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Voluntary intake and in vivo digestibility of four groundnut haulms varieties measured on Djallonké sheep in Benin

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Abstract

In Benin, fodder and crop residues are often used to fatten sheep. However, the quantities of ingested dry matter and their digestibility are not well documented. This study aimed to determine dry matter intake and in vivo digestibility of groundnut haulms in Djallonké sheep. Thus, eight sheep, weighting 15.3 ± 0.97kg were fed on four varieties of groundnut haulms (TS 32-1, ICGV SM 85045, 69-101, Moto Local). The experimental design used was a double latin square. The experiment was carried out through four periods of two phases each. Each period lasted 21 days of which 15 days for adaptation and 6 days for data collection. The 69-101 had the highest contents total crude protein (TCP) (13.5%) and energy (0.52 UFL and 0.39 UFV). However, its contents in parietal constituents (50.9% for NDF and 46.7% for ADF) were low. The daily quantities of ingested dry matter of 69-101 (73.1 g /LW0.75), TS32-1 (72.6 g /LW0.75), ICGV SM85045 (70 g /LW0.75) and Moto Local (69.6 g /LW0.75) varieties were not different. The apparent digestibility of DM, OM and TCP of 69-101 were better than those of the other varieties. The apparent digestibility of NDF and ADF did not vary according to groundnut haulm varieties. The 69-101 is the variety with the best nutritional values. However, weight performances results of the four haulms varieties were not significantly different. The evaluation of the four groundnut haulms varieties allow to accept any of them as forage source for fattening or growing sheep.

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Introduction

Groundnut is a plant of Fabaceae family (Priya *et al.*, 2013). It is one of the most important oilseeds cultivated worldwide, particularly in tropics and subtropics (Shiyam, 2010). It is grown for seeds, haulms and oil (Idinoba *et al.*, 2008).

These haulms are rich in protein (Sharma *et al.*, 2010) and are often used in ruminants feeding (Koura, 2015; Ojokoh & Oluwayemisi, 2016; Castro-Montoya & Dickhoefer, 2020). Thus, in Sudanian zone of Benin, three types of groundnut haulm producers exist depending on the level of use and the technical production route.

The type 1 produces very few groundnut haulm, the type 2 produces sufficient quantity without agricultural inputs and the type 3 produces very large quantity using agricultural inputs (Ahounou *et al.*, 2016). In this climatic zone, groundnut haulms are very well valued as diet food supplement of small ruminants during lean periods and mostly come from farmers own fields. Other breeders receive haulms as a gift or buy them from producers (Didagbe *et al.*, 2015; Ahounou *et al.*, 2017a). These haulms are from various cultivated varieties (Didagbe *et al.*, 2015; Loko *et al.*, 2020) whose productivity and fodder nutritional potential differ. In Sudanian zone of Benin, TS 32-1, ICGV SM 85045, 69-101 and Moto Local are the most cultivated varieties. Among them, the best fresh haulm yield is obtained with 69-101 while ICGV SM 85045 has the lowest fresh haulm yield (Ahounou *et al.*, 2017b).

The 69-101 variety also has the highest dry haulm yield and the Moto Local has the lowest dry haulm yield (Ahounou *et al.*, 2017b). The 69-101 variety has the best pod yield while the highest NDF contents are found in 69-101 and ICGV SM 85045 varieties (Ahounou *et al.*, 2017b). However, there are no results on animal side. The aim of the present study was to assess intake level and digestibility of the four groundnut varieties and their effects on growth performances of Djallonké sheep. This will help to promote varieties that can be used as strategies to improve the quality of sheep feed in Benin.

Material and methods

Study area

The study was carried out from April to July 2014 in the North Agricultural Research Center (CRAN), one of the research centers of the National Institute of Agricultural Research of Benin (INRAB), based at Ina in the Township of Bembéréké. This township is between 09°58' and 10°40' north latitude and between 02°04' and 03° East longitude. The Township has a Sudano-Guinean climate characterized by a rainy season (May to October), a dry season (November to April).

Animals, food and experimental design

Eight Djallonké sheep from Sheep National Center (CNO) located at Bétécoucou Breeding Farm (FEB) were used for this experiment. They had an average live weight of 15.3 ± 0.97kg. Each animal was housed in an individual metabolism cage. One week before the beginning of the tests, animals were dewormed with Bolumisole®.

