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Research Application Summary

Nutritional quality of early- or late- maturing varieties of groundnuts: Effects on digestibility and growth performance of sheep fed groundnut haulms

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Abstract

This study determined the digestibility and growth performance of sheep fed early- or late-maturing varieties of groundnut haulms. Early-maturing varieties (90 days) included Chinese, Yenyawoso and Sumnut 23 whereas late-maturing varieties (110−120 days) were Sumnut 22, Azivivi and Manipinta. Each variety was cultivated on four replicate plots of 2.4 × 4.0 m^2, 3.6 × 4.0 m^2, 4.8 × 4.0 m^2 and 6.0 × 4.0 m^2. At maturity, all the varieties were harvested. The pods were separated from the haulms (leaves and twigs) and equal portions of the haulms were combined into early- or late-maturing varieties. Each of the combined haulms were then dried to a DM of 92% and crushed to a theoretical length of 3–4 cm before being used to formulate two diets that were fed to West African Dwarf growing rams (14.75 ± 2.52 kg) in experiment I. In experiment II, two fistulated Nungua Black Head sheep were used to determine the *in-situ* digestibility of early- or late- maturing groundnut haulms. Even though the concentrations of ADF ($P = 0.01$) and ADL ($P = 0.02$) were greater in the early- compared to late- maturing haulms, differences in *in situ* digestibility ($P \geq 0.03$), growth performance ($P = 0.69$) of sheep were not significant. This study suggests that duration to maturity has no effect on the nutrient quality of groundnut haulms and on the growth performance of sheep.

Keywords: Early-maturing, groundnut haulm, late-maturing, *in situ* digestibility, sheep

Résumé

This study determined the digestibility and growth performance of sheep fed early- or late-maturing varieties of groundnut haulms. Early-maturing varieties (90 days) included Chinese, Yenyawoso and Sumnut 23 whereas late-maturing varieties (110−120 days) were Sumnut 22, Azivivi and Manipinta. Each variety was cultivated on four replicate plots of 2.4 × 4.0 m^2, 3.6 × 4.0 m^2, 4.8 × 4.0 m^2 and 6.0 × 4.0 m^2. At maturity, all the varieties were harvested. The pods were separated from the haulms (leaves and twigs) and equal portions of the haulms were combined into early- or late-maturing varieties. Each of the combined haulms were then dried to a DM of 92% and crushed to a theoretical length of 3–4 cm before being used to formulate two diets that were fed to West African Dwarf growing rams (14.75 ± 2.52 kg) in experiment I. In experiment II, two fistulated Nungua Black Head sheep were used to determine the *in-situ* digestibility of early- or late- maturing groundnut haulms. Even though the concentrations of ADF ($P = 0.01$) and ADL ($P = 0.02$) were greater in the early- compared to late- maturing haulms, differences in *in situ* digestibility ($P \geq 0.03$), growth performance ($P = 0.69$) of sheep were not significant. This study suggests that duration to maturity has no effect on the nutrient quality of groundnut haulms and on the growth performance of sheep.

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Introduction

Groundnut (*Arachis hypogaea* L.) is a member of the Fabaceae family and is cultivated in most tropical and subtropical nations, including Ghana (FAOSTAT, 2013). Groundnut, also referred to as peanut, is Ghana's most vital grain legume in terms of area under cultivation (MoFA-SRID, 2014). More than 70% of the total amount of groundnut produced in Ghana is traced to the Guinea savanna ecology (MoFA-SRID, 2014), which makes it the country's largest groundnut growing region.

In the sub humid zone of West Africa, groundnut is an essential plant in the production of fodder and seed in smallholder crop-livestock farming systems (Olorunju *et al*., 1996). Groundnut haulms in Ghana is often utilized as supplementary feed in ruminant production (Konlan *et al*., 2012) by small-scale farmers who rely mostly on natural grassland. Groundnut haulms are utilized as fodder for livestock, particularly throughout the lean seasons (Brandenburg *et al*., 2003). Groundnut haulm is the most vital of its by-products that maybe supplied as feed to livestock and as fodder providing additional financial gain to smallholder farmers (Arslan, 2005).

