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Anti-nutritional and phytochemical profile of some plants grazed upon by ruminants in North Central Nigeria during the dry season (January to April)

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During the dry season, most plants and grasses dry up and ruminants are left with fewer plants to graze on. The plants available during such periods have relatively lower moisture contents and higher antinutritional factors because of the dry nature of the soil and prevalent atmospheric conditions. Increased levels of antinutritional factors above acceptable values, could have a detrimental effect on the metabolic and health status of animals grazing on such plants. This research work sought to determine the phytochemicals present and the levels of some antrinutritional factors in plants (*Acacia senegal, Parkia biglobosa, Anogeissus leiocarpus, Acacia sieberiana, Vitellaria paradoxum, Tamarindus indica, Ficus carica, Ziziphus spinachristi Dichrostachus cinerea, Ziziphus mucronata*) commonly grazed upon by ruminants in this region, to educate farmers and policy makers on the safety of these plants for ruminant nutrition. The plants were collected and identified, while phytochemical and anti-nutritional profiles were analyzed using standard spectrophotometric procedures. Quantitative antinutritional factors analysis showed that the level of oxalate varied from 15 to 180 mg/100 g, phytic acid from 23.51 to 53.41 mg/100 g and tannins from 0.486 to 1.850 mg/100 g, which are within internationally accepted permissible limits. Results of qualitative phytochemical analysis showed that flavonoids, tannin, cardiac glycosides and steroids were present in all the plants, while anthraquinones were absent. The results suggest that the browse plants in this location contain anti-nutrients at relatively low levels which make these plants safe for ruminant consumption.

Key words: Plants, antinutritional factors, phytochemicals, grazing ruminants

INTRODUCTION

There is a wide distribution of biologically active constituents throughout the plant kingdom, particularly in plants used as feed by ruminants (Tutelian and Lashneva, 2013). The knowledge that these plant compounds elicit both beneficial and detrimental biological responses has given rise to several investigations in recent times as to their possible physiological implications in various biological systems

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Table 1. Anti-nutritional factors present in the browse plants.

Sample	Oxalate (mg/100 g)	Phytic acid (mg/100 g)	Tannins (mg/100 g)
Acacia senegal	410.00 ± 25.20	51.13 ± 1.23	0.978 ± 0.02
Parkia biglobosa	310.00 ± 17.61	43.37 ± 1.18	1.216 ± 0.14
Anogeissus leiocarpus	485.00 ± 22.41	50.22 ± 2.12	5.714 ± 0.57
Acacia sieberiana	15.00 ± 2.12	47.93 ± 1.11	0.488 ± 0.01
Vitellaria paradoxum	200.00 ± 7.24	53.41 ± 1.84	1.112 ± 0.11
Tamarindus indica	820.00 ± 34.20	29.22 ± 0.85	0.559 ± 0.01
Ficus carica	235.00 ± 8.23	53.41 ± 1.27	0.665 ± 0.02
Ziziphus spinachristi	190.00 ± 6.41	49.53 ± 2.04	1.486 ± 0.19
Dichrostachus cinerea	520.00 ± 17.93	51.59 ± 1.19	1.253 ± 0.11
Ziziphus mucronata	220.00 ± 7.52	23.51 ± 0.64	1.850 ± 0.23

(Njidda, 2010).

Anti-nutritional factors (ANF) are substances that when present in feed, reduce the availability or utilization of one or more nutrients, thereby altering the expected nutritional status of animals. The level of ANF in plants plays a major role in determining their safety in ruminant feeding (Akande et al., 2010). ANF includes saponins, tannins, flavonoids, alkaloids, trypsin inhibitors, oxalates, phytates, lectins, cyanogenic glycosides, cardiac glycosides and coumarins (Yankey et al., 2012). The mechanisms by which ANF exhibit their anti-nutritional effects differ including affecting the digestibility of protein and thus protein bioavailability (Sarwar et al., 2012), complexing with metaloenzymes cofactors and complexing with membrane sterols, resulting in increased permeability of the intestinal mucosa (Jamur and Oliver, 2010) among others.

During the dry season, most plants and grasses dry up and animals are left with a few plants to graze (Njidda, 2010). The plants have relatively lower water contents and higher ANF concentrations because of the dry nature of the soil and atmospheric conditions. Such increased levels of ANF could have an implication on the metabolic and health status of animals grazing on such plants, thus necessitating this study. Some of the plants commonly grazed upon by ruminants in North Central Nigeria are *Acacia senegal, Parkia biglobosa*, *Anogeissus leiocarpus*, *Acacia sieberiana*, *Vitellaria paradoxum*, *Tamarindus indica*, *Ficus carica*, *Ziziphus spinachristi Dichrostachus cinerea*, *Ziziphus mucronata*.

