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Biochemical Profiling of the Values of Dry Season Feed Resources in Pastoralcattle Environment in Nigeria

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ABSTRACT

The objective of the study was to evaluate the chemical composition of the most cherished crop residues, browses and water resources for cattle production during the dry season in Adamawa State, North-Eastern Nigeria. The identification of feed and water resources were done by questionnaires, interview and direct field observation. The most cherished feed resources from each location were collected and used for proximate analysis and fibre partitioning. Water samples were collected at random from three (3) different sources (hand pump borehole, well and stream) across the State for chemical analysis. The results of proximate composition and fiber partition of the most preferred crop residues at the study locationsshow high mean DM at 94.90±0.92%, with a range of 93.7 - 96.2%, indicating that the materials are very dry and that animals consuming them will require high water supplementation.The mean crude fibre (CF) was 37.98±7.82%, with maize straw recording the highest value of 45.5%, while the range was between 26.1 to 45.3%.The mean ether extract (EE) value stood at 1.70±0.30% with a range of 1.30 - 2.10%, indicating very low EE values of these crop residues.The mean ash value of 10.64±2.04 was high, with values ranging from 8.9 to 10.7%. The results showed mean nitrogen free extract (NFE) of 48.10±7.82% with a range of 35.4 to 56.5%, indicating high carbohydrate content although most of it may not be available to the animals due to rapid lignifications that accompany maturation of the straws.The mean neutral detergent fibre (NDF) of the crop residues was 55.62±11.86% with a range of 45.7% recorded by groundnut haulm to 75.5% recorded by maize straw.The mean acid detergent fiber (ADF) was 42.14±9.55%, with values ranging from 34.8 to 57.7%.The mean ADL was 5.78±3.26, with a range of 3.2 to 9.4%. Lignin is the prime factor influencing the digestibility of plant cell wall material.The results showed the mean HEM of 13.48±3.22%, with a range of 10.90 to17.80%, indicating that maize and sorghum straws have much higher digestible carbohydrates than the other crop residues. The mean DM content of the most preferred browses during dry season was 89.78±3.99% with the range of 84.90 to 94.24%.The mean crude protein of the preferred browse plants was 13.96±3.08% with a range of 9.35 - 16.73%.The mean crude fiber content of the browses was 26.93±3.45%. Panicum maximum recorded the highest crude fibre (CF) content of 32.50% followed by Mangiferaindica with 27.46%, while Khayasenegalensis had the lowest CF of 23.53%.The results of mean ether extract (EE) was 5.52±1.56%, withKhayasenegalensis having the highest value of 6.72%, followed by Balaniteaegyptica with 6.71%, while the lowest value of 2.89% was recorded by Panicum maximum.The mean ash value of the browse plants was 10.41±1.97%, with a range of 7.74 - 13.25%.Mangiferaindica had the highest value of 13.25% followed by Khayasenegalensis with 10.70% and the least value of 7.74% was recorded by Tamarinaeindica.The mean nitrogen free extract (NFE) was 49.66±1.87%, with a range of 47.67 - 52.45%. Panicum maximum recorded the highest value of 52.45% followed by Balaniteaegyptica with 50.23%, with Tamarinaeindica having the least value of 47.67%. Crop residue had significantly ($p<0.05$) higher DM, CF and NDF compared to browses. While, browses had significantly ($p<0.05$) higher CP, EE, ADL and HEM than crop residues, indicating that browses may be the best stable feed that could be used for nutritional intervention during the critical periods of dry season when forage grasses have been grazed to defund and crop residues have lost most of their nutrients.The concentration of chemicals in the water from the hand dug wells were higher than that of streams and the hand pump operated borehole water. However, the results were within the World Health Organization's (WHO) permissible values. Therefore, it was deduced that, the water sources in the study area are of good quality, safe and recommended for livestock and human consumption.

Keywords: *Nutrient, Resources, Pastoral Cattle, Dry Season, Nigeria.*

INTRODUCTION

The best way to evaluate feed and water quality is animal performance while intake, digestibility and efficiency of utilization are characteristics of feed and water that determine animal performance (Mertens, 1994). Chemical property of feed that have been linked with intake and digestibility are fibre, lignin and protein which are used increasingly to predict animal performance (Cherney and Mertens, 1998). Therefore, a systematic chemical characterization of feed for cattle must include determination of fibre, lignin, protein and critical to this is an accurate dry matter (DM) content determination (Adegbola, 1985 and Alhassan *et al*., 1987). To consolidate this assertion, Okoli *et al*. (2003) stated that, proximate analysis of feed is specifically useful, in screening the array of tropical browse plants utilized by indigenous farmers for ruminant feeding. Also earlier research has shown that, chemical analysis of feed provides valuable information about the actual chemical constituents influencing digestion (Van Soest, 1994).

