Use of Near Infrared Reflectance (NIR) Spectroscopy to Monitor Beef Cattle Nutrition in Southern Queensland and Use of Faecal Chemistry as an Index of the Nutritional Status of Bali Cattle in East Timor[1]

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Agriculture has always been, and remains, the cornerstone of the Timor-Lesté economy, and small-scale farming is the backbone of the sector. Subsistence sector technology is largely traditional and rain dependent, with very limited areas of irrigation. Livestock production is an integral part of the country's agricultural system. The various ecological zones allow the production of several species of livestock, which represent a part of national resources (Timor Agri 2004).

Livestock production systems in Timor Lesté are determined by the interactions of climate, vegetation, the types of crop grown, livestock species reared, and their economic importance to the farmer. In the highlands, livestock are subordinate but economically complementary to crop production, the main agricultural activity of the farmers. In this zone, livestock, especially cattle, provide draught power and manure, milk and meat (which may be sold as a cash product), and serve as a hedge against risk. In the semi-arid lowlands cattle, again, are the most important species because they provide various functions for the subsistence of the pastoral family. The productivity of this subsector suffers from numerous constraints, including inadequate animal nutrition, high prevalence of diseases and poor management of stock (FA-NUET, 2005).

One of the major constraints to cattle management in the tropics is inadequate and fluctuating feed supply. Changes in feed quality (Figure 1) are seasonal, accompanying changes in rainfall. However, problems of inadequate feed supply may result from poor feeding management and feed utilization, rather than from absolute shortages (Smith 1992).

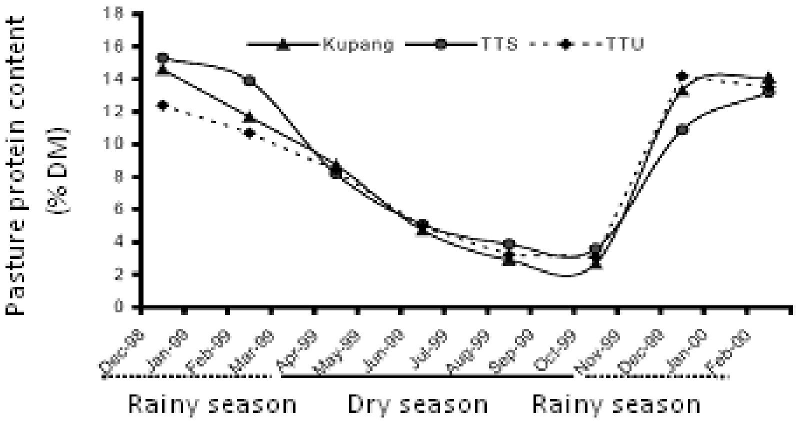

Figure 1. Seasonal changes in pasture protein content in three districts of West Timor, Indonesia. (Source: Jelantik 2003).

Problems of poor cattle production are caused by several factors such as: the low quality of native grasses (protein contents may fall below 4% in the dry season) and the inability of traditional grazing

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management methods to cope with this, poor health and breeding management, low reproductive performance, and heat stress (Timor Agri 2004).

Nitrogen (N) is an essential element in animal production as it is essential for protein formation. In animals, proteins form the major part of muscle, skin and hair, and constitute the enzymes and some of the hormones that are required for body growth and function and the deposition of non-proteins (e.g. bone) (Phillips and Leigo 2004). The protein of grasses and legumes is then an essential feed component for animal growth and development (Rotz, 2004). Under extensive pastoral conditions N may limit animal production. Understanding the role of N in the soil, forages and animal system can aid management decisions in nutrition to improve beef cattle production.

Near infrared reflectance spectroscopy (NIRS) is an advanced technology which was established to monitor animal performance e.g. cattle nutrition, growth rate, pregnancy, etc. The method is simple, rapid and inexpensive to use and requires only minimal sample preparation methods (drying and grinding) (Dryden, 2003). NIRS applied to faeces has been successfully used to predict the quality of livestock diets (Bos spp.: Boval et al, 2004; Coates, 1998; Lyons and Stuth, 1992; Capra hircus: Landau et al, 2004; Leite and Stuth, 1995).

Objectives

The objectives of this study were to: Monitor beef cattle nutrition through chemical and NIRS analysis of feeds and cattle faeces; Use chemical analysis as an index for Bali cattle nutrition in Timor Lesté and use the N contents of Bali cattle faeces to predict the quality of feeds to ensure that they meet requirements for beef cattle nutrition; Test the NIRS analytical system as an advanced technology to use in Timor Lesté as a tool to monitor agriculture production in general and specially livestock production.

