Browse abundance and the methodologies for their selection as candidate feed resources in Nigeria: A review

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Abstract: The objective of this paper is to review browse plants abundance and the methodologies for their selection as candidate ruminant and monogastric animals feed resources in Nigeria. Browses have the ability to supply all the nutrients needed to maintain highly productive animals, especially ruminants throughout the growing period. Its use as feed is usually limited by their poor intake, high fibre content and, in some cases the presence of toxic factors or metabolic inhibitors such as cyanogens, alkaloids, saponins, and tanins, low digestibility and low nutrient content and subsequent low animal performance. In the tropics browse plants have been found to be of significant potential in terms of adoptability, productivity and acceptability for ruminants in order to balance the difficulties of feed shortages in the dry season as many browses of economic importance have been identified and utilized in livestock feeding in the area. Some methodologies for browse selection have been identified and adopted over the years which mostly depend on the availability of biological diversity of the browse resources. Methodologies such as indigenous ranking, farmer's knowledge and assessment for nutrient prediction, laboratory protocols and modeling and most recently socio-cultural and phytochemical scoring protocols are being recommended for browse selection. Indigenous knowledge of browse diversity also serves as a veritable and reliable tool in assessing browse abundance in Nigeria. Major constraints to leaf meals utilization in the area include presence of anti-nutrients, high fiber and bulkiness among others. Therefore methods for upgrading leaf meal value include drying, heat treatment, additives treatment and fermentation. Identified and overlooked valuable indigenous browses of Nigeria which could serve as feed and medicinal resources for livestock improvement should be researched upon and be promoted in the area to optimize production efficiency.
[CC Achonwa, IP Ogbuewu, EC Ogundu, IH Kubkomawa, MC Uchegbu and IC Okoli. **Browse abundance and the methodologies for their selection as candidate feed resources in Nigeria: A review.** *Nat Sci* 2017;15(5):82-94]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature. 11. doi:10.7537/marsnsj150517.11.

Keywords: Browse, ruminants, livestock, feed resources, Nigeria

1. Introduction

With the increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, the future hope of feeding the millions of future generations and safeguarding their food security will depend on the better utilization of hitherto neglected food and feed resources (Makkar, 2002). This understanding has over the past few decades rekindled research interest in the use of indigenous browse plants as sources of nutrients for livestock in many tropical environments (Okoli *et al*., 2003a and 2014). Although the diversity and nutritional values of these indigenous browse species may be well known to local livestock farmers (Okafor and Fernandez, 1987; Okoli *et al*., 2003a), limited published information exist on the social and physicochemical issues associated with their use at different farming locations.

The use of tree fodders as feed in monogastric animal nutrition is usually limited by their poor intake, high fibre content and, in some cases the presence of toxic factors or metabolic inhibitors such as cyanogens, alkaloids, saponins and tanins, low digestibility, low nutrient content and subsequent low animal performance (Adegbola and Oduoza, 1992). There is therefore the need to properly assay the nutritional, physicochemical and toxicological potentials of novel candidate tropical feedstuffs such before they could be promoted as fodder of commercial value in ruminant animal production or raw materials for monogastric animal feeds formulation.

Indigenous fodder trees and shrubs remain green at critical times of the year (Balehegn *et al*., 2012) and produce large quantities of year round fodder which are regarded as unconventional feed sources. The year round availability of these unconventional fodders when incorporated to ruminant diets planning help to tackle the effects of poor nutrition which usually manifest as loss of weight and conditions, reduced reproduction capacity, increase mortality rate, poor carcass quality among ruminants reared in many tropical environments (Kubkomawa, 2016). Proper evaluation of the production characteristics of some

economic browse plants of southeastern Nigeria would provide reliable data to farmers and development workers on the social, nutritional and toxicological issues associated with such browse plants promotion in the area and beyond.

In recent times, a large number of researches have focused on phytochemicals as cheap sources of novel chemicals for animal production and human health/nutrition. Plants with antioxidant properties have received special research attention mainly due to their phenolic compounds (Florou-Paneri *et al*., 2006), which are beneficial in many applications in animal nutrition (Atawodi *et al*., 2013). Therefore, identification and characterization of such potential values of indigenous browse plants could lead to the improvement of the economic value of local plants, thereby encouraging their development for improved rural income.

The objective of this paper is to review browse plants abundance and the methodologies for their selection as candidate feed resources in Nigeria.