The chemical parameters useful for water quality assessment are determined by the presence of both organic and inorganic compounds that are either suspended or dissolved in it while some of these compounds are toxic to the ecosystem (Boukori *et al*., 1999). Water quality is made up of physical, chemical and biological factors which influence the use of water for human and livestock purposes (Kubkomawa and Williams, 2010). These factors include dissolved oxygen, pH, hardness, turbidity, alkalinity, ammonia, calcium, potassium, magnesium and temperature (Akitoye *et al*., 2014). The quality of a water resource depends on the management of anthropogenic discharges as well as the natural chemical characteristics of the catchment areas (Efe*etal*, 2005; Saba and Baba, 2004). Also, depending on the geology of an area, underground waters are typically rich in dissolved solids especially carbonates and sulphates of calcium and magnesium. Other ions may also be present including chlorides and bicarbonates. Hence, it is necessary to obtain chemical characteristics of water so as to monitor water quality and to determine the type of treatment that may be required before use (Odigure and Adeniyi, 2001). The objective of the study was to evaluate the chemical composition of the most cherished crop residues, browses and water resources for cattle production during the dry season in Adamawa State, North-Eastern Nigeria.

MATERIALS AND METHODS

Study Area

Adamawa State is located at the area where the River Benue enters Nigeria from Cameroon Republic and is one of the six states in the North-East geopolitical zone of Nigeria. It lies between latitudes 7^0 and 11^0North of the Equator and between longitudes 11^0 and 14^0 East of the Greenwich Meridian (Mohammed,1999). It shares an international boundary with the Republic of Cameroon to the east and interstate boundaries with Bornoto the North, Gombeto the North-West and Tarabato the West and South(Adebayo, 1999; ASMLS, 2010a; ASMLS, 2010b), as can be seen in Figure I.

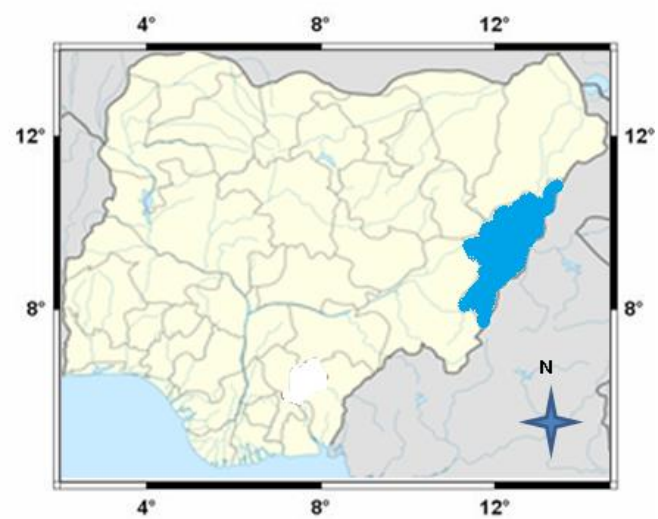

Figure1. *Map of Nigeria showing Adamawa state, the study area in blue*

The State has minimum and maximum rainfall of 750 and 1050mm and an average minimum and maximum temperature of 15^0C and 32^0C, respectively. The relative humidity ranges between 20 and 30% with four distinct seasons that include: early dry season (October – December); late dry season (January – March); early rainy season (April – June) and late rainy season (July – September) (Adebayo, 1999). The vegetation type is best referred to as guinea savannah (Areola, 1983; Adebayo and Tukur, 1997). The vegetation is made up of grasses, aquatic weeds along river valleys and dry land weeds inter-spaced by shrubs and woody plants. Plant heights ranges from few centimeters (Short grasses) to about one meter tall (tall grasses), which form the bulk of animal feeds.

Cash crops grown in the state include cotton and groundnuts, sugar cane, cowpea, benni seed, bambara groundnut, tiger nut, while food crops include maize, yam, cassava, sweet potatoes, guinea corn, millet and rice. The village communities living on the banks of rivers engage in fishing, while the Fulani and other tribes who are not resident close to rivers are pastoralists who rear livestock such as cattle, sheep, goats, donkeys, camels, horses and poultry for subsistence (Adebayo and Tukur, 1997; Adebayo, 1999).

Study Site

Three Local Government Areas, one from each of the three senatorial districts in the state were chosen for the study. The Local Government Areas were purposively selected to cut across the State which represents the pastoral zones with higher number of cattle producers in the State (Adebayo, 1999). The study areas include MubiNorth (Northern Senatorial Zone), Gombi (Central Senatorial Zone) and Jada LGAs (Southern Senatorial Zone) as shown in Figure II.