Small-scale crop-livestock farmers consider forage yield and quality and seed yield of groundnut as joint products with equal value and significance (Olorunju *et al*., 1996). Late-maturing groundnut varieties are preferred to the early-maturing varieties by the Small-scale crop-livestock farmers in subtropical zone of West Africa (Olorunju *et al*., 1996), since the late-maturing varieties yields more forage for livestock and seeds in addition.

Omokanye *et al*. (2002) reported that there was sufficient concentration of CP and NDF to sustain livestock production in the critical periods of the farming season in groundnut forage, with the improved cultivars out-performing the local cultivars. Crop residues degradation characteristics in the rumen is the main determining factor of haulms quality, and it is a top predictors of animal performance (Orskov, 1991).

Considerable attention has been drawn to the problems in feeding ruminants in the tropics and subtropics (Tesfayohannes, 2003). Poor quality, unavailability and insufficient forage crops and farm waste in most developing countries puts ruminants in constant hunger challenge from under feeding chiefly in the dry seasons (Nyako, 2015). The quantity and quality of feed in the dry season is the major challenge amidst the numerous limitations of livestock production in Ghana (Oppong-Anane, 2013). One attainable practice to lessen this drawback and retain production is to feed crop residue and browse plants to ruminants as alternative feed during the lean seasons in the tropics (Okafor *et al*., 2012).

Therefore, the aim of this study was to assess the effects of six groundnut varieties on nutritive value, *in vitro* (48 h), Dry matter (DM) disappearance and *in situ* ruminal disappearance kinetics on the growth performance of West African Dwarf (Djallonké) growing rams fed with them. The different varieties of groundnut were selected for this study because groundnut is a cash crop commonly cultivated in the sub-tropical countries including Ghana; its seeds are sold with haulms serving as a good source of feed for ruminants during the lean season.

Materials and Methods

Study Area . The animal experimentation was conducted at the Livestock Unit of the Department of Animal Science, Faculty of Agriculture (FOA) of the University for Development Studies

(UDS), located at Nyankpala. The chemical analyses were conducted at Livestock and Poultry Research Centre (LIPREC) – Legon. Nyankpala is situated on longitude 0º 58'47.57" W and latitude 9º 23'45.53" N and at an altitude of 168 m above sea level in the Guinea Savannah ecological zone of Ghana. Nyankpala has a unimodal rainfall pattern that begins in late April and reaches a peak in July to September; there is a sharp decline with most often no rain in November (SARI, 2004). The study was conducted during the dry season from 4th October, 2017 to 29th March, 2018. The mean annual rainfall is 1200 mm (SARI, 2004). Temperature generally fluctuates between 19 ºC minimum and 42 ºC maximum with a mean annual temperature of 28.5 ºC (SARI, 2015). The mean annual day time relative humidity is (27% – 40%); and sunshine (80% – 87%). The area experiences dry cold Harmattan winds from November to February and a period of warm dry conditions from March to Mid-April. Data on environmental conditions during this period were obtained from weather records of Savanna Agricultural Research Institute (SARI, 2004; SARI, 2015) situated 1.8 km (22 minutes) from the location of the experiment.

Experimental animals, housing and feeding trials. A total of 22 intact West African Dwarf (Djallonké) growing rams with average initial live weight of (14.75 ± 2.52 kg) were purchased from Council for Scientific and Industrial Research Animal Research Institute (CSIR-ARI) at Nyankpala in Ghana. Animals were given 16 days adaptation period to feed at the experimental site. Animals were given prophylactic treatment of Oxykel 20 L.A. (KELA, Belgium) applied against bacterial infections which was administered by deep I.M. injection: 1ml per 10 kg body weight per day while, ivermectin 1% (Hovione, Portugal) for treatment and control of internal and external parasites was administered by subcutaneous injection: 1ml per 50 kg body weight. Animals were randomly assigned to twenty two wooden pens (2.44 m × 0.87 m) with concrete floors, each pen contained a ram. This was done at the University for Development Studies, Tamale, Ghana.