Importance of browse plants

Browse has been defined as leaves, shoots and sprouts including tender twigs and stems of woody plants, which are cropped to a varying extent by domestic animals (Devendra and Burns, 1983). It could however, be extended to include the fruits, pod and seeds which provide valuable feed, especially, if the seed is deciduous (Obua, 2013). In the tropics, browse plants have been found to be of significant potential in terms of adoptability, productivity and acceptability for ruminants in order to balance the difficulties of feed shortages during the dry season (Hutagalung, 1981).

Browse quality and availability vary greatly from wet season to dry season which invariably affects productivity level of animals (Ogunbosoye and Babayemi, 2010). In Nigeria for example, traditional herdsmen and other pastoral groups habitually cut down branches from various browse tree species, making them available to livestock during the dry season when no other forage is available (Yahya *et al*., 2000). A number of such browse plants worldwide serve as alternative feedstuffs for livestock (Ammar *et al*., 2004; Aregawi *et al*., 2008; Rinehart, 2008; Fayemi *et al*., 2011). Animals under semi-intensive and free-range systems have been observed feeding on them, especially during the dry seasons characterized by lean feed resources (Apori *et al*., 2002; Isah *et al*., 1999, 2007 and 2012).

Thus, browse plants constitute one of the cheapest sources of feed for livestock, especially ruminants in the tropics (Okoli *et al*., 2003a; Ahamefula *et al*., 2006) and are good sources of essential nutrients such as proteins, carbohydrates, vitamins and minerals which are frequently inadequately represented in tropical grass pastures (Okoli *et al*., 2014). They constitute an abundant biomass in farmlands, bush fallows and forests in the humid tropical environment of southeastern Nigeria where they are commonly utilized in the wild by small-holder livestock farmers for feeding small ruminants (Uwechue, 1990; Okoli *et al*., 2001). Ruminants, especially sheep and goats but more likely goats can adapt to a wide variety of browse plants. In many tropical environments, these small ruminants roam free and eat variety of browses, especially during the dry season when green forages particularly grasses are less nutritive as a result of lignification (Mecha and Adegbola, 1980; Okoli *et al.,* 2003a).

The potential of leaves from tropical trees and shrubs to yield relatively higher levels of crude protein and minerals and lower crude fiber levels than tropical grasses has been recognized (Le Houerou, 1980; Mecha and Adegbola, 1980; Onwuka *et al*., 1989; D'Mello, 1992). Mecha and Adegbola (1980), Wahua and Oji (1987), Aletor and Omodara (1994), Oji and Isilebo (2000) and Okoli *et al*. (2001 and 2014) among others, have characterized the nutrient composition of some indigenous browse plants of southern Nigeria. These studies show that crude protein and crude fibre contents of such plants range from 15.3 to 33.3% and 2.7 to 15.6% respectively. However, tropical browses have been shown to contain varying quantities of condensed tannin and other anti-nutritional substances in their biomass that affect their optional utilization by animals (Aletor and Omodara, 1994; Onwuka, 1994 & 1996; Osagie, 1998; Udedibie, 2015).

Browses, in the form of fodder trees and shrubs, form an integral part of farming systems in the humid zones of West Africa. Apart from utilization as ruminant feed, browse bearing plants currently play important roles as fuel wood, shade, food (fruits), poles, etc. Also, their potential to improve soil fertility and conservation are added incentives (Atta-Krah *et al.,* 1986). Okoli *et al*. (2014) reported that among 93 browse plants studied in Southeastern Nigeria for their other indigenous uses, only 18 plants were being used solely as browse plants by farmers, while 27, 24, 16, and 8 plants were being used for 2, 3, 4, and 5 other purposes respectively. The other parts of these browse plants utilized by the farmers included the stem (log), stem back, root and fruits.

Browses such as *Gliricidia sepium* and *Leucaena leucocephala* have been promoted either as supplements to tropical forages or as sole feeds and has become part of viable feeding systems in some humid West African locations (Ademosun *et al*., 1988). While these exotic plants species have received extensive research attention in Nigeria, information on agricultural values of the abundant indigenous browse

species, especially those of Southeastern Nigeria, remain scanty. These indigenous species have however been shown to survive better in the acid soils of the region (Ndon and Essien, 1987; Okoli *et al*., 2001 and 2003a).

