *Leucaena leucocephala***

| Items | Diet 1 | Diet 2 | Diet 3 | SEM | P level |
|---|---|---|---|---|---|
| **Nutrient intake (g/d)** | | | | | |
| **Dry matter** | 490.8 | 519.1 | 540.8 | 19.3 | NS |
| **Organic matter** | 439.3 | 467.3 | 489.4 | 17.4 | NS |
| **Ash** | 51.5 | 51.8 | 51.4 | 1.86 | NS |
| **Crude protein** | 64.2$^c$ | 90.5$^b$ | 116.6$^a$ | 4.1 | *** |
| **NDF** | 299.4 | 302.0 | 300.0 | 10.8 | NS |
| **ADF** | 173.9 | 177.6 | 178.6 | 6.4 | NS |
| **ADL** | 18.3$^c$ | 35.5$^b$ | 53.0$^a$ | 1.8 | *** |
| **Cellulose** | 155.6$^a$ | 142.1$^{ab}$ | 125.6$^b$ | 4.8 | ** |
| **Hemicellulose** | 125.4 | 124.4 | 121.4 | 4.4 | NS |
| **Digestibility (0-1)** | | | | | |
| **Dry matter** | 0.703$^a$ | 0.653$^{ab}$ | 0.524$^b$ | 2.95 | * |
| **Organic matter** | 0.683$^a$ | 0.576$^b$ | 0.502$^c$ | 1.48 | *** |
| **Ash** | 0.621$^a$ | 0.472$^{ab}$ | 0.313$^b$ | 3.65 | ** |
| **Crude protein** | 0.711$^a$ | 0.616$^b$ | 0.579$^b$ | 0.94 | *** |
| **NDF** | 0.653$^a$ | 0.564$^{ab}$ | 0.513$^b$ | 2.17 | ** |
| **ADF** | 0.612$^a$ | 0.449$^b$ | 0.309$^c$ | 2.46 | *** |
| **ADL** | 0.133$^a$ | 0.064$^a$ | -0.240$^b$ | 5.95 | ** |
| **Cellulose** | 0.669$^a$ | 0.543$^b$ | 0.540$^b$ | 2.89 | * |
| **Hemicellulose** | 0.710 | 0.728$^{ab}$ | 0.813$^a$ | 1.90 | * |

*a,b,c Means in a row with different superscript differ significantly (P<0.05). *=(P<0.05); **=P<0.01; ***=P<0.001; NS=Not significant*

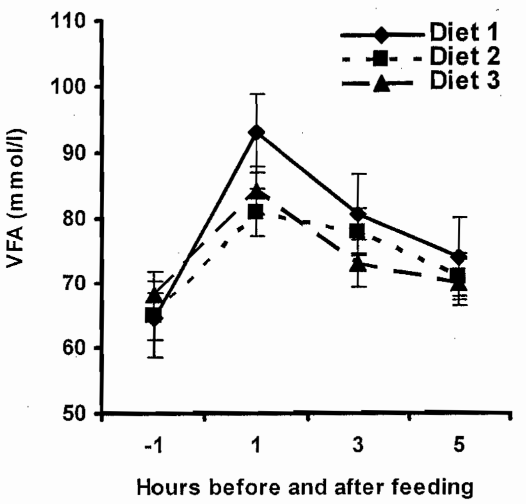


**Figure 3: Effect of *Leucaena leucocephala* supplementation on total volatile fatty acid concentration**

However, further increase in the supplementation level to 50% led to a decrease in the ruminal ammonia concentration. This reduction in ruminal ammonia concentration could be attributed to the inhibitory effects of tannins and mimosine on degradability of proteins by rumen microbes (Rodriguez *et al.*, 1975; Barry and Forss 1983).

The inferior total volatile fatty acid concentration of diets 2 and 3, respectively when compared to diet 1 would suggest an inhibitory effect of condensed tannins and mimosine on digestibility of cell wall carbohydrates by rumen microbes. This observation is consistent with the reports of Reed *et al.* (1990).

The present study showed that there were no differences in the dry matter intake, organic matter, NDF, ADF and hemicellulose intake among treatments but digestibilities of organic matter, crude protein, ADF and ADL decreased with supplementation. Barry and Manley (1984) reported that tannins may reduce the digestion of cell-wall carbohydrates. The decrease in the digestibility of organic matter, crude protein, ADF and ADL with supplementation could indicate an inhibition of digestive enzyme activity by dietary tannins. This observation is in agreement with the findings of Griffiths and Jones (1977).

**Conclusion:** The results presented here support the use and integration of *Leucaena leucocephala* trees into the farming systems of sub-Saharan Africa. Its high crude protein (30.1 %), energy (21.4 kJ/g) and relatively low content of condensed tannins (1.2 %) DM has placed it among useful fodder trees for livestock feeding during the dry season. *Leucaena leucocephala* should not be fed as sole feed due to its poor digestibility and low metabolisable energy value. An inclusion level of 25% is therefore recommended.