The groundnut haulms were obtained from six varieties of groundnut cultivated on the agronomic trial fields of Africa Research in Sustainable Intensification for the Next Generation (RISING) project of the International Institute of Tropical Agriculture (IITA) in Duko and Tibali communities in Savelugu-Nanton District, Cheyohi community in Kumbungu District and Tingoli community in Tolon District. The groundnut varieties were Chinese, ICGX SM 87057 (Yenyawoso), ICGV-IS 96894 (Sumnut 23), MS72.80 (Sumnut 22), RMP 12 (Azivivi), and Manipinta. Chinese, Yenyawoso and Sumnut 23 are classified as an early maturing varieties with 90-day maturity, Sumnut 22, Azivivi and Manipinta are late maturing varieties with maturity ranging from 110 to 120 days. Each variety was grown on four replicate fields measuring (2.4×4 m^2), (3.6×4 m^2), (4.8×4 m^2) and (6.0×4 m^2). A pre-emergence herbicide (Stomp) was sprayed immediately after planting and (Sun phosphate) was sprayed post-emergence. Exactly five weeks after planting weeds were removed with hoes. At maturity, the groundnuts were harvested manually and the pods separated from the haulms. The haulms which were mainly leaves and twigs were transported to the livestock unit of the Animal Science Department of UDS for shade drying which lasted for 12 days. The dried haulms were reduced to an average length (3 cm – 4 cm) and used to formulate two diets (EMGH and LMGH).

Sheep were weighed on two consecutive days at the beginning of the experiment and every two weeks thereafter until the end of the experiment, when two consecutive weights were taken again. The average of the consecutive weights at the beginning of the study and at the end were used as the initial and final weights, respectively.

Feed was mixed manually and delivered daily as a total mixed ration. The daily amount of feed offered was recorded and left overs were collected daily, weighed and sampled before being discarded. Samples of feed that were collected daily were composited into biweekly samples, subsampled and stored (1 ºC) for subsequent proximate analysis for *in situ* and *in vitro* digestibility trial. Dry Matter of leftovers were determined weekly. Animals were offered their

feed every morning (07:00 am) and every evening (05:00pm). The quantities of feed offered daily were adjusted to meet appetites of animals and to ensure minimal feed leftovers without limiting intake. Fresh water was supplied *ad libitum* daily per pen. Dry matter intake (DMI) of each pen was calculated as feed DM offered minus DM of the left-overs. The DMI, average daily gain (ADG), and feed conversion ratio (expressed as DMI/ADG) were estimated separately for the periods when the sheep were fed the EMGH diet and the LMGH diet, and for the whole 45-day experimental period. Feed offered was sampled biweekly and were used to determine DM. Dry matter of leftovers was determined in a force-air oven at 60ººC for 48 hours instead of the conventional 105 ºC for 24 hours because the diets contained groundnut haulms and whole cotton seed. These ingredients contain oils, carotenes, vitamins and other volatile compounds.

The nylon-bag technique/In Sacco (in situ) degradation. Biweekly sub-samples of each diet were also air-dried and ground through a 2 mm screen. Samples were incubated (sequential addition) in duplicates for 6, 12, 24, 48, 72, 96 and 120h in the rumen of two fistulated Nungua Black Head rams to measure the rate and extent of degradation of dry matter, of different diets. Sheep were allowed to graze the natural pastures with free access to water throughout the experiment. Approximately 2.0 g of DM of test feeds was weighed into the artificial nylon bags (7 cm × 14 cm) with a pore size of 40µm. It was tightly sealed and placed in the rumen of a fistulated animals. At the end of incubation, the nylon bags were withdrawn from the rumen and washed together with the zero-hour bag under a running tap until the dripping water was almost clear. The nylon bags were put in an oven at 80 ºC for about 48 hours. Degradability (or disappearance) of the substrate was determined by the weight loss during the incubation periods. In sacco rumen DM disappearance data were fitted to the first order exponential model with discrete lag (Martens, 1977) using the iterative Marquardt method and the NLIN procedure of 9.2 version of SAS (SAS Institute Inc., Cary, NC, USA). The model was of the form: $R_{(t)} = a*(exp^{-k_d*(t-L)}) + r$, where $R_{(t)}$ = total indigested residue at any time t, a = insoluble potentially digestible fraction, k_d = fractional rate of digestion of a, t = time incubated in the rumen in hour, L = discrete lag time in hour, and r = fraction not digested after 120h of incubation. The wash fraction (A) was the percentage of substrate washed out of the nylon bag at 0h. Effective ruminal degradability (extent of digestion, ERD) was calculated using the model of Orskov and McDonald (1979): $ERD = A + \{B * [k_d / (k_d + k_p)]\}$, where k_p = assumed ruminal passage rate of 0.05 per hour.