Okoli *et al*. (2002) reported that a number of browse plants utilized in ruminant feeding in southeastern Nigeria are also used to treat various illnesses of such animals. *Manniophyton fulvum, Microdesmis puberula, Spondias mombin* and *Aspilia Africana* among others have been positively identified to have prophylactic or therapeutic properties against different diseases (Etkin and Ross, 1982; Wahua and Oji, 1987). Numerous home remedies utilized in the treatment of different diseases and animal health conditions contain these and many other indigenous browse plants (Okoli *et al*., 2002). However, some of these plants may contain high levels of anti-nutritional substances such as tannins, oxalates, cyanogenic glycosides and phytates among others (Okoli *et al*., 2003b; Njidda and Ikhimioya, 2012; Udedibie, 2015).

Browse abundance and distribution in Nigeria

Herbs play important roles in livestock nutrition mainly during the wet season, since many of them are annuals, while browses constitute an abundant biomass in farmlands, bush fallows and forests in the humid tropical environment of southeastern Nigeria and are commonly utilized in the wild by small-holder livestock farmers for feeding small ruminants (Uwechue, 1990; Okoli *et al*., 2002). Over 5000 trees and shrubs have been listed as being suitable for feeding livestock in Africa (Le Houerou, 1980; Brewbaker, 1986; Okoli *et al*., 2002), and it has been suggested that only 80 are of real fodder value, while 5 may be recorded as good (Brewbaker, 1986). Okoli *et al.* (2003a) listed 163 indigenous and exotic plants, utilized as primary food and fodder for sheep and goats in Southeastern Nigeria, while Obua (2013) listed 177 for Ohaji/Egbema LGA alone in Imo state. This is an indication that there are much more forage resources in the region that may not have been listed.

About 40 families of non-leguminous trees and shrubs contribute forage species in Nigeria rangelands (Agishi, 1985). Most of the non-leguminous browses occur in the savanna, with the highest number in the northern guinea savanna. The high number of these forage plants in the Guinea zone is important as most of the ruminants are moved to this zone during the dry season. Agishi (1985) listed six families of non-leguminous herbs; Acanthaceae, Amaranthaceae, Capparidaceae, Compositae, Covolvulaceae and Euphorbiaceae that are well distributed throughout the vegetation zones except the montane. He however stated that the highest concentration of the species is found in the guinea savanna zone. About 143 legume genera are represented in Nigeria (Agishi, 1984).

Agishi (1985) also listed about 40 species of browse legume used in ruminant feeding of which Mimosaceae accounts for 55% compared with 27.5 and 17.5% for *papilionaceae* and *caesalpinaceae* respectively. *Afzelia africana, Daniella oliveri* and *Pterocarpus erinaceous* are heavily cropped by herdsmen for their livestock during the dry season and they are found in all the zones except the montane. Herbaceous forage legumes belong exclusively to the sub-family Papilionaceae, which is the main source of most of the pasture legumes in use and some of these indigenous legumes such as *Calopogonium mucunoides, Clitoria ternata, Alysicarpus vaginalis, Desmodium setigerum, Mucuna pruriens, Neonotoria wightii, Stylosanthes fruticosa and Vigna vexillata* are widely grown for pasture (Agishi, 1985). There are also a number of tree legumes and multipurpose trees such as *L. leucocephala, S. mombin, G. sepium* and *Erythrina spp* that provide foliage for livestock at all seasons of the year (Aregheore and Yahaya, 2001; Babayemi *et al*., 2014).

Grasses form the most important component in the diets of herbivores and are adapted to a wide range of environments as most grasses are grazed by livestock. According to Agishi (1985), field observations have shown that there are at least 202 forage grasses from 65 genera in Nigeria of which 35% are found on the montane, 46.5% occur in areas south of the derived savanna and the highest concentrations of 81 and 79% are in the southern and northern guinea savanna respectively (Agishi, 1985).

In the sahel zone, the dominant grass specie include *Aristida stipoides* and *Schoenefeldia gracilis*, while in the Sudan savanna, the dominant grasses include *Cenchrus spp*, *S. gracilis, Eragrostic tremula, Aristida* and *Loudetia species, Pennisetum pedicellatum, A. gayanus* and *A. pseudapricus*. The Guinea savanna zone also has predominant grasses such as *Chloris spp., Hyparrhenia spp., Paspalum spp., Melinis spp., A. gayanus, Imperata cylindrical, Pennisetum pedicellatum, Digitaria spp.* and *Setaria sphacelata* (Babayemi *et al*., 2014; Kubkomawa *et al*., 2015b). In a detailed study of browse abundance in the Ohaji/Egbema LGA of Imo State Southeastern Nigeria, Obua (2013) generated 49 families, 177 species and 120 genera of plants utilized for ruminant feeding.

