Asian Journal of Agricultural Sciences 8(4): 18-24, 2016
DOI:10.19026/ajas.8.3417
ISSN: 2041-3882; e-ISSN: 2041-3890

Submitted: September 8, 2016 Accepted: November 15, 2016 Published: December 15, 2016

Research Article

Seasonal Changes in the Chemical Composition of *Aspilia africana* Plant Grown in Nigeria

Oluwatosin Kennedy Oko, Magnus Izah Anya, Pascal Ogar Ozung, Iferi Ibiang Eyong and Lizubili Freeman Mboto
Department of Animal Science, Faculty of Agriculture, University of Calabar, Calabar, PMB 1115, Cross River State 540004, Nigeria

Abstract: The aim of the study was to evaluate the effects of season on the chemical composition of *Aspilia africana* leaf over a 12-month period. Biomass yield, proximate and mineral compositions were analyzed. Data collected were subjected to ANOVA in a completely randomized design using SAS software package. Post hoc analysis was conducted at 5% significance using the Duncan multiple range test. Five seasons (late dry, early rainy, peak rainy, late rainy and early dry) and three stages of plant maturity (growing, blooming and aging) were identified. Results showed no effect ($p>0.05$) of season on the proximate composition (except for moisture and crude ash) and fibre fractions of *Aspilia africana* leaf but mineral concentrations were influenced ($p<0.05$) by season. Crude protein and ash contents were higher during the rainy season but declined with the inception of the dry season while, crude fibre and its fractions were higher during the dry season. Calcium, zinc and phosphorus concentrations were highest during the peak rainy season then decline gradually as dry season progressed. Correlation result showed that an increased biomass yield led to increased ($p<0.05$) crude protein content with decreased crude fat, moisture and ash contents. Though biomass yield was higher between the late rainy and early dry seasons, results showed that there was no temporal variations in the nutrient composition of *Aspilia africana* leaf during the 12-month study. Therefore, *Aspilia africana* plant could be a valuable feed resource for all year fodder production.

Keywords: Fodder, plant yield, proximate composition, tropical weed

INTRODUCTION

According to the Food and Agriculture Organization (FAO, 2010a; FAO *et al*., 2015), the increasing demand for animal products in developing countries, is largely driven by urbanization, increasing population and income growth. This is an enormous challenge to national food security policy and planning (Coughenour and Makkar, 2012) of the countries as they strategize to boost economic growth and to reduce poverty. The desire to significantly enhance overall livestock output is constrained by the trade-off between competing demands for traditional livestock feed resources.

To surmount this constraint, relatively new inventories of forage legumes are being compiled based on scientific assessment of their potentials as livestock feed (Norton and Poppi, 1995; FAO, 2010b; Coughenour and Makkar, 2012).

In Africa besides grasses, browse plants including some weed species are the most available and cheapest feeds of ruminants (Ammar *et al*., 2005; Ikhimioya and Imasuen, 2007; Shamat *et al*., 2010). Browse plants provide digestible crude protein (35-60%) and serve as rich sources of vitamins and minerals, which are lacking in most grassland pastures (Yusuf *et al*., 2013). Abusuwar and Ahmed (2010) noted that the year-round evergreen foliage, vegetative cover and abundant nutrients in browse plants encourage their utilization for sustainable fodder production. Their biomass yields also influences the number of animals that can be reared in a pasture land.

In monogastric production, browses are suitable raw materials for leaf protein supplementation (Oko, 2011; Oko *et al*., 2012; Oko *et al*., 2013), yolk and meat pigmenting agents (Oko *et al*., 2011) as well as alternative to antibiotics (Hernandez *et al*., 2004; Cetingul *et al*., 2007; Oko *et al*., 2012). These feed resources are however neglected or underexploited probably due to insufficient information on their potential values as feeds.

According to Coughenour and Makkar (2012), forage quality represents an important factor for determining the total fraction of plant biomass that

Corresponding Author: Oluwatosin Kennedy Oko, Department of Animal Science, Faculty of Agriculture, University of Calabar, Calabar, PMB 1115, Cross River State 540004, Nigeria, Tel.: +234 8052299139

constitute feed in livestock production. Temporal variation is considered a significant factor of forage quality compared to annual forage yield since the periods of scarcity determines the number of livestock that can be sustained. Papachristou *et al*. (1999) reported that moisture and protein contents of forage determine its quality and exhibit the greatest variation between sites and stages of maturity. Therefore, the relationship between moisture and protein contents as well as plant age needs to be established for optimum forage utilization.