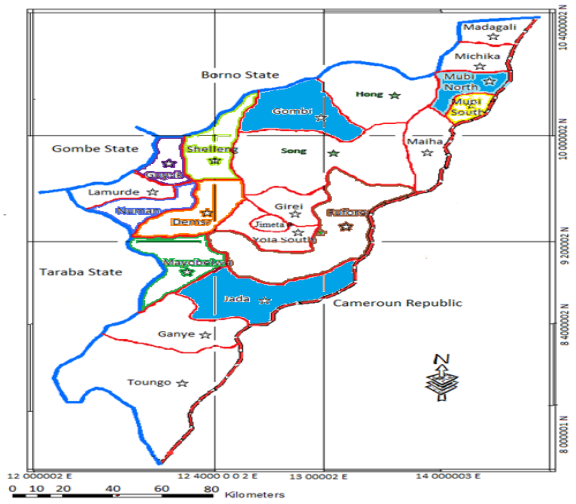

Figure2. *Map of Adamawa state showing the three study LGAs in blue*

Data Collection

The study was carried out between 2013 and 2014 and identification of feed and water resources were done by questionnaires, interview, kraal visits and direct field observation for at least two hours in the morning during grazing. About 500mg samples each of 10 most cherished feed resources from each location were collected and used for proximate analysis and fibre partitioning. The browse species were identified with the assistance of a botanist using Hausa, English and botanical names at the Department of Botany, Adamawa State University, Mubi and samples were deposited in the University herbarium.

Dry Matter (DM) Content:

The browse and crop residues identified as being dry season feed resources for cattle were collected (fresh or dry). The fresh samples were dried inside the Laboratory for 4 - 5 days to avoid lose of some nutrients. After drying, the samples were ground to gritty powder using muter and passed through a 1mm sieve. A quantity of 0.5Kg of each sample was preserved inside a sealed tube, labeled and stored for subsequent proximate analysis. Feed samples were analyzed for dry matter content in accordance with the methods of Association of the Official Analytical Chemists (AOAC, 1995; AOAC, 2004). Dry matter content for each sample was determined by oven-drying 3g at 105° C for 24 hours.

Crude Protein (CP):

Samples of the feeds were analyzed for nitrogen (crude protein) in accordance with the Kjeldahl method (AOAC, 1995).Crude protein were determined by measuring the nitrogen content of the feed and multiplying it by afactor 6.25.

Ash

About 3 grammes of each of the samples were analyzed for ash determination by complete combustion at 550^0 C in a furnace for 3 hours according to the methods of Association of the Official Analytical Chemists (AOAC, 1995; AOAC, 2004).

Fiber

Fibre was analyzed by the trichloroacetic acid (TCA) digestion as described in the methods of Association of the Official Analytical Chemists (AOAC, 1995; AOAC, 2004).

Ether Extract

Ether extract was determined by dry soxhlet method for fat extraction as stated in the methods of the Association of the Official Analytical Chemists (AOAC, 1995; AOAC, 2004).

Nitrogen Free Extract (NFE)

NFE was obtained by subtracting the sum ofpercentages of all the nutrients already determined from 100. That is by using the formular %NFE = DM - (% Ash + %CF = %EE + %CP).

Detergent System of Fiber Analysis (NDF, ADF and ADL)

This system was developed by Van Soest*et al*. (1991), and so is also referred to as the Van Soest system. This method separates cell contents from cell wall constituents which consist of hemicelluloses, cellulose, lignin and heat damaged protein.

Neutral Detergent Fiber (NDF)

This was carried out by boiling a sample of dry forage feed and refluxed in a neutral detergent solution (consisting of sodium lauryl sulphate, disodium dihydrogen ethylene amine tetra-acetate and phosphate buffer) after which, soluble carbohydrates, proteins and fats were extracted as described by Van Soest *et al*. (1991). The residue, which is mainly hemicelluloses, cellulose and lignin are components of the plant cell wall and is referred to as "neutral detergent fiber" (NDF).

Acid Detergent Fiber (ADF)

This was also carried out by boiling a sample of dry forage feed and refluxed in an acidified detergent solution (consisting mainly of cetyl trimethyl ammonium bromide in sulphuric acid); soluble carbohydrates, proteins, fats and hemicelluloses are extracted into solution as described by Van Soest *et al*. (1991). The residue, which is mainly cellulose and lignocelluloses is referred to as "acid detergent fiber" (ADF).

Acid Detergent Lignin (ADL or lignin)

Percentage acid detergent lignin (ADL) or lignin content was obtained by finding the differences between NDF and ADF values as described by Church (1991). However, van Soests' detergent method also provides a means of determining cellulose and lignin by digesting the ADF with 72% H_2SO_4.