Candidate Browse Resources for Improvement

Plant species in Nigeria have been estimated at about 5,000 species (FGN, 2002). However, available information on the diversity and distribution of browses and other forage crops of particularly southeastern Nigeria are scanty, mostly informal assessments and unpublished reports. Different studies have shown that livestock farmers are familiar with the vegetation present in their area and have identified

a number of promising browse species (Okoli *et al.*, 2003a; Shenkute *et al.*, 2012). Many such identified valuable indigenous trees, shrubs and fodder plants that could serve as feed and medicinal resources for livestock improvement have been overlooked. Boufennara *et al.* (2012) recently reported that many wild browse and bush species have not been characterized, while several identified ones are undervalued because of insufficient knowledge about their nutritional and medicinal potentials. Okoli *et al.* (2003a) listed 163 indigenous and exotic plants, utilized as primary food and fodder for sheep and goats in Southeastern Nigeria (SEN). In the same SEN, Okigbo (1980), Reynolds and Atta-Krah (1987), Orok and Duguma (1987), Okafor and Fernandez (1987) listed 14, 30, 44 and 27 browse species respectively for feeding ruminants. Okoli *et al.* (2003a), Onyeonagu and Ashiegbu (2006) and Chah and Igbokwe (2011) listed 47, 46 and 46 indigenous and exotic browse plants respectively as most preferred fodder for sheep and goats in southeastern Nigeria. Obua (2013) also listed 177 plants in a comprehensive study of the diversity of ruminants' browses in Ohaji/Egbema LGA of Imo State, southeastern Nigeria, indicating that there is much more browse and forage resources in the region than the few highlighted in other studies.

Methodology for browse selection

Obua (2013) observed that since man and his domestic animals such as ruminants still depend on the availability of biological diversity for sustenance, it brings to the fore a need for conservation of available animal feeds genetic resources. Availability of information on the diversity of browse plants in a given study area enables the selection process to meet the preferences of the indigenous farmers and research approaches for their improvement (Okoli *et al*., 2014). There is currently no clearly developed protocols or methodologies for selecting local materials of nutritional potentials out of the hundreds of candidate raw materials available in Nigeria. Development of such selection protocols could eliminate some of the frustrations experienced with many trial materials which usually arise from poor or non-existent selection process.

(a) Indigenous ranking

Most regions of the world have evolved relatively successful indigenous knowledge (IK)-based systems and practices in solving their problems almost successful (Okoli *et al*., 2010). The IK of livestock owners therefore form the foundation for and complement the success of all sustainable production programs in many developing countries such as Nigeria. It is however only recently that animal production scientists have begun to recognize the fact that livestock owners have holistic understanding and approach in dealing with livestock production problems. As a result of this, increasing interest is being shown at the global level on the important roles being played by IK in many sectors of agriculture including intercropping techniques, animal production, pest control, crop diversity, animal health care and seed varieties as well as other forms of natural resources management (Etuk *et al*., 2005).

In earlier studies, Okoli *et al*. (2001 and 2003a) had attempted to use IK as a tool for selecting plants of animal production potentials in southeastern Nigeria and concluded that apart from generating clues to candidate research materials, such studies could promote the development of useful concepts in animal production and encourage the maintenance of bio-cultural diversity. Specifically, Okoli *et al.* (2003a) showed that ruminant farmers in southeastern Nigeria listed 47 plants as the most preferred browses in the region. Frequency distribution of these preferred plants at the study locations, showed that 13 plants were commonly preferred at three locations, whereas 10 plants each were exclusively preferred at two locations. *Dactyledema barterii, Alchornea cordifolia, Aspilia africana, Maniophyton fulvum,* and *Costus afer* among others were named at the three sites, while *Urena lobata* and *Andropogon gayanus* were among those preferred at Umugo (Abia State) and Orsumoghu (Anambra State). *Microdesmis puberula* was preferred at Umugo and Umuokanne (Imo State), while *Albizia spp* and *Dialum guineensis* where specifically mentioned at Orsumoghu (Okoli *et al*., 2003a).