Aspilia africana plant is a semi-woody herb that occurs in farmlands and wastelands throughout the savannah and tropical regions of Africa. *Aspilia africana* commonly known as bush marigold is heavily browsed by cattle, sheep, goat, hare and rabbits (Ahamefule *et al*., 2006). The plant is gaining interest as potential raw material for the pharmaceutical, cosmetic and agricultural industries (Okoli *et al*., 2007; Oko *et al*., 2014). Studies have been conducted on the nutrient composition of *Aspilia africana* plant, leaf and its extracts; however there is dearth of information on its nutritive contents at different seasons.

This study was initiated to assess the impact of seasons on the proximate and mineral compositions of *Aspilia africana* leaf grown in the South-south region of Nigeria. Results obtained shall be used to ascertain the time and stage of harvest of the leaves for optimal fodder production in the tropics.

MATERIALS AND METHODS

Study area: The experiment was conducted in Calabar, Calabar, with a GPS reading of Longitudes 8.0°-8.3°E and Latitudes 4.4°-5.2°N is located in the South-southern part of Nigeria. It has a tropical humid climate with mean temperature of 26.10C. The average annual rainfall is 3050 mm, falling all through the year especially between March-October (Inyang, 1980).

The leaves of *Aspilia africana* plants were harvested from within the vicinity of the Research Farm, University of Calabar, Nigeria. A sample of the plant was identified using the macroscopic features described by Etukudo (2003). It was confirmed, authenticated and deposited at the Department of Botany's herbarium unit, University of Calabar, Nigeria.

Leaves were harvested on a monthly basis over a 12-month period (January 2015-December, 2015) to assess the seasonal effects on the biological properties of *A. africana*. Five different seasons and three stages of maturity were identified. Proximate and phytochemical analyses were carried out monthly from pooled samples collected.

Leaf samples were taken from January-December, 2015 and Leaf biomass was determined using quadrate and transects method. Simultaneously, organic matter, crude protein and fibre fractions of the leaves were analyzed. In each month, leaf samples were collected weekly along transect in the selected pasture area (2 ha) in triplicates of nine quadrates. Leaf yield was estimated from monthly pooled sample across quadrates.

Following leaf yield estimation, the leaves were processed by shredding and sun-drying for 3-days post harvesting. The leaves were ground using a 1-mm Wiley Mill screen (Marconi, Piracicaba, Brazil), packed in air-tight containers and stored in a well ventilated room until needed for analysis. All chemical analyses were conducted at the Animal Science Nutrition Laboratory, University of Calabar, Calabar.

On a monthly basis, leaf samples were analyzed for dry matter, nitrogen, ash and crude protein using AOAC methods as described by Li *et al*. (2016) while techniques described by Van Soest *et al*. (1991) were used for fibre fractions (neutral detergent fibre, acid detergent fibre and acid detergent lignin) determination.

Determination of Proximate composition: The leaf samples were oven dried at 103°C for 8 h to determine dry matter content (DM; method 934.01; AOAC, 2000) while moisture content was determined by the difference method. Ash was determined by incinerating leaf samples in a muffle furnace at 550°C for 4 h (Ash; method 942.05; AOAC, 1990). Total nitrogen (N) concentration was determined using a Total Nitrogen Analyzer (LECO®Corporation, St. Joseph, MI, USA; N: method 968.06; AOAC, 1990) then converted to crude protein (Nitrogen content x 6.25). Crude lipid was determined by Soxhlet extraction procedure using a Fat Analyzer (LECO®Corporation, St. Joseph, MI, USA; EE: method 991.36; AOAC, 2005). Crude fibre was determined using enzymatic gravimetric method (CF; method 962.09 AOAC, 2005). Nitrogen free extract was estimated by the subtracting sum value of protein, fats, fibre and ash from 100.

Neutral detergent fiber was determined using heat-stable alpha-amylase and sodium sulfite (NDF; Van Soest *et al*., 1991) and Ankom 2000 Fiber Analyzer (Ankom Tech. Corp., Fairport, NY, USA) was used for acid detergent fiber (ADF; method 954.01; AOAC, 1990).

