GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(RESEARCH ARTICLE)

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Effect of pelleting crop residues on feed intake and digestibility in Djallonke sheep in North-sudanian zone of Burkina Faso

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GSC Advanced Research and Reviews, 2023, 16(03), 078–085

Publication history: Received on 25 July 2023; revised on 06 September 2023; accepted on 09 September 2023

Article DOI: https://doi.org/10.30574/gscarr.2023.16.3.0353

Abstract

The effect of pelleting fodder on voluntary feed intake and digestibility in sheep was tested with sorghum straw and cowpea haulm in two forms (chopped and granulated). Twenty-four (24) sheep, of 18 to 24 months old, Djallonké breed were divided into 4 groups of 6 sheep following a random complete block device with four (04) treatments as follows: R1= 50% chopped sorghum straw + 50% chopped cowpea haulms, R2 = Granulated feed 1 (50% sorghum straw + 50% cowpea haulms), R3 = 50% chopped sorghum straw + 50% maize bran and R4 = Granulated feed 2 (50% chopped sorghum straw + 50% maize bran). Six (6) sheep per group underwent the intake trial, then consecutively five (5) sheep per group were retained and housed in digestibility cages for the digestibility test.

The voluntary intake of dry matter varied from 417.5 g/d for ration 3 to 600.5 g/d for ration 2. In terms of nutrient intake, ration 1 (75. 26g) records the highest intake of crude protein, followed by ration 2 (70.15g). There is no difference in voluntary intake within rations with forage chopped (R1 and R3) and pellet rations (R2 and R4). The digestibilities of DM and OM are lower with R2, followed by R4; on the other hand, R1 and R3 showed the best levels of digestibility. The crude protein digestibility value is higher for R1 than for the others. The grounding and pelleting of forage did not improve the intake and digestibility of the rations. Additional studies are needed, especially on the size of ground feed, in order to better elucidate the nutritional value of pelleted fodder.

Keywords: Crop residues; Dual purpose sorghum; Dual purpose cowpea; Pellets; Sheep

1. Introduction

In the Sahelian zones of Burkina Faso, the use of crop residues is a widespread feeding strategy during the dry season [1–4]. Indeed, during this period, crop residues remain the main food available for animals and can constitute 40-60% of the dry matter consumed by ruminants. In addition, these resources constituted the main feed used by all farmers for sheep fattening and for dairy cattle [5]. These feeds are often collected and usually distributed to animals without prior processing. This leads to important losses of up to 37% of the quantities distributed, through the parts refused by the animals [6]. These authors found that the grounding of sorghum straw can minimized these losses. However, fine shredding would reduce feed consumption by making it difficult for animals to grasp the fodder. This reduction in consumption could be lifted by granulation because the grounding of hay followed by agglomeration in granules makes it possible to increase the consumption of fodder [7]. According to YE et al. [8], the pellet-fed animal is more willing to absorb the whole of a mixed ration than that of raw components in their natural state. Studies carried out on granulation have focused on the consistency of the pellets and sometimes the chemical composition [8–10]; but few studies have addressed the study of the nutritional value of pelleted feed. Given the importance of crop residues in animal feeding,

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any technology aimed at the optimal use of these resources must be developed for better recovery of crop residues. The present study was carried out in order to evaluate the effect of the granulation of crop residues on intake and *in vivo* digestibility in Djallonké sheep.

2. Material and methods

2.1. Study site

This study was carried out in May 2021 at the Saria research station of the Institute of Environment and Agricultural Research (INERA). located around 20 kg from the municipality of Koudougou, province of Boulkiémdé, central west region. This station is located between 12°16̀' North latitude, 2°09' West longitude, with an altitude of 300 m. It belongs to the Sudano-Sahelian climate, characterized by two contrasting seasons: the shorter rainy season (June to September) and the longer dry season (October to May). Rainfall is characterized by its spatio-temporal heterogeneity, varying on average between 600 and 1000 mm per year [11]. Agriculture is the main activity of the population. Tillage is done manually and by animal traction in agropastoral and parkland systems; the main crops are millet, sorghum, maize, voandzou, groundnuts and cowpea [12]. Alongside these crops, market gardening is also practised, with onions, tomatoes and eggplants the main crops. Livestock farming is extensive, with cattle, sheep, goats, pigs, poultry and donkeys being the main species [11].

2.2. Experimental animals

24 male sheep, aged 18 to 24 months, of the Djallonké breed, Mossi variety, with a live weight of between 15.7 and 16.55 kg were used. The animals underwent internal deworming with KEPROMEC (Ivomectin) by subcutaneous and external injection with Kelanthic Bolus. They also received antibiotic therapy with Limoxin 200 LA by injection and were vaccinated against pasteurellosis with injectable Pastovin at a dose of 2 ml/head subcutaneously and against small ruminants pest with PPR- vac by subcutaneous injection (1ml/head). Seven (7) days later, the sheep received additional internal deworming with Kelanthic Bolus.

2.3. Experimental feeds

The rations consisted of crop residues chopped on the one hand and granulated on the other, which are sorghum straw (variety Sariaso 16) and cowpea haulms (variety KVX 745-11-P). All of these crop residues come from the experimental fields at the Center for Environmental, Agricultural Research and Training in Kamboinsé (CREAF) of the Institute for the Environment and Agricultural Research (INERA) after the harvests of the 2020-2021 agricultural campaign. They are dual-purpose varieties that produce grain for human consumption and good quality fodder for animal feed. A completely randomized design was used with four treatments of 6 sheep each. The treatments consist of four rations made up of sorghum straw and cowpea haulms, chopped or granulated as indicated in Table 1. The granulation was made according to two formulas: formula 1 containing 50% sorghum straw and 50% cowpea haulms and formula 2 composed of 50% sorghum straw and 50% maize bran. The pellets were obtained after grounding the fodder in a locally made multi-purpose grounder with resulting in around 8mm residues, and then introduced into an industrial granulator for the production of pellets.