***In vitro* digestibility procedure.** A total of 0.5 g of dried sample was weighed and placed into a labeled 50 ml centrifuge tube. To this tube, 28 ml of McDougall's solution was added in a pre-warm McDougall's solution in 39 ºC water bath. Subsequently, 7 ml of ruminal fluid (can alter quantity) was added at 4:1 ratio of buffer to ruminal fluid. Rumen content was collected from two fistulated Nungua Black Head rams and then strained through four layers of cheesecloth (with continues flushing with CO_2 gas) to obtain the rumen fluid. The ruminal fluid was placed on a stir plate to avoid settling. Also, there were four blanks (tubes containing NO sample and 35 ml of the McDougall's solution to ruminal fluid mixture). Also two blanks per time interval were included for estimating the rate of digestion. The samples were incubated for 48 hours and the tubes were inverted for 2, 4, 20, and 28 hours after incubation to suspend the sample. After 48 hours of incubation, the tubes were removed from the water bath and centrifuged for 15 minutes at 2,000 g and the liquid suction off by a vacuum. Then, 35 ml of pepsin solution was added to each tube and incubated for 48 hours in 39 ºC water bath while shaking at 2, 4, and 6 hours after pepsin addition. After completion of the digestion, the samples were filtered using the modified Buchner funnel and ash less filter paper. The filter paper containing the sample were placed in an aluminum pan and dried for 48 hours and the weights recorded.

To determine ash content, samples were heated at 500 ºC for four hours. *In vitro* dry matter disappearance after 48h incubation data were fitted in the equation:

$$\%IVDMD = 1 - \frac{[(\text{Residue} + \text{filter paper}) - \text{filter paper}] - \text{blank}}{(\text{Sample weight})\ (\text{DM})}$$

Blank = (blank residue + filter paper) – filter paper

Chemical analyses. Feed samples composited into biweekly samples were subsampled for chemical analysis according to the official methods of analyses described by Association of Official Agricultural Chemists (AOAC, 1990). All analyses were done in duplicate but in triplicate for *in vitro* digestibility trial. All nutrient constituents were expressed on DM basis.

Biweekly sub-samples of each diet were also air-dried and ground through a 2 mm screen to analyze Neutral Detergent Fibre (NDF), Acid Detergent Lignin, cellulose, silica and Acid Detergent Fibre (ADF), using the Association of Official Agricultural Chemists method (AOAC, 1990).

Statistical analysis. The results from the chemical analysis and growth parameters of the EMGH and LMGH diets were subjected to analysis of variance (ANOVA) using Genstat Eighteenth Edition. Significant differences between means were separated using least significant difference (LSD).

Results

Forage chemical composition. The Table 1 below shows that the CP concentration did not differ (P = 0.97) in LMGH and EMGH. The highest value (13.75%) was observed in LMGH and the lowest (13.69%) in EMGH. The disparity between the CP of EMGH and LMGH may be attributed to the genetic advancement of the varieties and or inherent genetic traits.

Table 1. Chemical composition of groundnut haulms obtained from early-maturing and late-maturing varieties.