METHODOLOGY

Ten browse plants (*A. senegal, P. biglobosa*, *A. leiocarpus*, *A. sieberiana*, *V. paradoxum*, *T. indica*, *F. carica*, *Z. spinachristi D. cinerea*, *Z. mucronata*) were collected from pastures in Plateau and Bauchi States, Northern Nigeria and identified with voucher number deposited at the herbarium of the Ahmadu Bello University, Zaria. The plants collected were washed thoroughly and air dried, after which they were ground to powder using a Pertern laboratory mill. The powdered plant samples (100 g) were weighed into sterilized conical flasks and 1000 ml of deionized water was poured into the flask. The contents of the flasks were shaken; the top was covered with aluminium foil and kept at ambient temperature for 48 h (2 days) after which the extracts were obtained by filtering using clean cloth with fine pore. The extracts were then concentrated in crucibles using water bath set at a temperature of 45°C. Quantitative antinutritional levels were determined in triplicates. Phytochemical screening was carried out using standard procedures of Harbone (1973), Trease and Evans (1978), El-Olemyl et al. (1994) and Wall et al. (1954). Saponins and total condensed tannin were quantitatively determined as reported by Babayemi et al. (2004) and Polshettiwar et al. (2007) respectively.

RESULTS AND DISCUSSION

The results from Table 1 revealed that the browse plants selected contained varrying concentration of oxalate, phytic acid and tannins. Oxalic acid is a primary toxic constituent in many plants. Although oxalate may play various roles in plants including calcium regulation, ion balance, plant protection, tissue support, and heavy metal detoxification, oxalates also affect *in vivo* calcium and magnesium metabolism by complexing with these metals and reducing their bioavailability and utilization (Franceschi and Nakata, 2005). Excessive intakes of oxalic acid can cause diarrhoea, gastroenteritis and renal damage (Roop-Ngam et al., 2012).

Oxalates also react with proteins to form complexes which have an inhibitory effect on peptic digestion (Ji and Peng, 2005). Chemical analysis carried by Alabi et al., (2005) reported oxalate concentration in locust bean seed, pulp and cotyledon as 4.96, 3.40 and 1.15 mg/100 g respectively. The recommended safe limit for oxalates in ruminants is $<2\%$ (Sidhu et al., 2014). The oxalate values obtained for the selected values lie below 2%, thus suggesting that oxalate concentration in these plants are within the safe range.

The analysis results for phytate in the plants showed that *V. paradoxum*, *F. carica* and *A. senegal* had the highest levels of 53.41 mg/100 g, 53.41 mg/100 g and 51.13 mg/100 g respectively. Phytic acid is the acid form of the anion phytate (myo-inositol hexa phosphate). Phytic acid can not be hydrolysed by enzymes secreted

Table 2. Phytochemical profile of the browse plants (aqueous and organic solvent extracts).

Plant	Flavonoids	Tannin	C/glycosides	Steroid	Alkaloid	Saponin	Anthra-quinone
Acacia senegal (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Acacia senegal (Aqueous)	+ve	+ve	+ve	+ve	+ve	-ve	-ve
Parkia biglobosa (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Parkia biglobosa (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Anogeissus leiocarpus (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Anogeissus leiocarpus (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Acacia sieberiana (Methanol)	+ve	+ve	+ve	+ve	+ve	+ve	-ve
Acacia sieberiana (Aqueous)	+ve	+ve	+ve	+ve	+ve	-ve	-ve
Vitellaria paradoxum (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Vitellaria paradoxum (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Tamarindus indica (Methanol)	+ve	+ve	+ve	+ve	-ve	-ve	-ve
Tamarindus indica (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Ficus carica (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Ficus carica (Aqueous)	+ve	+ve	+ve	+ve	-ve	-ve	-ve
Ziziphus spinachristi (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Ziziphus spinachristi (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Dichrostachus cinerea (Methanol)	+ve	+ve	+ve	+ve	-ve	-ve	-ve
Dundu (Aqueous)	+ve	+ve	+ve	+ve	-ve	-ve	-ve
Ziziphus mucronata (Methanol)	+ve	+ve	+ve	+ve	-ve	+ve	-ve
Ziziphus mucronata (Aqueous)	+ve	+ve	+ve	+ve	-ve	+ve	-ve

into the gut by mammals (Poulsen et al., 2001). The primary functions of phytate in seeds are storage of phosphates and as an antioxidant for the germinating seed (Raboy, 2007).