Obua (2013) also evaluated browse plants at Ohaji/Egbema, Imo State based on ratings by small holder farmers on the acceptability and preferences of the plants by goats. The rating was in the categories of least preferred, preferred and most preferred plants by goats. The preferred browses formed the highest proportion (45.76%), the least preferred formed 32.77%, while the most preferred browse plants formed the least proportion (21.47%). The plant species most relished by goats include *Microdesmis puberula, Glyphea brevis, Albizia lebbeck, Albizia feruginea, Alchornea cordifolia, Anthocleista djalonensis, Anthocleista vogeli, Aspilia Africana, Dialium guineense, Elaeis guineensis, Treculia africana, Pentaclethra macrophyla, Ficus ingens, Ficus thonningii, Gmelina arborea, Khaya senegalensis, Euphorbia heterophylla, Manniophyton fulvum, Manniophyton mannii, Mangifera indica, Persea americana, Pterocarpus santalinoides, Ricinodendron heudelotti, Baphia nitida, Spondias mombin, Tridax procumbens, Dacroydes edulis, Melicia excelsa, Amaranthus hybridus, Dactyledema barterii, Alternanthera bettzickiana, Maranthocloa leucantha, Syndrella nodiflora* and *Telfairia*

occidentalis. Forbs such as *Palisota hirsuta, Costus afer, Asystasia gangetica* and *Spigelia anthelmia* were also among the most preferred plants. Similar forage plants were also been reported as highly preferred by small ruminants in the region (Umoh and Udoh, 1993; Larbi *et al*., 1993; Okoli *et al*., 2003a & b; Oji and Kalio, 2004; Aju and Okwulehie, 2005; Onyeonagu and Ashiegbu, 2006; Ahamefule *et al*., 2006; Kalio *et al*., 2006; Onyeonagu and Ashiegbu, 2008).

In a most recent study by Achonwa (2016), that socio-cultural (representing the indigenous uses) and phytochemical score of *Ficus microcarpa* (a domesticated local plant) and six other plants growing in southeastern Nigeria were developed in other to identify the candidate plants for further livestock feeding research and development applications in the region. The socio-cultural value scores show that *F. microcarpa* recorded the highest score of 85.71% followed by *G. latifolium, G. kola* and *Nauclear popegnine* that scored 71.43% each. Of these four plants, *N. popegnine* is the only one that is not domesticated but has remained essentially a wild plant in southeastern Nigeria where its major use is in the treatment of malaria in humans. Thus, the socio-cultural functions of *F. microcarpa* may explain its domesticated plant status in the region. However, the fact that the highly valued *N. popegnine* remains a wild plant in the same region cannot be readily explained, even though it seems to mimic the neem plant (*Azadiractha indica*), an exotic plant that has received lots of developmental promotion in Nigeria (Ogbuewu, 2008; Obikaonu, 2009).

The phytochemical scores of the leaf meals of the seven plants based on nine phytochemical parameters return a moderate 47.61% for *F. microcarpa* while the best scores were the 65.08 and 63.49% recorded for *Manihot utilisima* and *G. latifolium* respectively. Specifically, there was clear dichotomy between the socio-cultural and phytochemical scores of *F. microcarpa* and *M. pruriens* with percentage differences between both scores in each plant ranging above 30%. A combination of the two scoring protocols to obtain an overall score for each plant shows that all the plants with exception of *M. pruriens* and *M. fulvum* recorded overall scores of more than 60.0% with *G.latifolium* (67.46%), *F. microcarpa* (66.66%), *G. kola* (66.66%) and *N. popegnine* (65.08%) scoring the highest values. Of all the high scoring plants, only *N. popegnine* has not been domesticated by farmers in southeastern Nigeria, while the others are domesticated for different human needs. Thus, *N. popegnine* may be the subject of further research and development activities for possible promotion as a plant of animal production and other human use promise.

(b) Farmer knowledge and laboratory assessment for nutrients prediction

The extent and utility of farmers' existing knowledge of the relative quality of different tree fodders and the factors affecting this was reported in the study of Thapa *et al*. (1997). The study showed that in spite of its largely empirical origin, the knowledge held by farmers was sophisticated to the extent of discriminating different characteristics of tree fodder with different implications on animal performance. In another study, the extent of consistency between predictions of the nutritive value of the fodder from eight trees species and landraces based on indigenous knowledge and laboratory indicators was reported by Thorne *et al*. (1997b). The study also considered the complementarity of the sources of information and whether this might be used to broaden both researchers' and farmers' knowledge of tree fodder quality. Thus, the consistency between farmers' knowledge and chemical indicators was demonstrated by simple correlation and indicated that farmers' knowledge is likely to be at least in part biologically based, and therefore interpretable. Conversely, laboratory indicators ought to be able to supply information that farmers consider important.