Item (% DM)	EMGH	LMGH	SED	P Value
ADF	28.71	26.35	0.27	0.01
Ash	8.87	8.24	0.16	0.06
Cellulose	19.24	17.09	0.53	0.06
CP	13.69	13.75	1.09	0.97
DM	92.36	93.31	0.13	0.02
ADL	7.63	6.65	0.13	0.02
NDF	33.19	30.34	0.87	0.08
Silica	1.83	2.61	0.24	0.08

DM= dry matter; EMGH= early maturing groundnut haulm; LMGH= late maturing groundnut haulm; CP= crude protein; NDF= neutral detergent fiber; ADF= acid detergent fibre; ADL= acid detergent lignin.

Nutrient intake and growth performance of animal. The daily DM intake did not differ significantly (P = 0.36) in LMGH and EMGH diets (Table 2). Dry matter intake is influenced to a large extent by dietary CP content. The highest value (0.72 kg/d) of daily DM intake was observed in LMGH which as well had the highest concentration of CP, and the lowest (0.68 kg/d) daily DM intake was observed in EMGH. The daily CP intake, daily NDF intake, daily OM intake and daily Silica intake were highest for LMGH and this could be attributed to its high Dry matter intake.

Table 2. Nutrient intake and growth performance of West African Dwarf (Djallonké) growing rams fed EMGH and LMGH

	Nutrient intake (DM basis)			
Parameter	**EMGH**	**LMGH**	**SED**	**P Value**
DMI (Kg/d)	0.68	0.72	0.04	0.36
Daily ADF intake (g)	196.2	193.4	0.78	<0.001
Daily NDF intake (g)	228.5	258.7	15.32	0.06
Daily OM intake (g)	615.0	657.0	39.5	0.31
Daily lignin intake (g)	51.6	47.6	3.00	0.20
Daily silica intake (g)	12.35	18.67	1.04	<0.001
Daily CP intake (g)	92.5	98.4	5.93	0.33
Daily cellulose intake (g)	129.9	122.3	7.66	0.33
Live weight and live weight gain				
Initial weight (kg)	14.66	14.61	1.15	0.96
Final weight (kg)	19.07	18.72	1.21	0.77
Weight gain (kg)	4.41	4.11	0.74	0.69
ADG (kg)	0.10	0.09	0.02	0.69
FCR (DMI/ADG)	7.41	7.74	0.97	0.74

DMI= dry matter intake; ADG= average daily weight gain; FCE= feed conversion Ratio; OM= organic matter.

In Sacco ruminal digestibility and IVDMD. EMGH (43.98%) had the lowest effective ruminal degradability (ERD) compared to LMGH (52.14%). The low (ERD) recorded in this study was probably due to the high content of ADL and NDF in EMGH. The *In Vitro* Dry Matter Disappearance was higher in EMGH (70.2%) than in LMGH (63.1%) even though EMGH recorded the highest NDF and ADF (Table 3). The higher concentration of NDF and ADF in EMGH may have subdued rumen microbe activity due to low levels of fermentable carbohydrates. This should have affected dry matter disappearance negatively.

Table 3. In Sacco DM disappearance kinetics (120h) and In vitro DM disappearance (48h) of EMGH and LMGH diets

Item	**EMGH**	**LMGH**	**SED**	**P Value**
In Sacco DM disappearance kinetics				
Rapidly soluble fraction (%)	0.935	0.936	0.054	0.99
Potentially degradable fraction (%)	55.7	70.6	8.84	0.24
Undegradable fraction (%)	33.2	29.7	2.11	0.24
Extent of digestion (%)	43.98	52.14	1.414	0.03
Lag time (h)	7.32	4.27	1.77	0.23
K_d (per h)	0.170	0.132	0.09	0.69
In vitro DM disappearance				
IVDMD (%)	70.2	63.1	8.07	0.43

K_d = fractional rate of digestion; IVDMD = In Vitro DM Disappearance after 48h incubation.