Although phosphorus is present in phytic acid, it has a low bio-availability because phytate can form complexes with a variety of minerals, including calcium, copper, cobalt, icon, magnesium, manganese, selenium and zinc, thus reducing the availability of these nutrients (Torres et al., 2005). Phytic acid can also form complexes with basic residues of proteins thereby interfering with the activity of endogenous enzymes and associated metabolic pathways (Torres et al., 2005).

Tannins are polyphenolic compounds capable of precipitating alkaloids and gelatine as well as other proteins from aqueous solutions. *A. leiocarpus*, *Z. mucronata* and *Z. spinachristi*, contained the highest tannin levels of 5.714 mg/100 g, 1.850 mg/kg, and 1.486 mg/kg respectively. Tannins form complexes with proteins and carbohydrates in feed, it also complexes with digestive enzymes and as a result nutrient digestibility is depressed (Wischer et al., 2013). In sheep and cattle, dietary tannin levels of 2 and 5% respectively have been reported to have adverse effects on digestibility (Okoli et al., 2003). However, at lower concentration levels, tannins have been reported to have two general traits that are relevant to grazing ruminants. They are prevention of bloat (McMahon et al., 2000) and suppression of internal parasites (Hoste et al., 2006). In this study the highest tannin level of 5.714 mg/100 g obtained is far much lower than even 1%, thus making it to be more of beneficial than deleterious.

Results for qualitative phytochemical analysis in Table 2 showed that flavonoids, tannin, cardiac glycosides and steroids were present in all the plants, saponin and alkaloids were present only in some of the plants, while anthraquinones were absent in all plants.

Apart from geographical location, plant composition of flavonoids is largely dependent on the plant species, developmental stage and key ecological influences of both biotic and abiotic origin (Iwashina, 2010). The best studied property of flavonoids is their capacity to act as antioxidants protecting the body against reactive oxygen species mediated oxidative stress (Santhosh and Suriyanarayanan, 2014). The presence of flavonoids in all browse plants selected is interesting, as ruminants fed on forages containing moderate amounts of flavonoids show reduced methane gas emission, which decreases the chances of a digestive disorder, known as bloat (Mouradov and Spangenberg, 2014).

Cardiac glycosides are secondary metabolites in several plants used in the treatment of congestive heart failure and cardiac arrhythmia. This beneficial property is attributed to increasing intracellular calcium, increased force of contraction, resulting in increased cardiac output (Vetter, 2000). Cardiac glycosides presence in the plants could enhance cardiovascular health of the grazing ruminants.

Saponins were found in some of the selected browse plants. Saponins are common in a large number of plants and plant products that are important in animal nutrition. A number of biological effects have been ascribed to saponins including altering membrane permeability, hypocholesterolaemic and anticarcinogenic properties. They have been found to significantly affect growth, feed intake, protein digestion, nutrient uptake and reproduction in animals (Francis et al., 2002). Their antinutritional properties seem related to their ability to form complexes with sterols, in particular those in membranes of animal cells, resulting in increased permeability of the intestinal mucosa (Podolak et al., 2010).

Alkaloids were found in some of the selected plants, and are known to contain nitrogen in a heterocyclic ring and often have a bitter taste. Alkaloids are present in many plants and are thought to serve as a chemical defence against herbivores. Alkaloids are oxidized in the liver resulting in metabolites, such as dehydrosparteine, which are responsible for their associated toxicity. The level of toxicity is influenced by the structure of the alkaloids (Kittakoop et al., 2014).

Anthraquinones were not found in the browse plants selected. Anthraquinones are a group of functionally diverse chemicals structurally related to anthracene. Due to the close similarity in structure between anthraquinones and the toxic analogue; anthracene, there is concern over the potential damage which these compounds may cause, which is reported to include toxicity and carcinogenicity (Sendelbach, 1989).

The results obtained from our study are similar to published results on antinutritional levels of browse plants in North-Eastern Nigeria (Njidda, 2010) as well as in South-Eastern Nigeria (Okoli et al., 2003). Both researchers analyzed and reported tolerable levels of anti-nutrients in commonly browsed plants sampled, thereby suggesting their safety for use in ruminant feeding.

Conclusion

The browsed plants selected and analyzed in this study were found to have some beneficial components including flavonoids. The levels of ant nutritional factors obtained were relatively low and within safe limits, thus making these plants safe and suitable for animal consumption. It is thus safe for Herdsmen in North Central Nigeria, to allow ruminants graze on the studied trees during the dried season.

Conflict of Interests

The authors have not declared any conflict of interests.

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