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Nutritive value of common tree leaves for livestock in the semi-arid and arid rangelands of Northern Pakistan

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ABSTRACT

The aim of this study was to establish a database on nutrients and mineral profile, *in vitro* dry matter digestibility (DMD) and *in situ* ruminal degradability characteristics of leaves from 21 fodder tree species commonly fed to livestock in semi-arid and arid zones of Northern Pakistan. Leaves from 13 fodder tree species: *Albizia lebbeck*, *Ailanthus altissima*, *Bauhinia variegata*, *Butea frondosa*, *Celtis australis*, *Ficus carica*, *Grewia oppositifolia*, *Leucaena leucocephala*, *Mallotus philippensis*, *Melia azedarach*, *Morus alba*, *Morus papyrifera and Ziziphus mauritiana* were sampled from semi-arid zone. Leaves from 8 fodder tree species: *Acacia modesta*, *A. lebbeck*, *Capparis aphylla*, *Olea cuspidata*, *Prosopis juliflora*, *Tecomella undulata*, *Ziziphus jujuba* and *Ziziphus mauritiana* were sampled from arid zone. Within each ecological zone, leaves of each tree species were collected at four sub-locations, from three randomly selected trees. The results showed a large variation in the concentration of all measured chemical components, DMD and ruminal degradation characteristics among the tree species. The contents of crude protein (CP) varied from 8.76% (*T. undulata*) to 24.0% (*M. alba*); ash from 7.41% (*O. cuspidata*) to 22.4% (*C. australis*); and neutral detergent fibre from 20.6 (*L. leucocephala*) to 56.5% (*C. aphylla*). Except for *T. undulata*, leaves from all tree species had CP content of $>10\%$, and 60% of the species had leaves with $>15\%$ CP, demonstrating that leaves from majority of tree species can be used as low-cost CP supplement. The mineral composition revealed that, except for *C. aphylla,* leaves from all tree species were rich sources of Ca, whilst most of the species were deficient in P, Na and Cu. The DMD of the majority (66%) of tree leaves were $<50.0\%$, ranging from 33.1% (*M. philippensis*) to 67.6% (*M. alba*). The *in situ* data further showed that a large fraction of ruminal degradable dry matter was instantaneously degraded (soluble). The potentially rumen degradable (D) fraction and rate of degradation (k_d) was highly variable, ranging from 0.234 to 0.958 and 0.026 to 0.99/h, respectively. The effective ruminal dry matter degradability (ED_{DM}) was higher than the *in vitro* DMD, ranging from 0.34 to 0.84, at an outflow rate of 0.05/h. This information on nutrients and mineral profile, *in vitro* DMD and *in situ* ruminal degradability characteristics of leaves from 21 fodder tree species, obtained under well replicated and uniform experimental conditions can be used to optimize diet formulation in terms of nutrients supply to the animals that will ensure better utilization of this nutrients-rich feed resource and will increase economic profitability of subsistence livestock farmers in the region.

1. Introduction

In the semi-arid and arid regions of many developing countries in the tropics, such as Pakistan, there is severe shortage of good quality forages for livestock production (Khan et al., 2015a). Livestock in these regions predominantly derive their feed from grazing on natural pastures. However, in the last few decades, the carrying capacity of grazing lands and nutritional quality of the pasture has been deteriorated due to recurrent droughts, continuous over-grazing and lack of range improvement interventions. The highly palatable and productive perennial grasses, legumes and herb species have been replaced with unpalatable, low quality annual species, with a concomitant loss of soil fertility. The nutritive value of the remaining predominant pasture species is very poor with an average crude protein (CP) content of less than 7%, and the grazing livestock are deficient in about 50% of their required CP intake (Khan and Habib, 2012). In addition, due to seasonal rainfall, the year-round feed availability and quality in these rangelands fluctuates substantially. For example, pasture

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abundance increases with a concurrent improvement in quality in the rainy seasons, whereas pasture abundance and quality generally declines at onset of the prolonged winter and summer dry periods. During pasture scarcity periods, livestock are stall-fed on cereal crop residues and low-quality rangeland hay. These low-quality forage based diets impede livestock productivity due to a lower dry matter (DM) intake, and lower digestibility and nutritive value of ingested feed. In most cases, livestock severely lose body weight, and the small-scale subsistence farmers often sell their animals at lower prices to avoid further production losses.

Research has established that supplementation of CP, minerals and energy-rich feeds optimizes microbial fermentation of low-quality fibrous feeds in the rumen that in turn increases total DM intake and improves animal productivity (Khan et al., 2009; Patra, 2010). However, in the predominant small scale, subsistence farming systems in the arid and semi-arid regions, most of the farmers cannot afford a continuous supplementation of concentrate feeds to their animals. Recent research is therefore directed towards the exploration of an affordable and abundant, alternate CP and energy rich feeds. In this regards, tree leaves have received increasing attention, due to many advantages such as supply of good quality green fodder during the dry periods, and high CP and minerals contents (Khan and Habib, 2012; Habib et al., 2013). Recent findings show that tree leaves can be more efficiently utilized as a low-cost CP and minerals supplement to the low-quality fibrous diets in the tropics, particularly during the prolonged feed scarcity periods (Pamo et al., 2007; Patra, 2010).

