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Growth performance and hematology of Djallonké rams fed haulms of four varieties of groundnut (*Arachis hypogaea* L.)

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ABSTRACT

The study was conducted to assess the chemical composition of the haulms of 4 dual-purpose groundnut (*Arachis hypogaea* L.) varieties and their effects on the growth and hematology of Djallonké rams. The groundnut varieties were ICGV 97049 (Obolo), ICGX SM 87057 (Yenyawoso), RMP 12 (Azivivi) and Manipinta. Rams (means \pm SD, live weight 15.0 ± 3.0 kg) were randomly assigned to 4 sole groundnut haulm meal (GHM) treatments, with 4 rams each in an individual pen per treatment (total $n = 16$ rams). Samples of the groundnut haulms were milled and analyzed for crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF). The CP concentration was higher ($P < 0.05$) in Azivivi, Manipinta and Yenyawoso than Obolo. The highest ($P < 0.05$) NDF and ADF fractions were obtained in Obolo. Whilst no significant difference was reported in total and daily dry matter (DM) intake among the varieties, CP, NDF and ADF intake all differed between Obolo and other varieties. The apparent nutrient digestibility did not differ ($P > 0.05$) when the Djallonké rams were fed the haulms. However, significant differences were observed in final live weight and average daily live weight gain. Rams fed the Yenyawoso variety had higher ($P < 0.05$) final live weight and average daily live weight gain compared with those fed Obolo and Azivivi varieties. Consumption of any of the 4 varieties of groundnut haulms by Djallonké rams did not have any harmful effect on their red and white blood cell numbers and hemoglobin concentration. The study revealed that the different varieties of groundnut haulms differs in nutrient composition and also affects the growth performance of the rams. The Yenyawoso variety may be used as a sole diet for fattening Djallonké rams.

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1. Introduction

Groundnut (*Arachis hypogaea* L.) is an important grain legume cultivated in most tropical countries including Ghana. The grains are very rich source of oil (48% to 50% of the grain), protein (26% to 28%) and carbohydrates (11% to 27%) (El Naim et al., 2011; Ibrahim

et al., 2013). It is cultivated in many countries world-wide with different climatic conditions (Upadhyaya et al., 2006).

Apart from their use as food for humans, the haulms of the crop are usually conserved as hay and fed to ruminant livestock as a supplement or as the sole diet. Grain yield, days to maturity and pest or diseases resistance have, over the years, been some of the objectives of groundnut varietal improvement programs across research institutes in the world (Pande et al., 2003; Parthasarathy and Hall, 2003). However, forage yield and quality are not part of the selection criteria in groundnut improvement programs in West Africa (Larbi et al., 1999).

Whilst some authors reported differences in the nutrient composition of haulms of different groundnut varieties (Larbi et al., 1999), others did not find differences (Etela and Dung, 2011). Similarly, significant differences of the effects of different groundnuts haulms on the live body weight gain of Djallonké sheep have been reported (Etela and Dung, 2011). When groundnut haulms

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were fed as a supplement to lambs feeding on different non-leguminous residues as a basal diet, there were significant improvements in their live weight gain (Abdou et al., 2011).

Available literature suggests that nutrient composition of groundnut haulms and their effect on growth of livestock could be affected by varietal differences. This provides justification to the current study that hypothesized that groundnut haulm nutrient composition and growth performance of Djallonké sheep fed different varieties of the groundnut haulm would differ.

Previous studies on the effect of groundnut haulm on growth of livestock have been conducted with the haulm as a supplement (Ikhatua and Adu, 1984; Abdou et al., 2011). Groundnut haulms and several other crop residues are often fed as a sole diet to ruminants in developing countries like Ghana, especially during the dry season. Devendra (1997) showed that the feed value of a crop depends on the biomass produced, voluntary intake, digestibility, and growth rate of the animal and this is best assessed through sole feeding. Literature on the effect of feeding groundnut haulm as a sole diet to ruminants is scant even though this is important information for small holder ruminant farmers. Etela and Dung (2011) found that West African Dwarf (WAD) sheep can be fed sole groundnut haulm from 6 dual purpose varieties without compromising nutrient intake and growth.

Hence, the aim of this study was to determine the nutrient composition of haulms of 4 dual-purpose groundnut varieties and their effect on the growth and the hematology of Djallonké rams.

2. Materials and methods

2.1. Location of the study

The animal experimentation and chemical analyses were conducted at the livestock unit and the Forage Evaluation Unit, respectively of the Department of Animal Science, Faculty of Agriculture (FOA) of the University for Development Studies (UDS), located at Nyankpala. Nyankpala is situated on longitude 0° 58'42" W and latitude 9° 25'41" N and at a height of 183 m above sea level in the dry savanna ecological zone of Ghana.