Haulms of four groundnuts varieties (69-101, ICGV SM85045, TS32-1 and Moto Local) were tested for this experiment. These haulms were obtained after harvesting groundnut varieties sown at Ina Agricultural Research Center. They have been chopped to facilitate gripping.

The experimental design used was a complete 4x4 double Latin square (4 varieties and 4 animals). It consisted of feeding each sheep with haulms of one groundnut variety for 21 days. Each period was divided into two phases: an adaptation phase of 15 days followed by a 6-days phase for intake measurement and for feces collection. The weight performance evaluation was performed over 21 days and animals were weighed at the beginning and at the end of each period. At the end of the four collection periods, each animal received haulms of the four groundnuts varieties.

The experimental feed was exclusively haulms of the 4 groundnuts varieties. The daily diet was distributed twice (400 g at 8 a.m. and 300 g at 2 p.m.) to animals. The KNZ® lick stone was used as minerals and

vitamin supplement. Water and lick stone were always available. During data collection period, feed leftovers and feces were collected daily and weighed before the daily diet service. Samples of haulms served, feed leftovers and feces were weighed daily during the digestibility assessment period. These samples were dried in a Memmert® brand oven at 60°C for the determination of the dry matter (DM) content. At the beginning and at the end of each data collection period, animals were weighed starved with a balancé of 50kg of capacity and of 100 grams of precision for weight gain determination.

Determination of chemical composition of groundnut haulms

Haulms and feces ashes were determined in a muffle-oven at 560°C for 8 hours and used for organic matter calculation. Haulms and feces dry matter was obtained after oven drying for 24 hours at 105 °C. The chemical analyzes were performed according to AOAC (2005) procedures. Total Crude Protein (TCP) was determined by the Kjeldahl method (N x 6.25), the extracted ether (EE) by the Soxhlet method and the cell walls of haulms and feces constituents (NDF and ADF) were determined using the Gerhardt Fiber bag method established by Van Soest *et al.* (1991).

Determination of nutritional values and apparent digestibility coefficient (ADC) of groundnut haulms

The equations used to calculate the gross energy, the metabolizable energy (ME), the Milk forage Unit and the Meat forage unit and OMD are those proposed by Baumont *et al.* (2010). The prediction formula used to estimate the digestible crude protein content (DCP) is that proposed by Guerin *et al.* (2002).

DCP (g/kg DM) = 9.29 * TCP- 35.2

The in vivo apparent digestibility of dry matter (DMD), TCP (TCPD), organic matter (OMD), NDF (NDFD) and ADF (ADFD) was calculated as follow:

$$DMD = \frac{(ingested\ matter - matter\ in\ feces) \times 100}{ingested\ matter}$$

Statistical analysis

The collected data were registered in Excel and analyzed using SAS software (SAS, 2013). For haulms nutrient values, dry matter intake (DMI) data and sheep growth performances, a single factor analysis of variance was used and groundnut haulm variety was the only fixed effect.

The factors trial period and animal effect were not significant and therefore were not considered in the variance analysis model. The Proc GLM procedure was used for the one-factor variance analysis and the F test was used to determine the effect of the variety on the variables. The means were calculated and compared with the paired student's t test.

Results

Chemical composition and nutritional values of groundnut haulms

The haulms chemical composition and nutritional value varied according to the groundnut variety (Table 1). Significant variations were observed between the organic matter, ash, ether extract, NDF, ADF and TCP contents of the four groundnuts varieties. The 69-101 variety showed the highest contents for organic matter (88.7%), total crude protein (13.5%) and ether extract (1.49%) while the lowest values of 86.2%, 11.9% and 0.97% respectively were obtained with Moto local.

The lowest parietal component contents (50.9% for NDF and 46.7% for ADF) were obtained with 69-101 while the highest NDF content (56%) was obtained with ICGV SM 85045 variety. Moto local and TS32-1 did not show any significant difference in their NDF contents. ICGV SM85045 and Moto Local had the highest ADF levels and also did not show any significant difference between them.

The variety had a significant effect on the haulms nutritional value. The same trend was observed for the gross energy content of the four varieties of haulms. The gross energy values calculated in the study varied between 4957 and 4925 kcal/kg of OM. The variation of the calculated organic matter digestibility (OMD) was inversely proportional to that of fiber contents. Thus, ME and net energy (UFL and UFV) values were affected accordingly.