Water Samples and Parameters

Water samples were collected at random from three (3) different sources (hand pump borehole, well and stream) across the state. The samples were collected the same day and kept in a refrigerator at the temperature of 0^0c to avoid subsequent contamination. The samples were taken to the laboratory for analysis within 24 hours. The water samples were analyzed for calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Copper (Cu), and Lead (Pb), which are considered critical for water quality in Adamawa State. The concentration of the alkali and alkaline metals (Na, Mg, K, Ca,) were determined in mg/litre. The trace elements (Cu and Pb) were also determined in Ug/litre due to their lower concentrations.

Analysis of Metals in Samples

Bulk 210 GP automatic absorption spectrophotometer was used for the major elements (Ca, Na, K, and mg), whereas Flame photometer was used for the minor elements (Cu and Pb). Other instruments used include digital P^H meter, normal parameters for Air/Acetylene flame according to WHO (1993).

Data Analysis

All survey data generated in this study were subjected to descriptive statistics such as frequencies and percentages.

RESULTS AND DISCUSSION

Chemical Characteristics of the Most Preferred Crop Residues and Browses during Dry Season in Adamawa State

It has been observed from this study that adequate nutrient supply, as a factor of production is a major constraint to cattle productivity in the study area. It has also been observed that cereal residues such as cowpea and groundnut haulms, sorghum, maize and rice straws and browse plants are the most considered alternatives to forage grasses for sustenance of ruminant animals during the critical off season periods. Based on this, the proximate composition of the agro-residues and browse leaves commonly utilized by the farmers during the dry season were determined. This was done in order to evaluate the appropriateness of the farmers preferences of these feeding materials since data generated from such experiments could inform policy on material to further develop for use by the farmers during those critical periods (Okoli *et al*., 2003).

Chemical Characteristics of the Most Preferred Crop Residues

Crop residues which are post-harvest materials or roughages left after the removal of the primary feed (grain) from crop plants constitute important feed for ruminants during the long dry season. In northern Nigeria, cereal residues such as cowpea and groundnut haulms, sorghum, maize straws and rice straws are the most important quantitatively are regularly used ruminant feeding.

Proximate Composition

Table 1a showed the proximate composition and fiber partition of the most preferred crop residues at the study locations. Mean DM was high at 94.90±0.92%, with a range of 93.7 - 96.2%, indicating that the materials are very dry and that animal consuming them will require high water supplementation. There may therefore be the need for pre-moistening/wetting or mixing of these crop residues with other high moisture materials such as molasses before offering them to the animals in order to improve their palatability and nutrient release (Okoli *et al*., 2009). The findings fall within the reference values for tropical crop residues and corroborate that of Onaleye *et al*. (2012), who reported similar DM content of crop residues in neighboring Taraba State, Nigeria to range from94.25 to 95.29%.

Table1. *Proximate composition (%) of the most preferred dry season crop residues in Adamawa state*

Parameters	Maize Straw	Sorghum Straw	Rice Straw	Cotton Haulm	Ground nut Haulm	Means/SD	Range
(a) Proximate Composition							
DM (%)	95.30	94.60	93.70	94.70	96.20	94.90±0.92	93.70 - 96.20
CP (%)	7.50	5.20	4.50	9.80	9.10	7.22±2.33	4.50 - 9.80
CF (%)	45.50	41.20	42.80	34.30	26.10	37.98±7.82	26.10 - 45.50
EE (%)	1.30	2.10	1.80	1.50	1.80	1.70±0.30	1.30 - 2.10
ASH (%)	10.00	8.90	9.50	14.10	10.70	10.64±2.04	8.90 - 14.10
(b) Fiber Partition							
NFE (%)	49.20	56.50	47.90	35.40	51.50	48.10±7.82	35.40 - 56.50
NDF (%)	75.50	52.80	56.30	47.80	45.70	55.62±11.86	45.70 - 75.50
ADF (%)	57.70	36.70	45.00	36.50	34.80	42.14±9.55	34.80 - 57.70
ADL (%)	3.20	3.40	3.60	9.40	9.30	5.78±3.26	3.20 - 9.40
HEM (%)	17.80	16.10	11.30	11.30	10.90	13.48±3.22	10.90 - 17.80

Note: Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE)

However, studies have shown some contradictory results such as Okah *et al*. (2012), who reported lower dry matter content of some crop residues in Southern Nigeria to range from 89.85 to 90.73%. The mean crude protein (CP) value of crop residues at 7.2% was low, with the range of 4.5 - 9.8%. The CP of 7.5, 9.1 and 9.8% obtained in maize straw, cowpea husk and groundnut hump are however high enough to support rumen microbial activities and energy supply, while sorghum straw and rice straw are too poor to be used alone in animal feeding. The results corroborate that of Onaleye *et al*. (2012), who reported similar CP of crop residues in neighboring Taraba State, Nigeria to range from 7.64 to 14.43%. Again, the findings support report of Malau-Adulia *et al*. (2004) on CP of some crop-residues in Zaria, Kaduan State,

Nigeria. Nonetheless the results disagree with that of Bogoro *et al*. (1994), who reported CP of groundnut haulm to be 10.1%, while Aregheore (2000) reported lower CP of crop residues and agro-industrial by-products in four pacific islandcountries, indicating differences in nutrient content of crop residues across different geographical locations.