Materials and Methods

Three experiments were conducted:

1. Development of an NIRS prediction equation to determine the N content of tropical forages used in cattle feeds.
2. Prediction of the growth rate of beef cattle grazing southern Queensland pastures, using NIRS analysis of faeces.
3. Investigation of the nutritional status of Bali beef cattle (Bos javanicus) in Timor Leste.

Experiment 1

The aim of this experiment was to begin the development of an NIRS-based method to predict the N content of forages typically used in southern Queensland beef cattle production.

Samples and their management

Seventy eight samples of different Queensland tropical grasses (Panicum maximum, Setaria sphacelata, and Hordeum spp.) and legumes (Gliricidia sepium and Leucaena leucocephala) were obtained. They were maintained in the School of Animal Studies laboratory at the UQ Gatton campus as dry samples.

Sampling and measurements

Samples were dried, after collection, at 53 oC for 48 h and milled (1 mm screen). The total N contents were measured using the Dumas method (Leco N determinator, Leco Inc.) and expressed on a dry matter basis (mg/g DM). After this preparation, a second set of samples was redried at 103 oC for 4 h to obtain the DM contents. A third set of samples was analyzed by NIRS to obtain NIR spectral information from which to predict N content. The NIR spectra were captured using a Bruker FT NIR spectrometer (Bruker AG, Germany).

Experiment 2

The second experiment aimed to predict the growth of beef cattle grazing a typical southern Queensland pasture, using the technique of faecal NIRS profiling.

Animal and their management
Fifty seven head of beef cattle (steers and bullocks, Bos taurus and crosses) from a property in southern Queensland. These animals were grazing a mixture of native and introduced pasture, without a supplement. The cattle were weighed on two occasions: the first on 9 May, 2007, and the second on 14 June, 2007, 36 days later. Faeces were obtained by rectal sampling at the first weighing.

Sampling and measurement
The faecal samples were dried at 55 oC for 48 h, then milled (1 mm screen) then scanned to obtain their NIR spectra as described for Experiment 1.

Experiment 3
The aim of this experiment was to determine the nutrient status of beef cattle maintained under conventional management in Timor Lesté, using body condition scoring and chemical analysis of faeces.

Animal and their management
Sixty Bali cattle were selected randomly from two sub-districts (sub-districts Cailaco and Maliana) in the District of Bobonaro, located west of Dili. Thirty animals were sampled from each sub-district. Faecal samples were collected from each animal (from the ground, after elimination) and processed as described below. Each animal was photographed, and a body condition score (BCS) assigned using the method of National Research Council (1996).

Sampling and measurement
Samples were dried (in the laboratory of the Faculty of Agriculture of the National University of Timor Leste in Dili) at 60o C for 48 h, and milled (1 mm screen). These samples were then imported into Australia, and irradiated (gamma irradiation, 50 kGy; Steritech Pty Ltd., Maroochydore). The prepared samples were then analysed for DM (103 oC for 4 h) and total N (Dumas method).

Results and Discussion

Experiment 1. Development of an NIRS equation to predict N in tropical forages

The total N contents (mean ± standard deviation, % DM) of tropical grass samples from Queensland (n = 77) were: Hordeum spp. 2.1 ± 1.14, Setaria sphacelata 1.5 ± 0.91, and Panicum maximum 2.2 ± 1.03; while the N contents of the two tree legumes tested were: Leucaena leucocephala 4.1 ± 0.97 and Gliricidia sepium 4.2 ± 1.26. The highest N concentration was in L. leucocephala (6.06% DM) while the lowest value was in S. sphacelata (0.81% DM). In general, the N contents of the two tree forages were markedly higher than in the grasses.

Pamo et al (2007) and Yousuf et al (2007) have also reported that throughout the year the Ncontents of multipurpose tree leaves are higher than grasses. The result of the present experiment showed that legumes are suitable to be used as feed supplements to improve the quality of grass-based diets.

NIRS predicted forage N contents very accurately. The fit between the observed N contents and those predicted from the NIR spectra of the samples is illustrated in Figure 2. These results showed that nitrogen contents of feed samples were predicted with a very good result (R2 = 0.998).