Calcium (Ca; method 984.01; AOAC, 1995), total phosphorus (P; method 965.17; AOAC, 1995), zinc (Zn; method 999.11 AOAC, 2000), potassium, magnesium and sodium were determined by atomic absorption spectrometry (method 985.01, AOAC, 1986).

Statistical analyses: The analysis of variance in a completely randomized design according to the general linear model procedure of SAS (2007) was employed in assessing the influence of season on leaf yield and chemical composition of *Aspilia africana*. Post hoc analyses were conducted at 5% significance using the Duncan multiple range test (Duncan, 1955).

Table 1: Effects of season (months) on herbage chemical composition (%)

Month	Moisture	Crude protein	Crude fat	Crude fibre	Ash
January	13.20a	20.90	2.39a	14.74	13.26
February	12.40b	21.30	2.24a	13.23	13.59
March	13.50a	21.73	1.52b	12.69	14.38
April	11.90b	20.92	1.77ab	13.84	14.52
May	13.20a	21.61	1.21b	13.91	15.79
June	13.40a	20.04	1.40b	12.87	17.01
July	12.70ab	23.50	1.59b	13.29	13.44
August	13.00a	18.53	1.41b	14.00	18.91
September	12.60ab	24.30	1.77ab	14.21	11.67
October	11.90b	20.54	1.58b	13.53	14.27
November	12.30b	27.17	1.36b	12.54	14.44
December	12.60b	24.78	1.87a	12.37	12.03
Mean ± SEM	*12.73±0.11	22.10±0.39	*1.68±0.08	13.43±0.13	14.44±0.33
Month	NFE	NDF	ADF	ADL	
January	35.51	27.33	23.05	9.08	
February	37.51	25.82	21.54	7.57	
March	36.18	25.28	21.00	7.03	
April	37.05	26.43	22.15	8.18	
May	34.28	26.47	22.22	8.25	
June	35.28	25.46	21.53	7.21	
July	35.48	25.88	21.60	7.63	
August	34.15	26.59	22.31	8.34	
September	35.45	26.80	22.56	8.55	
October	38.18	26.12	21.84	7.87	
November	32.19	25.13	20.85	6.88	
December	36.35	24.96	20.68	6.71	
Mean ± SEM	35.63±0.27	26.02±0.11	21.78±0.13	7.78±0.20	

a,b Means with different superscripts along column indicate significant ($p<0.05$) differences

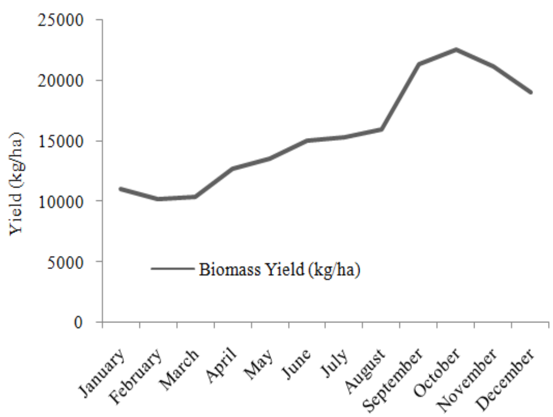

Fig. 1: Biomass yield production of *Aspilia africana* plant

RESULTS

Proximate and phytochemical compositions:

General observations: In the humid tropical environment, *Aspilia africana* plant grows throughout the year. For the purpose of this study, the seasons were divided as follows;

Late dry season;	January-February
Early rainy season;	March-May
Peak rainy season;	June-August
Late rainy season;	September-October
Early dry season;	November-December

Three stages of maturity were observed in *Aspilia africana* plant; the growing (April-August), blooming (September-November) and aging (December-March) stages.

Biomass yield production: Graphical presentation of the herbage yield of *Aspilia africana* plant studied over a 12 month period (January-December, 2010) is shown in Fig. 1. Herbage yield ranging from 10, 105-22, 468 kg/ha was observed to be influenced by season. Peak yield production was in the late rain which coincides with the blooming stage of the plant while, the least yield was recorded during the late dry to early rainy season (January-March).