Nyankpala has a unimodal rainfall pattern that begins in late April and ends in October. The mean annual rainfall is 1,043 mm. Temperatures generally fluctuate between 15 °C (minimum) and 42 °C (maximum) with a mean annual temperature of 28.5 °C. The mean annual day time relative humidity is 54%. The area experiences dry cold Harmattan winds from November to February and a period of warm dry conditions from March to Mid-April. The dry season therefore stretches from November to late April.

2.2. Experimental animals and diet

Sixteen Djallonké rams were obtained from the Animal Research Institute of the Council for Scientific and Industrial Research (CSIR) at Nyankpala in Ghana. The rams had average initial live weight of 15.0 ± 3.0 kg and were randomly assigned to 4 sole groundnut haulm meal (GHM) treatments with 4 rams per treatment. The GHM was fed as the only ingredient in the diet and the animals were housed indoors for the entire period of the experiment.

The GHM were obtained from 4 varieties of groundnut cultivated on the agronomic trial fields under Africa Research in Sustainable Intensification for the Next Generation (RISING) project of the International Institute of Tropical Agriculture (IITA) in Tamale. The groundnut varieties were ICGV 97049 (Obolo), ICGX SM 87057 (Yenyawoso), RMP 12 (Azivivi), and Manipinta. With the exception of Yenyawoso which is classified as a short duration variety with 90-day maturity, all other varieties were long duration with maturity ranging from 110 to 120 days. Each variety was

cultivated on 4 different replicate fields measuring 40 m × 25 m. A pre-emergence herbicide (glyphosate; 3 L/ha, 1 ha = 10,000 m²) was sprayed immediately after planting whilst pendimethalin (3 L/ha) was sprayed post-emergence. Weed removal was done by hoes 5 weeks after planting. At full pod maturity, the groundnuts were harvested manually and the pods separated from the residues/haulms. The haulms were mainly leaves and twigs and were transported to the livestock farm of the Animal Science Department of UDS for shade drying which lasted for about 14 days. The dry residues were chopped to an average length of 3.5 cm for feeding.

2.3. Chemical analysis and feeding trial

The rams were housed in individual wooden pens with concrete floors and fed the dry GHM *ad libitum* daily for 8 weeks (56 days). Feed orts were weighed at the end of each day and sampled for dry matter (DM) determination. Prior to this, the rams were allowed 10 days adjustment to the feed. Daily feed samples (100 g) were collected from each replicate animal at the time of feeding and bulked together for each animal after the experimental period. The bulked feed were further sampled (200 g) in duplicate and dried in a forced air oven at 60 °C for 48 h for DM determination. The weight of the dried ort and feed offered were used in the calculation of DM feed intake. After drying, the samples were ground through a 2-mm screen for chemical analyses.

Each ram was fitted with a faecal collection bag after 14 days of adjustment to the feed and the faecal bag. The bags were removed twice daily (07:00 and 17:00) to weigh the fresh faecal matter. After weighing, a sample of about 20 g of each ram's faecal matter was frozen (−4 °C) until the experiment was over. The daily faecal matter collected from each ram was bulked together after the experiment and 200 g duplicate sub-samples dried. The dried faecal samples were ground to pass through a 2-mm screen for chemical analyses.

Both feed and faecal matter were analyzed for nitrogen using the Kjeldahl method, after which the crude protein (CP) was calculated by multiplying the nitrogen by 6.25 (AOAC, 2000). Neutral detergent fiber (NDF) was determined with sodium sulfite and a-amylase and exclusive of residual ash, whilst acid detergent fiber (ADF) was determined exclusive of residual ash in accordance to Van Soest et al. (1991) using the Ankom200 fiber analyzer (Ankom ADF method 5 and NDF method 6).

Djallonké lambs were weighed weekly to enable calculation of the live weight parameters. At the end of the 56 days, blood was taken from the jugular vein of the rams using a sterile syringe and needle, and put into plastic test tubes containing ethylene diamine tetraacetic acid (EDTA). The blood was analyzed for red blood cells (RBC), white blood cells (WBC) and hemoglobin (Hb) concentrations using the Wintrobe's Microhematocrit, improved Neubauer hemocytometer and Cyanmethemoglobin methods, respectively (Baker and Silvertown, 1990).

2.4. Statistical analysis

Differences in chemical composition, feed intake, weight gain, digestibility and hematology were analyzed using the Generalized Linear Model Procedure (PROC GLM) of SAS (1999) in a one-way analysis of variance. The chemical composition data was analyzed using the model:

$$Y_{ijk} = \mu + B_i + C_j + e_{ijk},$$

where Y_{ijk} is an observation, μ is experimental mean, B_i is block effect, C_j is variety effect, and e_{ijk} is residual.