Thorne and Herrero (1998) reported in their Nepalese study that the main criteria applied by farmers are known as *Obanopan* (highly palatable fodder, eaten voraciously but liable to cause constipation) and *posilopan* (fodder is nutritious in that it promotes milk yield, live weight gain and good health). The strong correlation observed between *Obano* fodder quality and *in vitro* digestibility was negative, indicating that in favouring *Obano* fodder, farmers appeared to prefer less digestible feed. However, it should be noted that tree fodder is used mostly widely when feed biomass is in short supply.

Okoli *et al*. (2001) carried out laboratory assessments of the proximate compositions of the most preferred indigenous browses of Southeastern Nigeria to determine the reasons for the preference of the browses by small-scale ruminant farmers. The browses, *M. puberula* and *M. fulvum* from Imo State, *C. afer* and *U. lobata* from Abia State and *Ficus spp* and *Albizia spp* from Anambra State recorded a crude protein range of 15.22 - 33.33%, with the value for *M. puberula* being the highest and *M. fulvum* the lowest. *M. fulvum* that recorded the lowest crude protein content also recorded the highest ether extract content, supporting its use in post parturient fattening of does by farmers in the study area. These results show that the most preferred indigenous browse plants of Southeastern Nigeria are high in crude protein, indicating that exploitation of livestock production paradigms of indigenous farmers, which have been developed over centuries, through close observation

and practices, could form the starting point in the search for alternative feed resources urgently needed in modern livestock management.

Candidate alternative feed raw material scores was also developed by Okoli *et al.* (2014) based on indigenous use ranking and crude protein contents of 93 browse plants identified in southeastern Nigeria. Such rankings across leaf, stem, root, fruit and fuel values were used to select candidate browse plants for domestication, since most rural farmers in the study area tend to selectively allow plants of more than one value to grow in their compound farms. In this particular study, direct interviews of ruminant farmers in the study area were conducted to determine the various endogenous uses of selected browse plants. A ranking based on a score of 1 - 5, depending on whether the leaf, bark, root, log and fruit of the plants were being utilized endogenously was developed. The crude protein contents of the leaf meals of the plants were also determined and the results combined with the endogenous use ranking result to select endogenous browse plants for domestication in the region. Based on the results of this study, 18 indigenous browse plants, having endogenous use rankings of 2 - 5 and leaf crude protein of 14.88 to 32.27% were selected as candidate browse plants for possible domestication in the region (Okoli *et al*., 2014).

(c) Laboratory protocols and modeling

Decision support tools based on interpreting farmers' knowledge with description of biological processes are currently not available or highly limited. Zadeh (1965) conducted a modelling study that explored the potential of a fuzzy systems approach that allows the use of farmers' knowledge in this way based on the general biological interpretation of it. Thorne *et al*. (1997a) constructed a simple spread sheet model that integrated farmers' knowledge of tree fodder quality with a standard biological model of nutrients utilization in ruminant livestock (Jarrige, 1988).

Udedibie (2015) also attempted developing a more detailed laboratory protocol for selecting such candidate alternative feed raw materials for monogastric animal feeding trials. The scoring was based on the crude protein, metabolizable energy, copper, iron, antioxidants, and trypsin inhibitor contents of the leaf meals. These parameters were selected as important representative components of the physicochemical properties of the study materials and positive or negative attributes (Fibre and cyanide contents as negative and others as positive) assigned to them, in order to arrive at a functional and practical score for candidacy selection based on this scoring protocol. Scores of 1 - 3 were also assigned across the appraisal parameters, where 1 is the highest positive score, and 3 is the highest negative score. Based on this scoring protocol, it was determined that *Gacinia kola* and *Mucuna pruriens* leaf meals may serve as better alternative raw material leaf meals than *Gonglonema latifolium* for monogastric animal feeding trials (Udedibie, 2015).