The mean crude fibre (CF) was 37.98±7.82%, with maize straw recording the highest value of 45.5%, while the range was between 26.1 to 45.3%. High CF in feed may be detrimental to animal digestion since it represents insoluble carbohydrate e.g. alkali insoluble lignin, as well as fibre bound nitrogen and cellulose. There is however the need to partition these into beneficial and non nutritionally beneficial fibers. The results corroborate the earlier study of Onaleye et *al*. (2012), who reported CF of crop residues in Jalingo, Taraba State, Nigeria to range from 13.40 to 34.23%. Alhassan *et al.* (1986) also reported similar CF of maize and sorghum straw to be 46.2 and 41.1% respectively.

The mean ether extract (EE) value stood at 1.70±0.30% with a range of 1.30 - 2.10%, indicating very low EE values of these crop residues. The results are again similar to the findings of Okah *et al*. (2012), who reported analogous ether extract of some crop residues in Southern Nigeria to range from 1.84 to 2.73, while Aregheore (2000) reported lower EE of crop residues and agro-industrial by-products in four pacific islandcountries.

The mean ash value of 10.64±2.04 was high, with values ranging from 8.9 to 10.7%. Since the ash proximate composition represents the mineral content of the feed or forage this high ash could be of value in other agricultural applications such as straw treatment to improve their nutrient (Malau-Adulia *et al*., 2004). Adegbola (2002), Ngele (2008) and Bogoro *et al.* (1994), also reported similar ash content of rice straw and groundnut haulm respectively in Bauchi, northeastern Nigeria.

The results showed mean nitrogen free extract (NFE) of 48.10±7.82% with a range of 35.4 to 56.5%, indicating high carbohydrate content although most of it may not be available to the animals due to rapid lignifications that accompany maturation of the straws. Onaleye *et al*. (2012) reported similar NFE values (35.36 to 57.27%) in crop residues produced at Jalingo, Taraba State. Okah et *al*. (2012) also reported NFE of some crop residues from Southern Nigeria to range from 53.27 to 55.18%, indicating that higher carbohydrate values because of location of production.

Fiber Partition

Table 1b shows that the mean neutral detergent fibre (NDF) of the crop residues was 55.62±11.86% with a range of 45.7% recorded by groundnut haulm to 75.5% recorded by maize straw. NDF is the total cell wall which comprises the ADF fraction and hemicellulose. NDF fraction is therefore reflects the amount of forage the animal can consume and increases as dry matter intake decreases. The level of NDF in the animal ration also influences the time of rumination, although the concentration of NDF in feeds is negatively correlated with energy concentration (Ngele, 2008). The high NDF content of some crop residues in this study is probably due to longer time required for crop maturity in the study area that provides opportunity for fibre accumulation in plant tissues. The results agree with Onaleye et *al*. (2012), who reported NDF of crop residues in Jalingo, Taraba State, Nigeria to range from 27.61 to 70.91%.

The mean acid detergent fiber (ADF) was 42.14±9.55%, with values ranging from 34.8 to 57.7%. The ADF value refers to the cell wall portions of the forage made up of cellulose and lignin. ADF values relate to the ability of an animal to digest the forage. As ADF increases the digestibility of the forage decreases (Yitaye*et al*., 2001). The findings are again similar to that of Onaleye *et al*. (2012), who reported that ADF of crop residues at Jalingo, Taraba State, Nigeria ranged from 20.54 to 37.02%. Since the ADF values were high, strategic supplementation with protein from other sources is important to maintain optimum feed intake in animals grazing on crop stubbles in the study area.

The mean ADL was 5.78±3.26, with a range of 3.2 to 9.4%. Lignin is the prime factor influencing the digestibility of plant cell wall material. As it increases, the digestibility, intake and animal performance usually decreases. As

the percent of lignin increases, the percentage of ADF and NDF also increases in forages (Mohammed *et al*., 2001). The results agree with Onaleye *et al*. (2012), who reported ADL of crop residues in Jalingo, Taraba State, Nigeria to range from 3.16 to 9.33%. However, the values from this study are higher than those reported by Adebowale (1992).