Nutrient composition: Table 1 and Fig. 2 show the proximate and mineral compositions of *Aspilia africana* leaves. It was observed that season had no effect on the proximate composition of *Aspilia africana* plant but significantly ($p<0.05$) affected its mineral composition. Moisture and fat contents however differed ($p<0.05$) between months. Mean moisture content of about 12.73% was recorded which rose to 13.50% during the early rains (March) but dropped to 11.90% during the late rainy season (October).

Crude protein content ranging from 18.53 to 27.17% was not different between seasons. The least (18.53%) and highest (27.17%) values were observed in the month of August and November, respectively.

Crude fat content as low as 2.39% was obtained in the month of January but later dropped ($p<0.05$) to 1.21% in the month of May. Mean crude fibre content of 13.43% was obtained in this study and tended to increase as the plant matured. The least value was obtained in the month of December (12.37%) and the

Table 2: Correlations between biomass yield and chemical nutrients in *Aspilia africana* leaves

Parameter	Moisture	Crude protein	Crude fat	Crude fibre	Ash
Yield	-0.425	0.467*	-0.182	0.020	-0.271
ADL	0.027	-0.446	-0.060	0.999***	0.201
ADF	0.081	-0.497*	-0.098	0.986***	0.261
***NDF	0.023	-0.445	-0.054	0.999	0.201
NFE	-0.350	-0.400	0.656**	0.089	-0.350
Ash	0.332	-0.680**	-0.588*	0.201	-
Crude fibre	-0.160	-0.445	-0.060	-	
Crude fat	-0.451	0.068	-		
Crude protein	-0.229	-			
Moisture	-				

Parameter	NFE	NDF	ADF	ADL	Yield
Yield	-0.208	0.022	0.011	0.020	-
ADL	0.089	0.999***	0.986***	-	
ADF	0.077	0.991***	-		
***NDF	0.093	-			
NFE	-				
Ash					
Crude fibre					
Crude fat					
Crude protein					
Moisture					

Significant correlation at; *p<0.05; ** p<0.01; *** p<0.001; ADL: Acid Detergent Lignin; ADF: Acid Detergent Fibre; NDF: Neutral Detergent Fibre; NFE: Nitrogen Free Extract

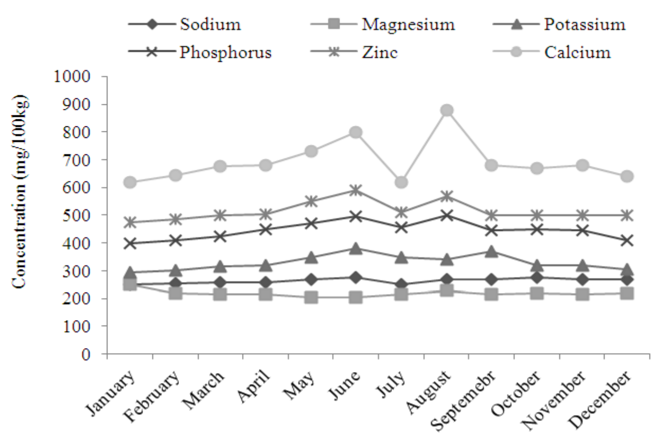

Fig. 2: Effects of season on mineral composition in *Aspilia africana* leaves

highest value in the month of January (14.74%). The period with the highest concentration of fibre was the late dry season and aging stage of the plant. All fibre fractions had higher values during the late dry season-January and tended to decrease as the wet season ensued.

High ash content ranging from 11.67 to 18.97% was observed in the leaves of *Aspilia africana* plant throughout the season. At the onset of bloom (August), ash content of about 18.97% was obtained but it dropped to 11.67% as flowering commenced (September).

Figure 2 illustrates that calcium had the highest value followed by zinc, phosphorus, potassium, magnesium and sodium. Significant (p<0.05) influences of season were observed between months on the different elements analyzed. The concentrations of calcium and phosphorus peaked in the month of August, while those of zinc and potassium peaked in the month of June.