Such scoring system has also been attempted using the physical and proximate biochemical characteristics of novel feedstuffs fed to poultry in Nigeria (Omede *et al*., 2012). In that study, the physical characteristics data such as bulk density (BD), water holding capacity (WHC) and specific gravity (SG) of three novel feedstuffs such as leaf meal (*M. puberula*), rumen digesta and poultry dung at different particle sizes were generated and related to available published and unpublished data on their proximate compositions. Particle size effects on BD of rumen digester and poultry dung were lower at the ≥ 1.00 mm PS than at the unmodified and < 1.00 mm PS, indicating that materials of similar crude fibre could be manipulated to yield different BD with possible ultimate effects on performance of birds. Again, the WHC of the leaf meal at < 1.00 mm PS level was seven times higher than that of unmodified and ≥ 1.00 mm PS, while rumen digesta value at the same < 1.00 mm PS level was two and four times higher than those of unmodified and ≥ 1.00 mm PS levels respectively. The study concluded that information on the feed physical characteristics could be used to rank the nutritional potentials of novel feedstuffs even before a feeding trial is carried out (Omede *et al*., 2012).

In another study, physicochemical and hydrogen cyanide contents values were used to rank the value of three processed cassava products used for feeding poultry in Nigeria (Okoli *et al*., 2012b). The three products, Abi, Nali and Local brands were analyzed for their BD, WHC, and SG; proximate compositions and hydrogen cyanide (HCN) contents. The Local and Abi brands had significantly higher WHC than the Nali brand, while the Local brand had the lowest BD and SG, which were also significantly different from those of Abi and Nali brands. These results point to significantly higher insoluble non starch polysaccharides (NSP) or indigestible fibre in the Local brand and is supported by similarities in the crude fiber, ash content and nitrogen free extract values of the Abi and Local brands. However, the higher crude fibre levels of the Nali brand could be made up mostly of soluble NSPs as shown by the lower WHC of the brand. Again, Nali brand recorded very high HCN value (100 - 200 ppm), while the Local and Abi brands recorded 5 – 15 ppm. In conclusion, it was suggested that the Nali and Abi brands processing methods could be combined to produce a superior cassava product for feeding poultry

since they were ranked higher than Local brand based on the parameters investigated (Okoli *et al*., 2012).

Leaf meals from browse plants, their preparation and uses

Leaf meals are leaves and twigs from browse plants that have been dried, ground, and used as livestock feed. They are not traditionally used in the ration of ruminants as these animals can be fed with fresh fodder. However, there are instances when leaf meal production is necessary and becomes the most practical way of conserving excess foliage. Leaf meals and other non-conventional feeding materials are gaining acceptance as feedstuff in livestock diets, since they are locally available in Nigeria and other sub-Saharan countries and are considered to be non-conventional feeding materials (Amata, 2010). In preparing leaf meals (LM), leaves and browsable twigs of selected fodder trees/shrubs are sundried for 12 or more hours under tropical conditions and then ground with a hammer mill and stored in sacks (Obikaonu, 2009).

For proper storage and to avoid spoilage, the leaves and twigs should be dried to 10 – 12% moisture content, especially when produced in the hot humid tropical environments (Okoli *et al*., 2013). Somasiri *et al*. (2010), reported a simple technique for the development of a leguminous leaf meal blocks as animal feed in Sri Lanka. Leaves and twigs of *Acacia mangium, G. sepium, L. leucocephala* and *Calliandra calothyrsus* were collected, sundried up to 20 – 30% moisture and ground to make leaf meal. A hydraulic press was used to compress the leaf meals into leguminous meal blocks. Shelf life of the blocks was determined by observing for change in appearances, odour and colour and also analyzing for biochemical changes during the period of storage. The nutrient profile of these leaf meals compared favorably well with some conventional feeding materials, therefore making them possible sources of cheap protein for livestock feeding.

Leaf meals have been shown to serve as sources of proteins, vitamins, minerals as well as carotenoids for non-ruminants (Esonu *et al*., 2001, 2002 & 2004). There are several reports on the effects of feeding incremental levels of leaf meals to non-ruminant (D'Mello, 1995). Parameters usually determined include feed intake, digestibility of feed as well as nitrogen balance and retention, effect on growth rate and feed conversion ratio (Halimani *et al*., 2005). Examples of leaf meals currently used in livestock feeding are *Gliricidia sepium* and *Leucaena leucocephala* (Herbert, 2001); *Microdesmis puberula* (Esonu *et al*., 2001, 2002, 2004); *Tithonia diversifolia Hemsl A Gray* (Togun *et al.,* 2006a, b), wild sunflower (Odunsi *et al.,* 1996 & 1999), *Vernonia amygdaliana* leaf meal (Fasina *et al*., 2004), *Azadirachta indica* (Sokunbi and Egbunike, 2000a, b; Esonu *et al*., 2005; Oforjindu, 2006; Bawa *et al*., 2006); *Centrocema pubescens* (Ngodigha, 1994; Omeje *et al*., 1997; Nwaorgu, 2015) and cassava leaf meal (Ogbonna and Oredein, 1998; Adeyemi *et al*., 2008 and 2012) among many others.