The results showed the mean HEM of 13.48±3.22%, with a range of 10.90 to17.80%, indicating that maize and sorghum straws have much higher digestible carbohydrates than the other crop residues. Again, the findings fell within the reference values for tropical crop residues and corroborate that of Onaleye *et al*. (2012), who reported similar DM content of crop residues in neighboring Taraba State, Nigeria to range from94.25 to 95.29%.

Proximate Composition and Fiber Partition of (%) of the Most Preferred Browses During Dry Season

Proximate Composition

The results showed mean DM content of the most preferred browses during dry season was 89.78±3.99% with the range of 84.90 to 94.24% as presented in table 2a. The *Balaniteaegyptica* with 84.90% DM and therefore 15.10% moisture content was not properly dried and grow mold if stored for extended period. The results however fell within the reference values for tropical browse crops and agree with Gidado *et al*. (2013), who reported similar mean dry matter (MDM) content of some browse species in Taraba State to be 86.97%. These values are much higher than the mean dry matter value of 65.1 % reported by Carew *et al*. (1980) for browse plants in the derived savannah area of Nigeria.

Table2. *Proximate composition (%) of the most preferred browses during dry season in Adamawa State*

Parameters	*B. Egypt*	*K. Senegalensis*	*T. Indica*	*P. Maxim*	*M. Indica*	Means/SD	Range
(a) Proximate Composition							
DM (%)	84.90	88.60	87.64	93.54	94.24	89.78±3.99	84.90 - 94.24
CP (%)	14.71	16.73	16.50	9.35	12.54	13.96±3.08	9.35 - 16.73
CF (%)	26.37	23.53	24.80	32.50	27.46	26.93±3.45	23.53 - 32.50
EE (%)	6.71	6.72	5.62	2.89	5.67	5.52±1.56	2.89 - 6.72
ASH (%)	10.53	10.70	7.74	9.87	13.25	10.41±1.97	7.74 - 13.25
NFE (%)	50.23	49.70	47.67	52.45	48.27	49.66±1.87	47.67 - 52.45
(b) Fiber Partition							
NDF (%)	48.50	40.20	43.26	64.50	47.00	48.69±9.41	40.20 - 64.50
ADF(%)	22.64	19.60	23.25	39.40	34.53	27.88±8.57	39.40 - 19.60
ADL (%)	5.62	5.61	5.44	9.61	13.45	7.94±3.54	5.44 - 13.45
HEM(%)	25.90	20.60	20.00	25.90	12.50	20.98±5.50	12.50 - 25.90

Note: *Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE);*

The mean crude protein of the preferred browse plants was 13.96±3.08% with a range of 9.35 - 16.73%. *Khayasenegalensis* had the highest CP of 16.73% followed by *Tamarinaeindica* with 16.50%, while the least was recorded by *Panicum maximum* (9.35%) which actually is a grass but was selected by the farmers for unknown reasons. Therefore, all browse plants have a reasonable quantity of crude protein which can be used in cattle production. The results agree with that of Njidda (2010), who reported similar CP content of semi-arid browse forages of North-Eastern Nigeria. Omoniyi *et al*. (2013) also reported *P. maximum* a tropical natural grass in humid and sub humid regions of Nigeria to have 9.27%, while *M. aegyptia* was reported to yield 19.63% CP. Norton (2003) also justifies the use of browse forages in small quantities in order to supplement poor quality pastures and crop residues.

The mean crude fiber content of the browses was 26.93±3.45%. *Panicum maximum* recorded the highest crude fibre (CF) content of 32.50% followed by *Mangiferaindica* with 27.46%, while *Khayasenegalensis* had the lowest CF of 23.53%. The crude fiber content of the various browse plants is within the range of 15 - 20% CF recommended for improved intake and production in finishing ruminants since it represents insoluble carbohydrate such as alkali insoluble lignin, fibre bound Nitrogen and cellulose (Buxton, 1996).

The results of mean ether extract (EE) was 5.52±1.56%, with *Khayasenegalensis* having the highest value of 6.72%, followed by

Balaniteaegyptica with 6.71%, while the lowest value of 2.89% was recorded by *Panicum maximum*. Ether extracts content of browses in this study fell within the range of 4 – 10% EE recommendation (Preston, 1995 and Campbel *et al.*, 2006). The results agree with that of Njidda (2010), who reported a range of 2.00 to 5.00% for EE of Northeastern Nigerian browse forages. The value for all the browse species in this study are higher than the 3.0% reported by Dibal (1991) and Ifut (1982) in semi-arid Northeastern Nigeria and for browse plants in Western Nigeria.