Correlation result (Table 2) indicated that herbage yield correlated positively (p<0.05) with crude protein (r = 0.467) but negatively with moisture, crude fat, ash and nitrogen free extracts. Significant relationships were observed between crude fat and NFE (r = 0.656; p<0.01), yield and fibre (r = 0.020; p>0.05) as well as between ash and crude fat (r = -0.588; p<0.05) in *Aspilia africana* leaves. Crude protein had negative relationships with ash (r = -0.680; p<0.01) and ADF (r = -0.497; p<0.05) while moisture content had positive (p>0.05) relationships with ash (r = 0.332) and fibre fractions (r = 0.023-0.081). These results indicated that increase in herbage yield led to significant increase in the crude protein but non-significant increase in fibre contents in the leaves of *Aspilia africana* plant. A resultant increase in crude protein content could lead to a substantial decrease in the concentrations of ash and ADF in the leaves. When moisture increases in the leaves, the amount of ash and fibre fractions increase, whereas, an increase in ash content leads to significant reduction in crude fat content.

DISCUSSION

In the month of January (late dry season), it was observed that while other plants dried up, *Aspilia africana* continuously produced green leaves though the stem became more fibrous during the late dry season. At the start of the wet season (April), high amount of the fresh plants were still seen sprouting around the experimental site. In the month of May, greener fresh stands had developed. Blooming and flowering commenced in the month of September and peaked in November. Haddi *et al*. (2003) had also identified three stages of maturity in some halophyte shrubs. This implies that the quantity and stage of vegetation is dependent on the season and amount of rainfall. It was also observed that yield production was significantly ($p<0.05$) correlated with the stage of maturity as earlier observed by Mountousis *et al*. (2006), Abusuwar and Ahmed (2010) and Oko *et al*. (2012). Mean biomass yield obtained (15,635 kg/ha) indicated that *Aspilia africana* plant has a large vegetative cover throughout the year and could be a valuable feed resource for all year round ruminant and feed productions. Yield recorded were comparable to values reported for common tropical browses (Kallah *et al*., 2000; Mako *et al*., 2012). Mountousis *et al*. (2006) had also reported a significant effect of season on biomass production in forages grown in Greece. Generally, the quantity of nutrients in the leaves of *Aspilia africana* plant did not follow any pattern over the 12-month study period. The decrease in the quantity of moisture in the foliage from the rainy to the dry season may be attributed to the reduction in rainfall as well as the increase in the age of the forage as the season progressed. Low moisture content is desired in forages since it will enhance rapid drying, reduce spoilage and prolong forage utilization, including for use, as silage or hay materials *(*Bamikole *et al*., 2006; Akinwande *et al*., 2011). This implies that *Aspilia africana* has potential as a feed resource for year-round fodder production.

The decline in crude protein observed in the month of August could have been due to the setting in of phenological development in the plant transiting from the vegetative state to its flowering stage in the month of September. Earlier studies have shown similar crude protein patterns due to seasonal variations (Kallah *et al*., 2000; Chemman *et al*., 2009; Jimoh *et al*., 2011). Soni *et al*. (2015) showed that seasonal variations occurring in some metabolites of medicinal plants could affect their efficacies. The mean crude protein value (22.10%) was comparable to the ranges (14.26-26.88%) earlier reported by Oko and Agiang (2011) and Yusuf *et al*. (2013) for *Aspilia africana* leaves but higher than the 14-18.4%, 14.70%, 15.57% reports of Kallah *et al*. (2000), Ahamefule *et al*. (2006) and Ikhimioya and Imasuen (2007), respectively; for some leguminous fodder plants. Contrary to the observation of Minson (1990), there was no tremendous drop in the protein contents in the leaves of *Aspilia africana* plant all through the year. This could suggest that the plant can sustain animal performance all through the year. Plant materials that contain above 12% crude protein have been considered to be valuable sources of protein (Minson, 1990). *Aspilia africana* may thus be considered a valuable feed ingredient for animals feeding on low quality materials.