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**REFERENCES**

ADEMOSUN, A. A. (1988). Appropriate management systems for the West African Dwarf goat in the humid tropics. Pages 21 – 28. *In:* Smith, O.B. and Bosman, H.G. (Eds). *Goat production in the humid tropics. Proceedings of a workshop at the University of Ife, Ile-Ife, Nigeria, 20-24 July 1987.* Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen, The Netherlands.

AOAC (1990). *Official Methods of Analysis.* 15th Edition. Association of Official Analytical Chemists, Washington, DC, 2044.

ATTA-KRA, A. N., SUMBERG, J. E. and REYNOLDS, L. (1986). Leguminous fodder trees in the farming system: An overview of research at the Humid Zone Programme of ILCA in southwestern Nigeria. Pages 307 – 330. *In:* Haque, I., Jutzi, S. and Neate, P. J. H. (Eds). *Potentials of forage legumes in farming systems of sub-Saharan Africa.* ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

BARRY, T. N. and FORSS, D. A. (1983). The condensed tannins content of vegetative *Lotus pedunculatus*, its regulation by fertiliser application and effect upon protein solubility. *Journal of the Science of Food and Agriculture, 34:* 1047 – 1056.

BARRY, T. N. and MANLEY, T. R. (1984). The role of condensed tannins in the nutritional value of *Lotus pedunculatus* for sheep. 2. Quantitative digestion of carbohydrates and proteins. *British Journal of Nutrition, 51*: 493 – 504.

CAMMANN, K. (1979). *Working with ion selective electrodes.* Springer-Verlag, Berlin. pp 1 – 11.

DUNCAN, D. G. (1955). Multiple range and multiple F-tests. *Biometrics, 11*: 1 – 42.

GRIFFITHS, D. W. and JONES, D. I. H. (1977). Cellulase inhibition by tannins in the testa of field beans (*Vicia faba*). *Journal of the Science of Food and Agriculture, 28:* 983 – 989.

MAKKAR, H. P. S., BLÜMMEL, M., BOROWY, N. and BECKER, K. (1993). Gravimetric determination of tannins and their correlations with chemical and protein precipitation methods. *Journal of the Science of Food and Agriculture, 61*: 161 – 165.

McLEOD, M. N. (1974). Plant tannins-their role in forage quality. *Nutrition Abstract Review, 44*: 803 – 815.

OSAKWE, I. I. (2003). Effect of feeding a hay diet supplemented with *Daniellia oliveri* leaves to sheep on volatile fatty acid concentration and nitrogen balance. *Journal of Sustainable Agriculture and the Environment, 5(1)*: 47 – 52.

OSAKWE, I. I., STEINGASS, H. and DROCHNER, W. (1999). The feeding value of *Dialium guineense* as a supplement to West African dwarf sheep fed natural grass hay. *Animal Research and Development, 49:* 24 – 31.

REED, J. D., SOLLER, H. and WOODWARD, A. (1990). Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of phenolics on nitrogen utilization. *Animal Feed Science and Technology, 30:* 39 – 50.

REYNOLDS, L. (1989). Effects of browse supplementation on the productivity of West African Dwarf goats. Pages 237 – 250. *In:* Wilson, R.T. and Azeb, M. (Eds). *African small ruminant research and development. Proceedings of a conference held at Bamenda, Cameroon, 18 - 25 January, 1989.* African Small Ruminant Research Network. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

REYNOLDS, L. and ADEDIRAN, S. O. (1988). The effects of browse supplementation on the productivity of West African Dwarf sheep over two reproductive cycles. Pages 83 – 91. *In:* Smith, O. B. and Bosman, H. G. (Eds). *Goat production in the humid tropics.* Centre for Agricultural Publishing and Documentation (Pudoc), Wageningen, The Netherlands.

RODRIGUEZ, D., MULLER, L. D. and SCHINGOETHE, D. J. (1975). In vitro and mouse evaluation of methods for protecting whey protein and casein from ruminal degradation. *Journal of Dairy Science, 58:* 1841 – 1846.

SAS (1985). *User's Guide 1985 Edition.* Statistical Analysis Systems Institute Inc, Cary, NC, USA.

VAN SOEST, P. J., ROBERTSON, J. B. and LEWIS, B. A. (1991). Methods for dietary fibre, neutral detergent fibre, and non-starch polysaccharides in relation to animal nutrition. *Journal of Dairy Science, 74:* 3583 – 3597.

ZIJLSTRA, J. B., BEUKEMA, J., WOLTHERS, B. G., BYRNE, B. M., GROEN, A. and DANKERT, J. (1977). Pre-treatment methods prior to gas-chromatographic analysis of volatile fatty acids from faecal samples. *Clinica Chimica Acta, 78:* 243 – 250.