Table 1. Chemical composition and nutritional values of haulms of four groundnut varieties.

		69-101	ICGV SM 85045	Moto Local	TS32-1	RSD	*p*
Organic Matter (%)		88.7a	87.7b	86.2c	87.6b	1.057	0.0008
Ash%		11.2c	12.3b	13.7a	12.4b	1.057	0.0008
Ether extract (%)		1.49a	1.13b	0.97c	1.08b	0.194	<.0001
NDF (%)		50.9a	56.0b	53.7b	54.3b	2.74	0.0084
ADF (%)		46.7c	53.3ab	53.3a	52.0b	2.774	0.0001
Total Crude Protein (%)		13.5a	12.3b	11.9b	13.2a	0.825	0.0014
Digestible Crude Protein (g/kg DM)		90.4a	79.2b	75.5b	87.9a	7.67	0.0014
Gross Energy (kcal/kg OM)		4957a	4931b	4925b	4957a	20.7	0.0142
OMD (%)		45.23a	37.75b	37.69b	39.17b	3.21	<.0001
Metabolisable Energy (kcal/kg)		1627a	1309b	1303b	1371b	133	<.0001
Net energy	UFL/ Mkg	0.52a	0.41b	0.41b	0.43b	0.048	0.0001
	UFV/DMkg	0.39a	0.29b	0.28b	0.3b	0.048	<.0001

Means of the same row followed by different letters differ significantly at the threshold of 5%; UFL: RSD: Residual Standard Deviation; ADF: Acid detergent fiber; NDF: Neutral detergent fiber; OMD: *in vitro* Organic Matter Digestibility.

The highest OMD was obtained with 69-101. Those of the other varieties showed no significant difference. The same observations were made for the metabolizable and net energies contents for the four groundnut varieties. The 69-101 had a ME content of 1627 kcal/kg DM, for the relative net energy values. These values were significantly higher compared to those of the other varieties of haulm of which the contents varied between 1371 and 1302 kcal/kg DM for ME, but not significantly different.

Intake and digestibility of groundnut haulms

The DMD, OMD and TCPD varied significantly according to the groundnut varieties (Table 2). The 69-101 had higher DMD, OMD and TCPD than the other varieties ($p<0.05$). The DMD of ICGV SM85045 and that of Moto Local were similar but higher ($p<0.05$) than that of TS32-1. The OMD values of ICGV SM 85045 and of TS32-1 were significantly higher than that of Moto Local. ICGV SM85045, Moto Local and TS32-1 had TCPD which varied between 95.2 and 94.7% and which were similar ($P>0.05$).

The ADFD (77.4%) and NDFD (76.9%) values of 69-101 were lower than those of the other varieties.

The highest ADFD (82.9%) and NDFD (79.7%) were obtained with ICGV SM85045.

Intake and growth performances of sheep

The DMI did not vary from one haulm variety to another (table 2). Djallonké sheep ingested 73.1; 72.6; 70 and 69.6 g/d/LW0.75 of dry matter, respectively for 69-101, TS32-1, ICGV SM 85045 and Moto local varieties and no significant difference was observed between these quantities.

Table 2. Haulms dry matter intake (DMI) and in vivo digestibility of DM (DMD), organic matter (OMD), total crude proteins (TCPD), NDF (NDFD) and ADF (AFD) of four groundnut varieties in Djallonké sheep.

	69-101	ICGV SM 85045	Moto Local	TS32-1	RSD	*p*
DMI (g DM/kg $LW^{0.75}$)	73.1	70.0	69.6	72.6	6.96	0.67
DMD	66.9a	62.1b	61.9b	60.1c	3.26	0.0018
OMD	73.9a	68.8b	62.2c	70.1ab	3.72	0.0017
TCPD	96.1a	94.9b	95.2b	94.7b	3.04	0.0157
ADFD	77.4a	82.9a	81.7a	81.7a	6.17	0.319
NDFD	76.9a	79.7a	77.3a	79.0a	2.83	0.169

NDF: Neutral detergent fiber; ADF: Acid detergent fiber; RSD: residual standard deviation; Means of the same row followed by different letters differ significantly at the threshold of 5%

Discussion

Chemical composition and nutritional values of haulms

The groundnut haulms tested in this study have very variable chemical composition. The TCP contents recorded varied according to the varieties. A significant variation in the TCP contents of haulms from several groundnuts varieties was reported by Nigam and Blümmel (2010), Oteng-Frimpong *et al.*

(2017) and Ansah *et al.* (2017). By contrast, in the studies of Etela and Dung (2011) and Ahounou *et al.* (2017b), the variety did not have any effect on the TCP content. The TCP in the current study varies between 11.9% and 13.5% and this rate is higher than the critical threshold of 7% to 8% required for an efficient rumen functioning (Babatounde *et al.*, 2010).