Constraints to leaf meal utilization

Some factors can serve as constraints to leaf meal utilization in livestock feeding. The nutritional values of leaves often fall short of that expected from their chemical compositions. This is chiefly due to factors such as fibre content, presence of anti-nutritional factors and deficiencies of certain amino acids (D'Mello, 1992). The leaves and seeds of fodder trees and shrubs are known to contain a wider range of compounds capable of reducing the performance of animals. According to D'Mello (1992), this complex combination of different groups of compounds such as toxic amino acids, tannins, cyanogenic glycosides and protease inhibitors may occur in tree species. The need to remove these compounds before using the leaf meals as feedstuff has stimulated much work on method of detoxification and upgrading of such leaves and seeds. The production of leaf meals for non-ruminant feeding therefore involves some of these processes.

The use of leaf meals in feeding chicken for example, has been reported to be limited by their high fibre contents (Ganzon-Naret, 2014). Fasuyi and Aleto (2005) reported that the challenges that have to be overcome before leaf protein concentrates from leucena and cassava, two of the high density mono-culture crops, become viable protein sources for monogastrics include the high fibre content and other anti-nutritional factors such as phytate, cyanide and tannin. Available literature suggest that poultry producers in the tropics could benefit economically by incorporating leaf meals at low levels, since they can play useful roles as sources of protein, minerals, xanthophils and unidentified growth factors for poultry (Ravindran *et al*., 1987b; Esonu *et al*., 2002). However, the poor effects of high dietary levels of most leaf meals are due to bulkiness, reduced energy supply and essential amino acids deficiency. Specifically, at high level of inclusion, bulkiness is probably the major limiting factor, which in this context pelleting may help to overcome.

Leguminous plants and trees contain a diverse combination of anti-nutritional factors which impair both nutrient metabolism and other physiological processes. Some leaves contain repulsive odour and bitter taste, which can put animals off on the first introduction of the feed. The chief among such leaves include *Veronia amgydalina*, *Leucaena leucocephala* and *Azadiractha indica* (Herbert, 1998).

Methods for upgrading of leaf meals for non-ruminant animal feeding

Sun drying remains the simplest method of choice in the tropics for removing toxic substances from leaf meals. For example, Ravindran *et al*. (1987b) reported that sun-drying cassava leaves may reduce HCN concentration by as much as 90%. Thermal processing has also been shown to effectively upgrade plant products through inactivation of heat labile anti-nutrients. Visitpanich *et al*. (1985) were able to eliminate all adverse performance effects in pigs fed 300 g seed/kg of feed formulated with pigeon pea heated at 120ºC for 15 minutes indicating that trypsin inhibitor activities were reduced in the heat treated grains.

Additive treatments such as Ferric sulphate and polyethylene glycol (PEG) were used to complex with mimosine and tannin respectively, with marked improvements on the growth of chickens fed Leucena-based diets (D'Mello and Acamovic, 1989). Methionine inclusion has also been shown to affectively detoxify leaf meal based diets fed to chickens and pigs (D'Mello, 1992). During storage, the cyanide content of cassava leaf meal as well as its crude protein content gradually decline. Preliminary investigations by Ravindran *et al*. (1987b) also showed that no moulding or insect infestation occurred even after eight months of storage of such processed leaf meals (Ravindra *et al*., 1987a).

Conclusion and Recommendation

Browses have the ability to supply all the nutrients needed to maintain highly productive animals, especially ruminants throughout the growing period if properly utilized. Though their nutritive value fall rapidly with maturity and during the dry season, but browses still remained the most outstanding feed material for ruminants in Nigeria and other tropical countries. Identified and overlooked valuable indigenous browses of Nigeria that could serve as feed and medicinal resources for livestock improvement should be researched upon and promoted in the area to optimize production efficiency.

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4/10/2017