Previous studies had reported fat content of over 7% in the leaves of *Aspilia africana* plant (Oko and Agiang, 2011; Yusuf *et al*., 2013) though Mountousis *et al*. (2006) reported fat content (1.72-2.21%) comparable to values in the present studies for forages grown in Greece. Irrespective of season, the NDF had the highest values than ADF and ADL since it was most efficient in extracting microbial matters. As the plant matured, the lignin became higher in January (late maturity phase >2%). Van Soest *et al*. (1991) earlier purported that a good forage quality is determined by the lower fibre fractions and higher protein content. The fibre fraction contents were lower than the values of 49.9-54.2% (Sophal *et al*., 2010), 55.60% (Mako *et al*., 2012) and 35.59-60% (Yusuf *et al*., 2013) reported for some browses. Above 55% fibre fractions have been reported (Meissener *et al*., 1991) to have depressing effect on forage intake by animals. The low fibre content in the leaves of *Aspilia africana* makes it highly digestible and appropriate feedstuff for all classes of animal as earlier observed by Oko *et al*. (2012). The high ash content is attributed to the extensive absorbing ability of the plant while, the drop in ash content could be an impact of flowering. There were noticeable reductions in the concentrations of minerals in the month of July. This could be attributed to the change in rainfall pattern or stage of maturity of the plant. The amount of sodium in the leaves was not influenced by season, though a slight increase was observed during the late dry season. Values comparable to those obtained have been reported (Oko and Agiang, 2011; Yusuf *et al*., 2013). Results were in line with the report of Backlund and Belskog (1991) that high calcium and potassium contents were found in herbs.

Some correlation relationships exhibited are consistent with the observations of Ammar *et al*. (2004, 2005) and Mountousis *et al*. (2006) that crude protein is positively correlated with biomass production but correlates negatively with fibre fractions. From the results, it is obvious that, irrespective of season or stage of maturity, *Aspilia africana* leaves maintain their nutritive contents similar to findings by Haddi *et al*. (2009) that season had no effect on the chemical compositions of six Algerian forages.

CONCLUSION

The present study revealed no significant variations in the chemical composition of *Aspilia africana* leaves between seasons. The foliage of *Aspilia africana* showed high yield, crude protein and ash contents, sufficient to be considered a suitable supplementary fodder in low quality roughage feeding programmes.

CONFLICT OF INTEREST STATEMENT

All authors have approved the submission of this manuscript and do declare that there is no conflict of interest. The manuscript has not been published previously and is not under consideration for publication elsewhere.

ACKNOWLEDGMENT

This study was supported by the International Foundation for Science, Stockholm, Sweden and the Organisation for the prohibition of Chemical Weapons, The Hague, The Netherlands, through Grant number “IFS Gt B/4719 Olawoyin” to evaluate the potentials of *Aspilia africana* leaf as growth promoter in poultry.

REFERENCES

Abusuwar, A.O. and E.O. Ahmed, 2010. Seasonal variability in nutritive value of ruminant diets under open grazing system in the semi-arid rangeland of Sudan (South Darfur State). Agric. Biol. J. N. Am., 1(3): 243-249.

Ahamefule, F.O., B.E. Obua, J.A. Ibeawuchi and N.R. Udosen, 2006. The nutritive value of some plants browsed by cattle in Umudike, Southeastern Nigeria. Pak. J. Nutr., 5(5): 404-409.

Akinwande, V.O., A.A. Mako and O.J. Babayemi, 2011. Silage quality, voluntary feed intake (VFI), nutrient digestibility and nitrogen balance in WAD sheep fed ensiled water hyacinth in Nigeria. Proceedings of the 36th Annual Conference of the Nigerian Society for Animal Production. University of Abuja, March 13-16, pp: 509-512.

Ammar, H., S. Lopez, J.S. Gonzalez and M.J. Ranilla, 2004. Seasonal variations in the chemical composition and in vitro digestibility of some Spanish leguminous shrub species. Anim. Feed Sci. Technol., 115(3-4): 327-340.

Ammar, H., S. López and J.S. González, 2005. Assessment of the digestibility of some Mediterranean shrubs by *in vitro* techniques. Anim. Feed Sci. Technol., 119(3-4): 323-331.

AOAC, 1986. Official Methods of Analysis. 14th Edn., Association of Official Analytical Chemists, Arlington, VA, pp: 250-400.

AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists. Washington, D.C., pp: 805-845.

AOAC, 1995. Official Methods of Analysis. 16th Edn., Association of Official Analytical Chemists. Arlington, VA.

AOAC, 2000. Official Methods of Analysis. 17th Edn., Association of Official Analytical Chemists, Gaithersburg, MD.

AOAC, 2005. Official Methods of Analysis. 18th Edn., Association of Official Analytical Chemists, Washington, DC.

Backlund, M. and J. Belskog, 1991. The role of trees and shrubs in livestock production in central Tanzania. A survey of their nutritive value during the dry season. International Development Centre, Swedish University of Agricultural Science, Uppsala, pp: 24.