Discussion

Chemical composition, nutrient intake and animal growth performance. The concentrations of DM, Lignin and ADF differed significantly among the EMGH (Chinese, Yenyawoso and Sumnut 23) and LMGH (Sumnut 22, Azivivi and Manipinta) varieties (Table 9). LMGH had the

highest (P= 0.02) DM compared to EMGH. The dry matter (DM) content of EMGH (92.36%) and LMGH (93.31%) are comparable to the (91.6%) reported by Nyako (2015) and the (94.5%) reported by Yahaya *et al*. (2001) in groundnut haulms. Similarly, the ash content for EMGH (8.87%) and LMGH (8.24%) were higher than the 2.5 % recorded by Yahaya *et al.* (2001) and the (5.0%) reported by Nyako (2015) for groundnut haulm but fairly comparable to the 8.1% reported by Ansah *et al.* (2017).

The CP concentration did not differ (P = 0.97) in LMGH and EMGH (Table 3). The highest value (13.75%) was observed in LMGH and the lowest (13.69%) in EMGH. Nevertheless the CP content in EMGH and LMGH was higher than what was reported by Etela and Dung (2011), Khan *et al*. (2013) and Ansah *et al*.(2017) but comparable to those reported by Oteng-Frimpong *et al*. (2017). However, they were lower than values reported by Foster *et al*. (2011). Blümmel *et al*. (2005) reported a CP range of (100–180 g/kg DM) in peanut hay. The disparity between the CP of EMGH and LMGH, and those reported by other authors may be attributed to the genetic advancement of the varieties and or inherent genetic traits. Antwi *et al*. (2014) noted similar genetic variability in haulm quality of cowpea varieties. The Crude protein (CP) estimated in EMGH and LMGH were 13.69 and 13.75, respectively, and were above the recommended 70 g/kg DM (7%) minimum requirements for ruminants (Van Soest, 1982; NRC, 2007). Hence, EMGH and LMGH can supply enough rumen nitrogen for microbial activities just as Van Soest (1982) reported. The CP content of EMGH and LMGH fell within the stated range of 8 to 15% (Ozyigit and Bilgen, 2013). Crude protein (CP) content is a key indicator of nutritional quality. Thus, EMGH and LMGH the varieties are supplements for poor quality natural pasture and crop residues (Antwi *et al*., 2014).

Neutral detergent fibre (NDF) concentration was not significantly different (P = 0.08) among the EMGH and LMGH (Table 3), however, it was lower than in earlier reports on groundnut fodder by Etela and Dung (2011), Foster *et al*. (2011), Khan *et al*. (2013), Ansah *et al*. (2017) and Oteng-Frimpong *et al*. (2017). Acid detergent fibre (ADF) content was also significantly different (P = 0.01) among the EMGH and LMGH (Table 3). The EMGH had highest ADF content (28.71%) compared to LMGH (26.35%) unlike in the case of the CP content. However, values were lower than for values reported by Ozyigit and Bilgen (2013) and Oteng-Frimpong *et al*. (2017) but comparable to the 28.1% reported by Foster *et al*. (2011) and 338 g/kg DM reported by Khan *et al*. (2013). Usually, forage with high ADF indicates that it is of poor nutritional quality, has poor digestibility, and decreases animal growth when fed over a long period of time without supplementation (Owen, 1994).

Estimates for lignin (ADL) revealed lower ranges from 6.65% (66.5 g/kg) to 7.63% (76.3 g/kg) and possibly contain protein contamination, as well as ADF soluble. The lignin content reported in this study however is lower than the 105g/kg to 135 g/kg reported by Etela and Dung (2011), but comparable to the 7.2 % to 8.0% reported in alfalfa hays by Van Soest (1965). The observed differences in lignin and cellulose are likely to influence intake and digestibility of the EMGH and LMGH varieties. Cellulose contents of EMGH and LMGH are about equal, but are lower than reported in alfalfa hay (Van Soest, 1965). Lignin is regarded an anti-quality factor in forages because of its adverse effects on the nutritional availability of plant fiber (Moore and Jung, 2001).