The mean ash value of the browse plants was 10.41±1.97%, with a range of 7.74 - 13.25%.*Mangiferaindica* had the highest value of 13.25% followed by *Khayasenegalensis* with 10.70% and the least value of 7.74% was recorded by *Tamarinaeindica*. The results agree to that of Njidda (2010), who reported a range of 8.00 to 18.00% for ash of northeastern Nigerian browse forages. Omoniyi *et al*. (2013) also reported that ash content in *M. indica* was higher (13.66%) than other plants. In Southern part of Nigeria, Ahamefule *et al*. (2006), reported ash content of heavily browsed plants to be comparatively higher than values obtained in this present study. Le Houerou (1980a) and Gohl (1981) stated that the different figures obtained in the ash content of browse plants in many regions may be due to differences in oil, species and season.

The mean nitrogen free extract (NFE) was 49.66±1.87%, with a range of 47.67 - 52.45%. *Panicum maximum* recorded the highest value of 52.45% followed by *Balaniteaegyptica* with 50.23%, with *Tamarinaeindica* having the least value of 47.67%. These results fell within the recommended values a feed would have for livestock feeding as NFE represents the soluble carbohydrate of the feed, such as starch, sugars, pectin, organic acids, hemicelluloses and alkali-soluble lignin.

Fiber Partition

The browse forages in the study area had low to moderate content of fibre. This is a positive attribute of the browse forages since the voluntary DM intake and digestibility are dependent on the cell wall constituents (fibre), especially the NDF and lignin (Bakshi and Wadhwa 2004). The availability of a variety of browses and the selection process enable cattle to extend as well as meet their feed preferences. Traditional farmers in the semi-arid region of Nigeria allow their cattle to browse on tree forages in the range lands and they cut and feed these tree foliages as supplements based on experience and convenience.

Neutral Detergent Fiber (NDF) mean value obtained from the present study (Table 2b) was 48.69±9.41%, with a range of 40.20 - 64.50%. The results therefore showed that *Panicum maximum* had the highest value of 64.50% followed by *Balaniteaegyptica* with 48.50%, whereas *Khayasenegalensis* had the lowest with 40.20%. The results agree with Gidado *et al*. (2013), who reported similar mean NDF values for the browse plants analyzed to be 48.97%, higher than the as 25 - 45% and 20 - 35% reported by Le Houerou (1980b) and Norton (1994) respectively. The results, again, corroborate that of Njidda (2010), who reported fibre contents of 37.3 to 51.2% for NDF for browse forages in northeastern Nigeria.

The results *Panicum maximum* recorded the highest value of 39.40% followed by *Mangiferaindica* with 34.53%, while the lowest value of 19.60% was recorded by *Khayasenegalensis*. Mean value stood at 27.88±8.57% and agrees with Gidado *et al*. (2013), who reported similar ADFin 30 browse species to be 23.30%. The results again corroborates that of Njidda (2010), who reported ADF contents of 16.2 to 41.2% for browse forages in northeastern Nigeria.

The results show that *Mangiferaindica* recorded the highest ADL of 13.45% followed by *Panicum maximum* with 9.61%, while the least was recorded by *Tamarinaeindica* with 5.44%. The results corroborate that of Njidda (2010), who reported 4.9 to 12.7% ADL for browse forages in northeastern Nigeria. Omoniyi *et al*. (2013) also reported variations in the ADL from 6.46% - 34.53% for some browses.

The mean hemicellulose value was 20.98±5.50%, with a range of12.50 - 25.90%, indicating that *B. egyptica* and *P. maxim* had the highest level of digestible carbohydrates. The results again, corroborate that of Njidda (2010), who reported 4.9 to 12.7% ADL for browse forages in northeastern Nigeria.

Comparison of Chemical Characteristics of Crop Residues and Browses

Table 3 showed that crop residue had significantly ($p<0.05$) higher DM, CF and NDF compared to browses. While, browses had significantly ($p<0.05$) higher CP, EE, ADL and HEM than crop residues, indicating that browses may be the best stable feed that could be used for nutritional intervention during the critical periods of dry season when forage grasses have

been grazed to defund and crop residues have lost most of their nutrients. The findings fall within the reference values for tropical crop residues and browses (Onaleye et *al*., 2012). The results corroborate earlier studies that characterization of forage fibre, lignin, protein and other chemical components are used increasingly to predict animal performance. Forage chemical analyses could be used to identify factors in forages that may be limiting animal performance (Minson, 1981).