These results are similar to those reported by other workers. Lyons, et al (1995) successfully predicted diet protein and digestible organic matter contents with R2 = 0.98 and 0.87, respectively, and SEP of 0.49 and 1.12 %, when they used NIR equations to predict nutritive values of four different native pastures and a ryegrass pasture. Leite and Stuth (1995) developed prediction equations for a variety of Texas pasture species. They predicted the diet in vitro digestible organic matter (IVDOM) and protein contents accurately (R2 = 0.94 and 0.92, bias = 0.16 and 0.18 %, and SEP corrected for bias = 1.28 and 2.12 % for protein and IVDOM). Coates (1998, cited in Dryden, 2003) developed prediction equations for northern Australian tropical pastures species grazed by beef cattle. These equations, for diet protein content, digestible dry matter content and DM digestibility, had R2 = 0.95, 0.86 and 0.73 for these variables respectively.

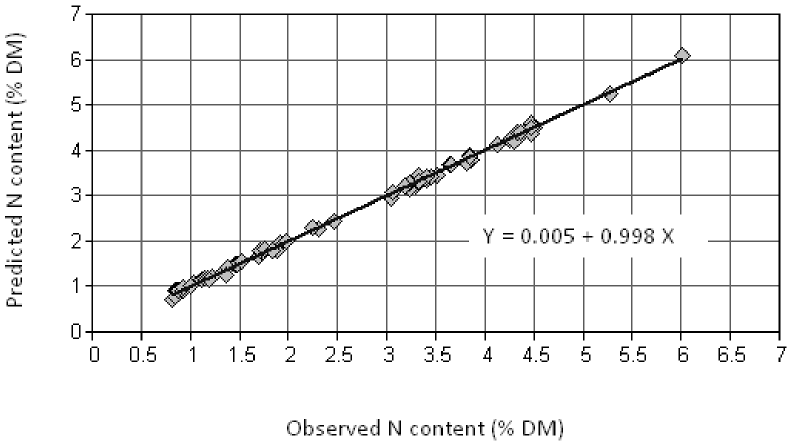

Figure 2. The prediction of nitrogen contents from the NIR spectra of tropical forages.

Experiment 2. Prediction of growth in beef cattle from faecal NIR spectra

The mean N content of faeces collected from these southern Queensland beef cattle was 1.49% DM (range 0.95 to 2.15% DM). The prediction of faecal N content from the faecal NIR spectra gave acceptable results (Figure 3). The prediction equation explained a large amount of variability (R2 = 0.80). Lyons and Stuth (1992) suggested that predictions are unsatisfactory if R2 is approximately 0.6 and good if R2 exceeds 0.9.

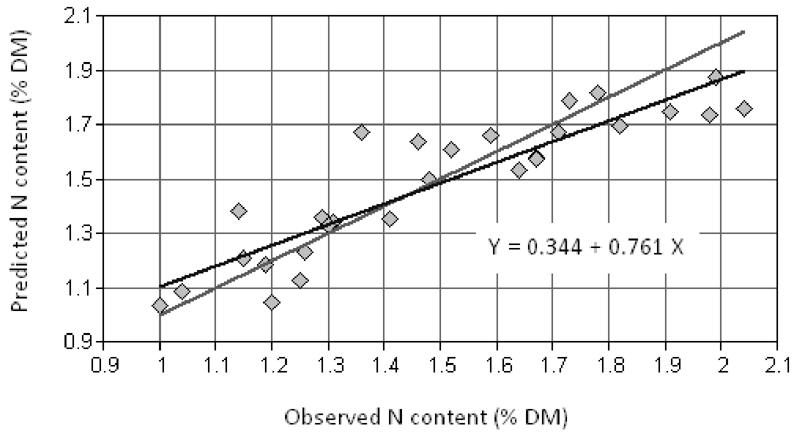

Figure 3. Prediction of the N content of cattle faeces from their NIR spectra.

The average initial and final weights of the cattle in this experiment (mean ± standard deviation) were 353 ± 41.2 and 370 ± 42.4 kg, and the average growth rate was 474 ± 326.3 g/day. Contrary to expectation the heaviest cattle did not grow faster and higher faecal N contents were only weakly associated with higher live weight gains ($p = 0.55$; Figure 4).

The highest daily gain was more than 1000 g/d. However, two animals lost weight in this period. The variability in growth rate may have been caused by the difficulty in measuring liveweights in the field, or by differences in the quality of diets selected by individual animals. Faecal analysis suggested that the diets ingested by these cattle varied between 0.95 and 2.15% N (DM basis), i.e. ranging from diets which supplied barely enough N for maintenance to ones which would have easily sustained growth.

This result indicates the difficulty of predicting growth performance of beef cattle given a feeding regime in which pasture stage of maturity changes as the pasture ages. This would have caused changes in pasture nutrient content and digestibility which could not have been predicted from faecal samples which were collected at the beginning of the period over which growth was measured.