The fact that the lignin level of forages is negatively associated to digestibility is well established (Jung and Deetz, 1993). The silica contents in EMGH and LMGH were not significantly different (P = 0.08). Although LMGH had the highest concentration of silica 2.61 (26.1 g/kg) as compared to 1.83 (18.3 g/kg) in EMGH, the values were lower than the 130 g/kg reported in rice straw (Van Soest, 2006).

Agbagla-Dohnani *et al*. (2003) reported on the way by which silica concentration in a forage inhibits digestibility with the aid of a silicified waxy cuticular layer in leaf blades, a barrier to

digestion of unsilicified tissue. The authors suggested that silica appeared to inhibit parenchyma degradation, due to inhibition of cellulolytic enzymes. Treatment with ammonia does not remove silica, but damages the cuticular layer, which allows access by rumen bacteria (Ha *et al*., 1994a, b). Unlike lignin, which protects cell wall carbohydrates via bonding and sets an ultimate limit to digestion, silica appears to operate by coating (Van Soest, 2006). Unlike lignin, silica is a nutrient element and likely functions in more than one way in plant metabolism (Van Soest, 2006). The plant organisms that accumulate silica do so through active transport and spend one ATP per silicon atom. Silicon deficiency in animals promotes failure of normal collagen and results in impaired bone formation (Carlisle, 1978).

The daily DM intake did not differ significantly (P = 0.36) in LMGH and EMGH diets (Table 4). Dry matter intake is influenced to a large extent by dietary CP content (Rogosic *et al*., 2006). The highest value (0.72 kg/d) of daily DM intake was observed in LMGH which as well had the highest concentration of CP while correspondingly the lowest (0.68kg/d) daily DM intake was observed in EMGH. Nevertheless, the daily DM intake content in EMGH and LMGH were lower than the (1,383g/d) reported by Khan *et al*. (2013) and (893.0g/d – 903.4 g/d) reported by Ansah *et al*. (2017) but comparable to the 766.70 g/h/d recorded by Nyako (2015). The daily CP intake, daily NDF intake, daily OM intake and daily Silica intake were highest for LMGH and this could be attributed to its high Dry matter intake.

The average daily live weight gain (ADG) of Djallonké rams fed EMGH and LMGH variety diets are shown in (Table 2). The average daily live weight gain (ADG) for EMGH and LMGH did not differ significantly (P = 0.69). The highest ADG was recorded in Djallonké rams fed EMGH (0.10kg) with the least for Djallonké rams fed LMGH (0.09 kg). They are however comparable to (96.40g) recorded in rams fed groundnut haulms supplemented with cotton seed cake and (94.60g) observed in rams fed groundnut hay + maize bran by Nyako (2015). However, higher than the (10.7 g – 52.7 g) range obtained by Ansah *et al*. (2017) and the (66.07g) recorded by Nyako (2015) in groundnut haulms as a sole diet. The high average daily live weight gain observed in this study shows that Djallonké rams fed LMGH and EMGH variety diets were able to take up adequate nutrients and use it to increase total live weight gain as suggested earlier by Okoruwa *et al*. (2013). This increase in total live weight gain suggests that there were enough nutrients in EMGH and LMGH variety diets to support growth performance and this can be employed in fattening of Djallonké rams. The performance of the Djallonké rams on the EMGH and LMGH diets agree with the claim of Vazquez and Smith (2000) that the balance between energy and protein in a ration augments live weights gain.

The LMGH had high nutritive value likely due to its high CP concentration and low ADF content. It as well had the highest Feed Conversion Ratio (7.74) compared to (7.41) for EMGH. EMGH had a weight gain of (4.41 kg) compared to (4.11 kg) for LMGH. The FCR range of values (14.06-45.68) reported by Ososanya (2013) when sheep were fed with diets containing graded levels of maize cob and (22.0) by Ansah *et al*. (2014) for sheep fed groundnut chaff is higher than the (7.41 and 7.74) FCR obtained in this study. However, the results were comparable to the range of (6.84-10.84) reported by Hossain *et al*. (2003) for goats under grazing conditions.