Bamikole, M.A., O.J. Babayemi and A. Omojola, 2006. Evaluation of the nutritive value and free choice intake of two aquatic weeds (*Nephrolepis biserrata* and *Spirodela polyrhiza*) by West African Dwarf goats. Trop. Subtrop. Agroeco., 6(1): 15-21.

Cetingul, I.S., I. Bayram, A.B. Akkaya, C. Uyarlar, M. Yardimci, E.H. Sahin and E. Sengor, 2007. Utilisation of oregano (*Origanum onites*) in laying quails (*Coturnix coturnix japonica*) (2): The effects of oregano on performance, carcass yield, liver and some blood parameters. Arch. Zootech., 10: 57-65.

Chemman, M., N. Moujahed, R. Ouzrout and M.A. Guellati, 2009. Seasonal Variations of Chemical Composition, Intake and Digestibility by Ewes of Natural Pasture in the South-Eastern Regions of Algeria. In: Papachristou, T.G., Z.M. Parissi, H. Ben Salem and P. Morand-Fehr (Eds.), Nutritional and Foraging Ecology of Sheep and Goats. CIHEAM/FAO/NAGREF, Zaragoza, 8: 123-127.

Coughenour, M.B. and H.P.S. Makkar, 2012. Conducting national feed assessments. By FAO Animal Production and Health Manual No. 15, Rome, Italy.

Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11(1): 1-42.

Etukudo, I., 2003. Ethnobotany: Conventional and Traditional Uses of Plants. The Verdict Press, Uyo.

FAO, 2010a. The state of food and agriculture 2009: Livestock in the balance. Food and Agriculture Organization of the United Nations, Rome, Italy, pp: 176.

FAO, 2010b. 2000 World census of agriculture. FAO Statistical Development Series 12. FAO, Rome, Italy.

FAO, IFAD and WFP, 2015. The State of Food Insecurity in the World 2015. Meeting the 2015 International Hunger Targets: Taking Stock of Uneven Progress. Food Agriculture Organisation, International Fund for Agricultural Development and World Food Programme, Rome, FAO.

Haddi, M.L., S. Filacorda, K. Meniai, F. Rollin and P. Susmel, 2003. In vitro fermentation kinetics of some halophyte shrubs sampled at three stages of maturity. Anim. Feed Sci. Technol., 104(1-4): 215-225.

Haddi, M.L., H. Arab, F. Yacoub, J.L. Hornick, F. Rollin and S. Mehennaoui, 2009. Seasonal changes in chemical composition and *in vitro* gas production of six plants from Eastern Algerian arid regions. Livest. Res. Rural Dev., 21(4): 47.

Hernandez, F., J. Madrid, V. Gracia, J. Orengo and M.D. Megias, 2004. Influence of two plant extracts on broilers performance, digestibility and digestive organ size. Poult. Sci., 83(2): 169-174.

Ikhimioya, I. and J.A. Imasuen, 2007. Blood profile of West African Dwarf goats fed *Panicum maximum* supplemented with *Afzelia africana* and *Newbouldia laevis*. Pak. J. Nutr., 6(1): 79-84.

Inyang, P. E. B. 1980. Pollution: A factor in the climate of Calabar and environs. Proceedings of the 23rd Conference of Nigerian Geographical Association, University of Calabar, Calabar, March 16-21, pp: 7-22.

Jimoh, F.O., A.A. Adedapo and A.J. Afolayan, 2011. Comparison of the nutritive value, antioxidant and antibacterial activities of *Sonchus asper* and *Sonchus oleraceus.* Rec. Nat. Prod., 5(1): 29-42.

Kallah, M.S., J.O. Bale, U.S. Abdullahi, I.R. Muhammad and R. Lawal, 2000. Nutrient composition of native forbs of semi-arid and dry sub-humid savannas of Nigeria. Anim. Feed Sci. Technol., 84(1-2): 137-145.

Li, Q.P., S.R. Gooneratne, R.L. Wang, R. Zhang, L.L. An, J.J. Chen and W. Pan, 2016. Effect of different molecular weight of chitosans on performance and lipid metabolism in chicken. Anim. Feed Sci. Technol., 211: 174-180.