Table3. *Comparison of chemical composition of the crop residues and browses*

Parameter	Crop residues	Browses	P value (<0.05)
DM	94.76[a]	89.76[b]	0.04
CP	7.22[b]	13.96[a]	0.05
CF	32.40[a]	26.94[b]	0.00
EE	1.70[b]	5.52[a]	0.00
ASH	10.64	10.42	0.87
NFE	48.10	49.68	0.72
NDF	42.14[a]	27.88[b]	0.11
ADF	55.62	48.70	0.40
ADL	5.76[b]	7.94[a]	0.03
HEM	13.48[b]	21.06[a]	0.02

Note: *Dry matter (DM); Crude protein (CP); crude fiber (CF); Nitrogen Free Extract (NFE); Neutral Detergent Fiber (NDF); Acid Detergent Fiber (ADF); Acid Detergent Lignin (ADL); Ether extract (EE);*

Chemical Characteristics of Available Water Resources for Cattle in Adamawa State

Amongst all the numerous natural resources on earth, water is one of the most essential for life support especially in tropical Africa. Water is required for domestic, industrial and animal agricultural purposes in both rural and urban areas. The sources of water include: rivers, streams, ponds and wells (Akintoye*et al*., 2014). In most rural communities in Nigeria, valuable man-hours are spent on seeking and fetching water which is often of doubtful quality (Efe*et al*., 2005; Kubkomawa and Williams, 2010).

The chemical parameters useful for water quality assessment are determined by the presence of both organic and inorganic compounds that are either suspended or dissolved in it, while some of these compounds are toxic to the ecosystem (Boukori*et al*., 1999). Water quality is made up of physical, chemical and biological factors which influence the use of water for human and livestock purposes (Kubkomawa and Williams, 2010). Hence, it is necessary to obtain physicochemical characteristics of water so as to monitor water quality and determine the type of treatment that may be required before use (Odigure and Adeniyi, 2001).

The results of mean chemical characteristics of water resources for cattle in three LGAs of Adamawa state are presented in table 4. The results show the concentrations of Calcium (Ca), Magnesium (Mg), Potassium (K), Sodium (Na), Copper (Cu), Lead (Pb) and pH of water from hand operated boreholes, hand dug wells and streams in the study area and the water quality standard values as documented by WHO (1993). The concentration of chemicals in the water from the hand dug wells were higher followed by that of streams and the least was hand operated borehole water. This could be linked to the soil type which is ferruginous tropical soils of Nigeria based on genetic classification of soils (FAO, 1996). It could also be because of the seasonality of rainfall and the nature of the wood-land vegetation of the zone and perhaps the mineral resources found in the state which include iron, lead, zinc and limestone (Adebayo and Tukur, 1997).

Table4. *Mean Chemical Characteristics of Water Resources for Cattle in Adamawa State*

Parameters	Borehole	Well	Stream	WHO 1993
Calcium (mg/1)	72.144	85.156	82.144	250
Magnesium(mg/1)	19.444	20.474	20.844	80
Potassium (mg/1)	3.000	4.000	3.520	-
Sodium (mg/1)	0.0545	0.0745	0.0845	200
Cupper (ug/1)	0.061	0.081	0.071	2
Lead (ug/1)	0.010	0.020	0.020	0.01
pH	7.3	6.0	6.3	<8.0

However, the results were within the World Health Organization's (WHO) permissible values. Therefore, it was deduced that the water sources in the study area are of good quality, safe and recommended for livestock and human consumption. The findings revealed that ground water such as wells and boreholes are limited, while surface water such as streams, ponds, rivers runs dry, especially during the critical periods of the dry season leaving livestock owners to continue shifting camps in search of water resources.

CONCLUSION AND RECOMMENDATIONS

It was observed that, adequate nutrient supply as a factor of production is the major obstacle to cattle productivity in Northern Nigeria. The situation is worse during the long dry season when animals are unable to meet their protein and energy needs from available low-quality herbage with consequent marked weight loss and productivity. Cereal residues such as cowpea and groundnut haulms, sorghum, maize and rice straws and browse plants are the most considered alternative feed resources used by famers to support ruminant animals. All the browse plants offered to the animals, especially *B. aegyptica, K. senegalensis and T. indica* yielded higher leaf crude proteins and lower crude fibers than the crop residues, indicating that the browse plants could form better dry season feed resources if found in enough quantities

Amongst all the numerous natural resources on earth, water is one of the most essential for life support especially in the tropical Africa. Water is required for domestic, industrial and animal agricultural purposes in both rural and urban areas. The sources of water include: rivers, streams, ponds and wells. In most cities, towns and villages of Nigeria, valuable man-hours are spent on seeking and fetching water which is often of doubtful quality from distant sources. This problem of acute water supply have resulted in proliferation of hand operated boreholes, hand dug wells and the use of streams and ponds with some of them located within the close proximity of soak always, refuge dumps and pit latrines. Feed resource preservation and storage culture should form part of our norms and values as an agrarian country who depend so much on agricultural products. Government and private stake holders should find a lasting solution to water problem in sub-Saharan Africa for better and quality life in general.

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