Table 1
Chemical composition of experimental diets (% DM basis).

Item	Treatments (GHM varieties)				SEM	P-value
	Azivivi	Manipinta	Obolo	Yenyawoso		
DM	84.9 ^b	87.2 ^a	84.7 ^b	88.2 ^a	0.6	<0.01
CP	11.2 ^a	10.3 ^a	6.8 ^b	11.4 ^a	0.5	<0.01
Ash	10.9	8.1	10.1	9.7	0.9	0.19
NDF	42.5 ^b	44.9 ^b	53.0 ^a	42.7 ^b	1.0	<0.01
ADF	39.0 ^b	36.7 ^b	49.5 ^a	36.6 ^b	1.5	<0.01

DM = dry matter; GHM = groundnut haulm meal; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber.

^{a,b} Within a row, means with different superscript differ ($P < 0.05$).

The live weight gain of rams was analyzed using the initial live weight of each ram as a co-variate in the model:

$$Y_{ij} = \mu + V_i(x_{ij} - \pi_i) + e_{ij},$$

where Y_{ij} is an observation, μ is experimental mean, V_j is variety effect, x_{ij} is the observation of covariate under the i_{th} group, π_i is the i_{th} group mean and e_{ij} is residual.

The effect of treatment was tested and significant differences between treatment means established by Duncan's Multiple Range Test at $P < 0.05$.

3. Results and discussion

The concentrations of DM, CP, NDF and ADF differed among the 4 varieties of GHM (Table 1). The highest DM was found in Yenyawoso and the least in Obolo. The CP concentration was significantly lower (6.8%) in Obolo compared with the other 3 varieties. However, the Obolo had the highest ($P < 0.05$) concentration of NDF and ADF. The CP concentrations reported in the current study, with the exception of Obolo, was slightly higher than previously reported for similar dual-purpose groundnut varieties (Etefa and Dung, 2011). Similarly, the NDF and ADF fractions were all lower than reported by the same authors. The differences observed in the CP, NDF and ADF are attributable to the genetic variation among these varieties,

which could strongly influence their ability to assimilate soil nutrients and produce carbohydrates through photosynthesis. Yenyawoso is a relatively short duration variety with 90 days to maturity, compared to the 110 to 120 days to maturity for the other varieties. This may have also contributed to the lower cell wall fraction in the Yenyawoso variety. The CP concentration of Azivivi and Yenyawoso were above the minimum range of CP (11.1% to 13.0%) required for the maintenance and growth of small ruminants (Van Soest, 1982; NRC, 2007), which suggests that these varieties could support growth of small ruminants as a sole diet.

Table 2 shows the results for nutrient intake, live weight gain and apparent nutrient digestibility of the GHM. Daily CP, NDF and ADF intake differed significantly among the varieties. Rams fed Obolo had significantly lower CP intake but higher NDF and ADF intake, as expected due to the lower CP and higher NDF and ADF concentration in this variety. The lack of significant difference in the total and daily DM intake of the varieties, despite the higher ADF in the Obolo variety, suggests that the concentration of the structural carbohydrates did not inhibit voluntary feed intake. High ADF concentration has been found to be associated with a decline in voluntary feed intake in ruminants due to the slow rate of digestion (Riaz et al., 2014). The apparent nutrient digestibility did not differ ($P > 0.05$) among the varieties. Nonetheless, rams fed Obolo variety tended to have lower nutrient digestibility relative to those fed the other varieties (Table 2).

The final live weight, live weight gain and average daily live weight gain (ADWG) of the Djallonké rams differed significantly due to GHM (Table 2). The highest ADWG ($P < 0.05$) was obtained in rams fed Yenyawoso, with the least for rams fed Azivivi. The ADWG reported in rams fed Obolo and Azivivi varieties were lower than reported for Djallonké rams managed under extensive system with no supplementation (Baiden and Duncan, 2009; Ansah et al., 2016). The low growth rate reported in these animals fed Obolo and Azivivi may be an indication of poor nutrient utilization from the haulms of these varieties. This suggests that these 2 varieties need to be supplemented when fed as sole diets for fattening rams in order to achieve live weight gains greater than those found previously. Whereas the concentration and intake of CP, NDF and ADF did not differ in rams that were fed Azivivi, Yenyawoso and

Table 2
Nutrient intake and apparent nutrient digestibility of the groundnut haulm meal (GHM) fed to Djallonké rams, and growth of the rams.¹