Mako, A.A., V.O. Akinwande, O.I. Abiola-Olagunju, O.J. Babayemi and A.O. Akinsoyinu, 2012. Variations in chemical nutrients and mineral concentrations of water hyacinth (*Eichhornia crassipes* Mart. Solms- Labauch). Niger. J. Anim. Prod., 39: 199-205.

Meissener, H.H., M.O. Viljoen and W.A. Van Niekerk, 1991. Intake and digestibility by sheep of antephora, panicum, rodes and smut finger grass pastures. Proceedings of the International Rangeland Congress, 4: 648-649.

Minson, D.J., 1990. Forage in Ruminant Nutrition. Academic Press, San Diego.

Mountousis, I., K. Papanikolaou, F. Chatzitheodoridis, C. Roukos and A. Papazafeiriou, 2006. Monthly chemical composition variations in grazable material of semi-arid rangelands in North-Western Greece. Livest. Res. Rural Dev., 18(11).

Norton, B.W. and D.P. Poppi, 1995. Composition and Nutritional Attributes of Pastures Legumes. In: De Mello J.P.F. and Devendra C. (Eds.), Tropical Walling Food. U.K., pp: 23- 46.

Oko, O.O.K., 2011. Comparative efficacy of meal and extracts of *Aspilia africana* leaf in laying quails. J. Anim. Sci., 89(E-Suppl. 1): 724.

Oko, O.K. and E.A. Agiang, 2011. Phytochemical activities of *Aspilia africana* leaf using different extractant. Indian J. Anim. Sci., 81(8): 30- 34.

Oko, O.O.K., E.A. Agiang and A.F. Afolabi, 2011. *Aspilia africana* leaf meal as an egg booster and yolk colourant in quails. Int. J. Agric., 3(1): 103-108.

Oko, O.O.K., E.A. Agiang and I.E. Iso, 2012. Dietary *Aspilia africana* leaf on nutrients digestibility and physio-chemical properties of intestinal segments in quails. J. Anim. Sci., 90(Suppl. 3): 136.

Oko, O.O.K., E.A. Agiang and P.O. Ozung, 2013. Hen performance as influenced by dietary *Aspilia africana* leaf. J. Anim. Sci., 91(E-Suppl. 2): 154.

Oko, O.O.K., E.A. Agiang and E.E. Osim, 2014. Pharmacognosy of *Aspilia africana* Plant: Phytochemistry and Activities. In: Umar K. (Ed.), Perspectives for Modern Medicine. 2nd Edn., ASTRAL, 2: 383-409.

Okoli, C.O., P.A. Akah and A.S. Okoli, 2007. Potentials of leaves of *Aspilia africana* (Compositae) in wound care: An experimental evaluation. BMC Complem. Altern. M., **7**: 24.

Papachristou T.G., P.D. Platis, V.P. Papanastasis and C.N. Tsiouvaras, 1999. Use of deciduous woody species as a diet supplement for goats grazing Mediterranean shrublands during the dry season. Anim. Feed Sci. Technol., 80(3-4): 267-279.

SAS, 2007. Statistical Analysis System. SA/STAT User's Guide Version 9.13, Cary, NC, USA.

Shamat, A.M., I.A. Babiker, M.S. Mukhtar and F.A. Ahmed, 2010. A study of the seasonal and regional variations in nutritive value of some important plant species selected by camels in Arid and Semi-Arid Lands (ASAL) of Sudan. J. Appl. Sci. Res., 6(8): 1265-1272.

Soni, U., S. Brar and V.K. Gauttam, 2015. Effect of seasonal variation on secondary metabolites of medicinal plants. Int. J. Pharm. Sci. Res., 6(9): 3654-3662.

Sophal, C., K. Borin and T.R. Preston, 2010. Effects of supplements of water hyacinth and cassava hay on the performance of local "yellow" cattle fed a basal diet of rice straw. Livst. Res. Rural Dev., 22(9).

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74(10): 3583-3597.

Yusuf, K.O., O.A. Isah, O.M. Arigbede, A.O. Oni and C.F.I. Onwuka, 2013. Chemical composition, secondary metabolites, in vitro gas production characteristics and acceptability study of some forage for ruminant feeding in South-Western Nigeria. Niger. J. Anim. Prod., 40(1): 179-190.