In Sacco ruminal digestibility and IVDMD. Among EMGH and LMGH diets shows that the DM fraction was slightly greater for LMGH (0.936) than EMGH (0.935) (Table 3). However, values were lower than ranges of 181 g/kg-347 g/kg (18.1% - 34.7%) and 126 g/kg-242 g/kg (12.6% - 24.2%) reported by Larbi *et al*. (1999) in leaf and stem of groundnut respectively; 197 g/kg-351 g/kg (19.7% - 35.1%) by Etela and Dung (2011) in groundnut stover; 37.2% and 31.6% by Foster *et al*. (2011) in annual peanut and perennial peanut, respectively. The potentially degradable DM fraction was highest in LMGH (70.6%) and lowest in EMGH (55.7%). The potentially degradable DM fractions were both above the recommended 50% digestibility for

maintenance in ruminants (Elgunaid, 1994). They are comparable to range 584 g/kg-687 g/kg (58.4% - 68.7%) obtained by Etela and Dung (2011) but higher than 43.7% and 48.3% reported by Foster *et al*. (2011). The undegradable DM fraction was greatest in EMGH (33.2%) and lowest in LMGH (29.7%).

Foster *et al*. (2011) reported a lower undegradable fractions (19.0% and 20.2%) compared to the current study. EMGH (43.98%) had the lowest effective ruminal degradability (ERD) compared to LMGH (52.14%). Digestibility of groundnut haulms ranges from 74% to 88% in ruminants and support animals' growth performance even when fed as sole feed (Karbo *et al*., 1997). This is not in agreement with the results obtained in the current study. The low (ERD) recorded in this study is probably due to the high content of ADL and NDF in EMGH. Kamstra *et al.* (1958) and Van Soest (1967) reported that poor digestibility is related to the extent of lignification of the cell wall components of the low-quality roughages. However, results are comparable to 415 g/kg-489 g/kg (41.5% - 48.9%) range reported by Etela and Dung (2011) but lower than 63.2% and 65.9% recorded by Foster *et al*. (2011). The lag time was longer for EMGH (7.3 in h) and shorter for LMGH (4.27 in h). The lag time before DM disappearance was longer for EMGH due to the greater NDF content. They are higher than that reported by Foster *et al*. (2011). The fractional rate of digestion was slower for LMGH (0.132 /h) than EMGH (0.170/h). However, they were higher than 0.11/h and 0.09/h recorded by Foster *et al*. (2011) in annual peanut and perennial peanut, respectively.

The *In Vitro* Dry Matter Disappearance was higher in EMGH (70.2%) than in LMGH (63.1%) even though EMGH recorded the highest NDF and ADF (Table 3). The higher concentration of NDF and ADF in EMGH probably subdued rumen microbe activity due to low levels of fermentable carbohydrates (Wilson and Hatfield, 1997). This may have been affected dry matter disappearance negatively. The IVDMD-value recorded for EMGH is comparable to 710 g/kg (71%) reported by Fernandes *et al*. (2013) in peanut forage hay, but lower than (75.18% - 84.13%) reported by Felix *et al*. (2018) in perennial peanut hay.

Conclusion

The nutritive estimates of the EMGH and LMGH varieties were all good and can sustain the productive performance of ruminants when offered in right quantities.The results show that LMGH had the highest nutritive value due to its high CP concentration, low NDF and low ADF content. EMGH had the lowest characteristic of nutritive quality due to its low CP, high NDF and high ADF contents. LMGH varieties thus provide quality groundnut haulm for use as feed for ruminants. However, LMGH had the highest Feed Conversion Ratio (7.74) compared to (7.41) for EMGH. The low Feed Conversion Ratio is a good indication of high quality feed and how efficient the Djallonké rams converted ingested feed into body mass. Even though LMGH had the highest CP content and low ADF (a characteristic of a top-quality groundnut haulm as a feed for ruminants), it had low FCR compared to EMGH, using the weight gain as an indicator.

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