Parameter	Treatments (GHM varieties)				SEM	P-value
	Azivivi	Manipinta	Obolo	Yenyawoso		
Nutrient intake (DM basis)						
Total DM intake, kg	50.6	50.0	50.6	50.4	0.3	0.89
Daily DM intake, g	903.4	893.0	903.5	899.1	4.9	0.89
Daily CP intake, g	101.1 ^a	92.0 ^a	60.9 ^b	102.9 ^a	0.9	<0.01
Daily NDF intake, g	382.8 ^b	399.2 ^b	481.7 ^a	382.8 ^b	3.2	<0.01
Daily ADF intake, g	353.0 ^b	327.3 ^b	448.5 ^a	329.6 ^b	3.4	<0.01
Nutrient digestibility, % DM basis						
DM	71.4	77.8	65.9	79.9	4.8	0.21
CP	75.3	81.0	58.5	84.5	6.7	0.07
NDF	56.6	65.3	55.8	69.2	5.9	0.33
ADF	61.2	65.2	58.8	68.4	5.4	0.61
Live weight and live weight gain						
Initial live weight, kg	15.3	14.0	16.0	14.6	1.8	0.85
Final live weight, kg	15.9	16.0	16.9	17.6	1.7	0.87
Live weight gain, g	600 ^a	2,000 ^{ab}	925 ^a	2,950 ^b	361.6	<0.01
ADWG, g	10.7 ^a	35.7 ^{ab}	16.5 ^a	52.7 ^b	6.5	<0.01
Adjusted ² final live weight, kg	15.6 ^a	16.9 ^{ab}	15.9 ^a	17.9 ^b	0.3	<0.01
Adjusted ² live weight gain, g	619 ^a	1935 ^{ab}	994 ^a	2927 ^b	361.3	<0.01
Adjusted ² ADWG, g	11.1 ^a	34.6 ^{ab}	17.8 ^a	52.3 ^b	6.4	<0.01

DM = dry matter; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; ADWG = average daily live weight gain.

^{a,b} Within a row, means with different superscript differ ($P < 0.05$).

¹ Four rams each in individual pens per GHM variety (total $n = 16$).

² Adjusted using initial live weight as a covariate.

Table 3
Effects of groundnut haulm meal (GHM) on mean hematological parameters of Djallonké rams.¹

Parameter	Treatments (GHM varieties)				SEM	P-value
	Azivivi	Manipinta	Obolo	Yenyawoso		
White blood cells, $\times 10^3/\mu\text{L}$	8.8	10.0	10.4	9.1	0.86	0.54
Red blood cells, $\times 10^6/\mu\text{L}$	4.1	4.3	4.4	4.5	0.46	0.92
Hemoglobin, g/dL	15.7	16.8	16.3	17.2	1.84	0.94

¹ Four rams each in individual pens per GHM variety (total $n = 16$).

Manipinta varieties, the growth of the rams fed these diets differed. It is suggested that Djallonké rams fed Yenyawoso and Manipinta varieties had a better nutrient absorption and utilization which resulted in a significantly higher ADWG and final live weight as compared to those fed the Azivivi variety. Efficiency of energy utilization for growth is influenced by energy loss as heat, or heat increment (McDonald et al., 2011). Heat increment may be higher with poor quality forages such as those with high concentrations of lignin. Similarly, enteric methane emission has been found to be influenced by quality of diet with higher emissions associated with highly lignified or poor-quality diets (O'Hara et al., 2003). Methane emissions result in a loss of gross energy which could impact negatively on the growth of ruminants (Johnson et al., 1993; Pen et al., 2006). In the present study, lignin was not quantified, but may be a contributor to differences in utilization of nutrients. Plants with relatively longer days to maturity often accumulate more stem mass than leaves. Stems of most forages have higher concentration of non-photosynthetic tissues with higher lignin concentration (Wilson and Kennedy, 1996). Since Yenyawoso is a short duration variety, it may be the case that it had a lower concentration of lignin than Azivivi, a long duration variety. This may have accounted for the improved growth performance of rams fed Yenyawoso.

There was no significant effect of GHM varieties on the hematology of the rams (Table 3). Blood parameters are important indices of physiological, pathological and nutritional status in living organisms (Ewuola et al., 2004). The hematological values fell within the ranges reported for WAD Sheep (Baiden et al., 2007; Bawala et al., 2007). The lack of difference suggests that the GHM varieties did not compromise the health status of the rams.

4. Conclusion

The groundnut haulm varieties possessed different nutrient qualities with the Yenyawoso, Azivivi and Manipinta varieties having the higher CP and lower NDF and ADF concentrations. These differences in nutrient quality led to a variation in the live weight gains of Djallonké rams when the haulms were fed as sole diets, with the highest gain obtained in rams fed the Yenyawoso variety. The Yenyawoso variety could be considered for use as a sole diet for fattening Djallonké rams.

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