The utilization of tree leaves in ruminants ration depends on their chemical composition and nutrient digestibility. Recent research show that the chemical composition and ruminal degradability of the leaves have a large variation due to differences in tree species and environmental conditions. For example the ruminal degradability of leaves varied from 11% to 68% among tree species in the semi-arid rangelands of Swaziland (Tefera et al., 2008); from 40% to 78% among tree species in semi-arid regions of northern Egypt (Salem et al., 2007); and from 36% to 80% between different tree species of Nepal (Khanal and Subba, 2001). Fodder trees are one of the dominant surviving fodder species in the arid and semi-arid rangelands of Northern Pakistan, however, to the author's knowledge no systematic research has been conducted to evaluate the nutritional value of tree leaves in ruminants ration. The present study was, therefore, designed to determine the nutrients and mineral profile, *in vitro* digestibility and rumen degradation characteristics of leaves from fodder tree species commonly fed to ruminants in the arid and semi-arid zones of Northern Pakistan. Data on the above characteristics of tree leaves is required for their strategic feeding and supplementation to livestock ration in the region.

2. Materials and methods

2.1. Samples collection and processing

Samples from 21 fodder tree species commonly fed to livestock in semi-arid and arid zones of Northern Pakistan were collected for the present study. Leaves from 13 fodder tree species, namely, *Albizia lebbeck*, *Ailanthus altissima*, *Bauhinia variegata*, *Butea frondosa*, *Celtis australis*, *Ficus carica*, *Grewia oppositifolia*, *Leucaena leucocephala*, *Mallotus philippensis*, *Melia azedarach*, *Morus alba*, *Morus papyrifera and Ziziphus mauritiana* were sampled from semi-arid areas of District Sawabi (34°11′ N latitude, 72°28′ E longitude), Khyber Pakhtunkhwa, Pakistan. Leaves from 8 tree species, namely, *Acacia modesta*, *A. lebbeck*, *Capparis aphylla*, *Olea cuspidata*, *Prosopis juliflora*, *Tecomella undulata*, *Ziziphus jujuba* and *Ziziphus mauritiana* were sampled from arid zone of District Kohat (33°33′ N′ latitude, 71°16 E′ longitude), Khyber Pakhtunkhwa, Pakistan. Within each ecological zone, leaves of each tree species were collected at four sub-locations, from three randomly selected trees. The leaves from each sub-location were pooled by tree species, mixed, and a representative sample of ~5 kg was immediately brought to the Animal Nutrition laboratory of The University of Agriculture Peshawar. Each sample was divided into two portions, one part was immediately frozen and the other part was dried under shade. The dried leaves were ground in a Wiley hammer mill on a 1 mm sieves, and stored in pre-labelled bottles for chemical analysis.

2.2. In vitro dry matter digestibility

The single stage procedure was adopted to determine the *in vitro* DM digestibility (DMD) as reported by Khan et al. (2015a). Briefly, 0.5 g ground tree leaves sample was weighed and transferred to *in vitro* tubes, 40 ml McDougall's buffer (artificial saliva) and 5 ml fresh rumen fluid (microbial culture) were added in each tube. The tubes were incubated in a shaking (20 times/min) water bath for 24 h at 38 °C under anaerobic condition. The DMD of the samples was determined at weekly intervals in a series of successive batches (100 tubes/batch), along with two standard samples with known DMD for adjusting variation among the different batches. For each tree species the *in vitro* DMD was determined in two replicate runs using triplicate tubes within each run.

Fluid was collected from two rumen cannulated dry, Nili–Ravi buffaloes. The animals were fed fresh whole crop maize fodder *ad libitum*, and had 24 h/d access to fresh drinking water. Concentrate mixture (4 kg/day) was fed twice a day (2 kg each time).

2.3. In situ rumen incubations

Three multiparous (~5 years of age), dry, Nili–Ravi buffaloes (400 ± 50 kg body weight), fitted with permanent rumen fistulas (13 cm internal diameter; Bar Diamond, USA) were used for the *in situ* incubation study. The experimental animals were handled and cared according to the guidelines of the Ethical Committee of the University of Agriculture Peshawar. The animals were fed fresh (unensiled) whole crop maize fodder *ad libitum*, with 24 h/d access to fresh drinking water. Concentrate was individually fed twice daily at milking times (2 kg per milking time). The standard method of rumen incubation as described by Khan et al. (2015b) was used to determine the rumen degradation characteristics. Briefly, 5 g of coarsely ground (2 mm particle size) sample of each tree species was weighed into pre-weighed and coded nylon bags (bag size 90×140 mm; porosity 26%; pore size 40 μm). The gradual addition, all-out method was used, and the bags were randomly incubated for 24, 12, 8, 4, 2 and 0 h in the rumen of the three fistulated buffaloes. To hold the bags in the bottom liquid phase of the rumen a large polyester mesh bag (45×45 cm^2, fixed to rumen cannula with a 90 cm long rope), containing a 250 mL plastic bottle filled with gravel, was used. At the end of incubation period the bags were removed from the rumen and immediately rinsed with tap water to remove adhering stuffs, and stored at −20 °C for at least 24 h to stop enzymatic reactions. The frozen bags were thawed and washed in the washing machine (AEG-Electrolux Öko Turnamat 2800, Stockholm, Sweden) for 40 min using tap water at 25 °C. The 0 h bags were washed in the washing machine as described above without incubation in the rumen to determine the washout (*W*) fraction. The washed bags were oven dried to constant weight at 70 °C, and reweighed.

2.4. Calculations

The effective rumen degradability of DM (ED_{DM}) was calculated according to the first-order kinetics equation of Ørskov and