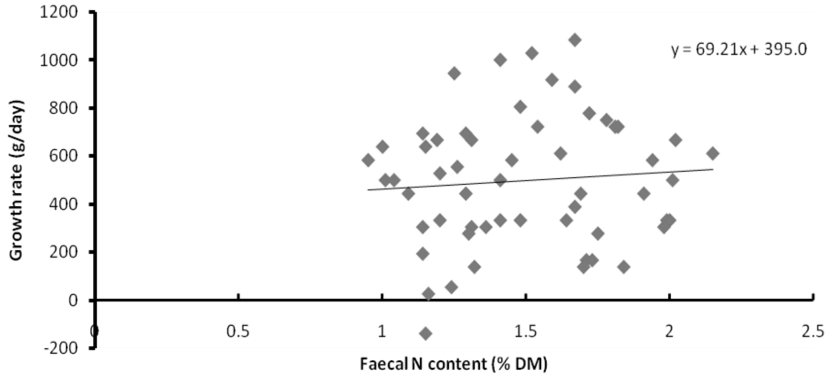

Figure 4. Relationship between faecal N content and growth rate in cattle (Bos taurus and crosses) grazing southern Queensland pastures.

Experiment 3. Using faecal NIRS profiling and body condition scoring to assess the nutritional status of Bali cattle in Timor Leste .

The Bali cattle had an average live weight of 175.8 kg (range 108 to 328 kg) and grew at an average of 281g/day, although growth rates ranged from 78 to 956 g/day. These growth rates compare favourably with those summarised by Jelantik, et al (2003) for Bali cattle in West Timor.

The N contents of the faeces collected from Bali cattle in this experiment were between 1.33 and 2.17% DM (1.71 ± 0.219% DM, mean ± standard deviation), and these animals had BCS of between 4 and 8 (6 ± 1.2, mean ± standard deviation). Regression analysis indicated some relationship ($p < 0.01$) between BCS and faecal N content (Figure 5).

Faecal samples are useful indicators of dietary protein levels. Faecal N levels (DM basis) of between 1.2 and 1.4%, or 1.7 and 2.5% (Mubanga et al 1985; Philips et al 2004) indicate a diet sufficient in protein for maintenance and live weight gain. Chemical and NIRS analysis of Bali cattle faeces indicated that the diets eaten by these cattle provided 1.33 to 2.17% N (DM basis). These data, and the BCS recorded in this experiment, indicated the diets given to these cattle during the early dry season (June/July) supplied sufficient nutrients for growth.

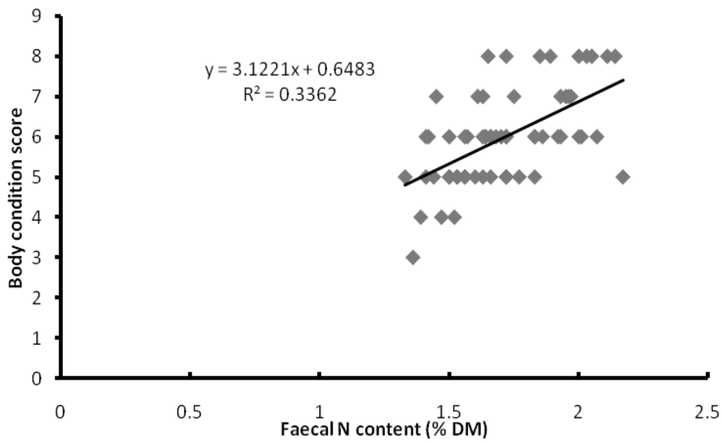

Figure 5. Relationship between faecal N content and body condition score.

Conclusions

Near infrared reflectance spectroscopy gives an alternative tool to accurately, rapidly and inexpensively estimate animal forage nitrogen content. This experiment shows that the nitrogen content of tropical legumes and grasses can be accurately predicted.

The result also provided data that tree legumes (e.g. Leucaena leucocephala and Gliricidia sepium) have a higher N content than grasses.

More work is needed before it will be possible to predict growth from faecal N content.
The diets fed to Bali cattle in Timor Leste during July (early dry season) contained between 1.33 and 2.17% N (DM basis) and provided sufficient protein for maintenance and growth.
This result provides important information to the government and people of the East Timor on the use the local forages for beef cattle and other ruminants.

To better manage pasture grasses to improve animal production around the year a monitoring system to predict animal performance and production is needed.

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