The wall constituents (NDF and ADF) values varied significantly according to the varieties. The lowest values were those of 69-101 and the highest were those of ICGV SM85045. Contrary to our study results, Etela and Dung (2011), Ansah *et al.* (2017) and Oteng-Frimpong *et al.* (2017) did not observe significant differences between NDF contents of several groundnut haulms varieties. However, the variety effect on ADF was significant according to Oteng-Frimpong *et al.* (2017).

The differences observed for the TCP, NDF and ADF contents in our study could be attributed to the genetic variation between varieties which can influence their capacity to assimilate nutrients from soil and to produce carbohydrates through photosynthesis. In another study, Ahounou *et al.* (2017b) reported lower values on the same varieties. The difference between the results of the current study and those of Ahounou *et al.* (2017b) can be explained by the chemical composition of experimental plots soil. In fact, nutrients mobilization in the groundnut vegetative part is linked to the soil nutrient content (Bloukounon *et al.*, 2015). Thus, the groundnut haulms used in the study of Ahounou *et al.* (2017b) and those of the current study come from different plots of which fertility couldn't be the same. Energy and nitrogen values of the studied groundnut haulms varied according to the varieties.

The differences may be due to genetic origin, harvest organization (leaf and stem ratio) and to haulms management (drying and storage). Since haulms energy and nitrogen values are in a relationship with their average chemical compositions and digestibility. To the best of our knowledge, there is no previous study on the varietal effect of groundnut haulms on the nutritional value.

Intake and growth performances of sheep fed with haulms of four groundnut varieties

The voluntary intake values recorded in this study were not influenced by the groundnuts varieties. These results are similar to those obtained by Etela and Dung (2011), who didn't observe significant variation in the haulms intake of 6 groundnuts varieties by Djallonké sheep in Nigeria. The lack of significant difference may be linked to groundnut haulm size and presentation that were similar.

Final weight and average daily gain of Djallonké hoggets were not influenced by the varietal effect. Similar observations have been made by Etela and Dung (2011) concerning the initial and final weight of Djallonké sheep fed exclusively on haulms of different groundnut varieties in Nigeria. The short data collection duration of 21 days could justify this absence of difference. Increasing this duration may allow animals to better express their weight performance. Other authors such as Etela and Dung (2011) and Ansah *et al.* (2017) found that weight gains were affected by the groundnuts varieties used. The weight gain results in the present study showed that groundnut haulms have enough nutrients to cover maintenance and growth needs of Djallonké sheep.

Haulms digestibility

The apparent digestibility of dry matter, organic matter and total crude protein varied according to the groundnut varieties while, digestibility coefficients of wall constituents (NDF and ADF) did not differ significantly. However for the variety 69-101, these wall constituents were less digested by animals. Etela and Dung (2011) have shown that all nutrients digestibility is affected by the variety of the groundnut haulms used. This finding is contrary to that of Ansah *et al.* (2017). According to these authors, the variety had no effect on the digestibility of the groundnut haulms nutrients they tested. The 69-101 has the highest digestibility rates compared to the other varieties. This is probably due to its low fiber content (ADF) since the high level of lignocellulose reduce digestibility (Louacini *et al.*, 2015). The same observation was made by Etele and Dung (2011) and Ansah *et al.* (2017).

Conclusion

This study revealed that groundnut haulms have different chemical compositions and nutritional qualities depending on the varieties. The 69-101 has the best nutritional values because it has the highest levels of organic matter, Total Crude Protein and the lowest fiber content. In addition it has the highest DM and OM digestibility and DM intake. However, a positive change in weight was noted for all the sheepfed on the four groundnut haulms. The differences in the chemical composition, nutritional values and digestibility of the four varieties of groundnut haulms have no effect on growth performances of sheep fed exclusively on these haulms. These results show that the four varieties of groundnut haulms have enough nutrients to ensure maintenance and growth needs of Djallonké sheep.

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