Table 1 Composition of rations in % feed component

Types of feed	**Rations (%)**			
	R1	**R2**	**R3**	**R4**
Chopped sorghum straw	50	0	50	0
Pellets of sorghum straw and cowpea haulms	0	100	0	0
Chopped cowpea haulms	50	0	0	0
Pellets of sorghum straw and maize bran	0	0	0	100
Maize bran	0	0	50	0
Mineral block	Ad libitum			

2.4. Voluntary intake of rations

The animals were housed in a sheepfold compartmented in boxes. The trial lasted 21 days including 14 days of adaptation and 7 days of data collection. Feeds were offered twice a day, at 8:00 a.m. and 4:00 p.m.; refusals are removed and weighed daily before each new distribution. Each animal had at its disposal a mineral block and water ad libidum. The daily feed supply was calculated on the basis of 4% of the initial live weight of the animals to begin with, then the quantities were adjusted in order to keep a refusal rate between 10 and 20%.

The animals were weighed at the start and at the end of the experiment. Voluntary feed intake was determined by difference between feed offered and feed refused. Composite samples of each type of feed were taken at the beginning, in the middle and at the end of the trial for the determination of the nutrient content in the laboratory.

2.5. *In vivo* digestibility

At the end of the voluntary intake trial, 20 sheep were randomly selected to continue the digestibility trial with the same ration i.e. five sheep per treatment. The sheep, equipped with faeces collection bags, were kept in digestibility cages for the measurement of the quantities of feed ingested and faeces emitted each day. The adaptation and measurement periods were respectively 7 days for adaptation in the cages and 7 days for data collection. The quantities of feed distributed were limited according to the maintenance needs of the animals, i.e. 600 to 700 g depending on the weight of the animals. The digestibility of the ration (dR) was calculated according to the following formula:

$$dR = (\boldsymbol{I} - \boldsymbol{F}) / \boldsymbol{I} \times 100,$$

with I: amount of DM ingested and F: amount of faeces excreted.

2.6. Chemical composition analysis

Samples of each feed were ground in a Wiley mill through a 1 mm screen and were analysed for DM, CP, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and ash. DM, CP, ADF and ash were analysed according to the standard methods of [13]. NDF and ADL was determined by the methods of Van Soest et al. [14]. The lignin content was determined by solubilisation of cellulose with sulphuric acid.

2.7. Statistical analysis

Data analysis was performed using IBM SPSS version 22 software. Voluntary intake and digestibility data were subjected to an analysis of variance according to the model: $y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ where y is the dependent variable, μ is the mean, α is the effect of ration type and ε the error term. Treatment means that showed differences at the probability level of $p < 0.05$ were compared using the Scheffé test.

3. Results

3.1. Chemical composition of feed

The dry matter content of the feed used during the trial was between 88.75% (maize bran) and 94.66% (pellet 2). The CP content of cowpea haulms (15.88%) was higher than that of other feeds (Table 2). The low CP content is observed with sorghum straw (8%). In addition, the contents of NDF (62.51%) and CF (28.50%) of sorghum straws were the highest.

Table 2 Chemical composition of feeds (%)

Feeds	DM	OM	Ash	CP	CF	NDF	ADF	ADL
Chopped sorghum straw	94,53	87,21	7,32	8,04	28,50	62,51	32,00	3,50
Chopped cowpea haulms	94,48	84,20	10,28	15,88	25,20	41,19	26,31	4,51
Pellet 1 (GSS + GCH)	94,20	85,31	8,89	11,00	25,00	54,38	29,27	4,15
Pellet 2 (GSS + bran)	94,66	86,25	8,41	10,12	18,50	50,36	21,13	1,96
Maize bran	88,75	83,80	4,95	11,53	5,47	36,03	6,36	0,26

DM : dry matter; OM: organique matter; CF: crude fiber; CP: crude protein; NDF: neutral detergent fiber; ADL: acid detergent lignine; GSS: ground sorghum straw; GCH: ground cowpea haulms.

The lowest lignin contents (ADL) were observed in maize bran and pellet 2. Both types of pellets have similar contents in CP (10.12 and 11% respectively for pellet 2 and pellet 1). Pellet 1 has relatively higher crude fiber, NDF, ADF and ADL contents (25%, 54.38%, 29.27%, 4.15% respectively) compare to pellet 2 (18.5%, 50.36%, 21.13% and 1.96%).

3.2. Voluntary intake of rations

The results showed similar level of consumption of rations R1 (570.85 g/d) and R2 (600.54 g/d) composed of sorghum straw and cowpea haulms chopped on the one hand and pelleted on the other hand. (Table 3). Statistical analysis shows difference ($P < 0.05$) between the voluntary intake of rations containing sorghum straw and cowpea haulms and those where sorghum straw is associated with maize bran. However, the rations pelleted were slightly better consumed. Thus, the ingestion of ration 2 (pellet 1) shows a value of 600g, against 570.8 g for ration 1 with chopped forages; similarly, ration 4 (pellet 2) records a consumption of 462 g against 417 g for ration 3 (chopped sorghum straw). This same trend was observed at the level of DM intake per kg of live weight and per kg of metabolic weight of sheep.

Table 3 Voluntary feed intake of rations

Feeds	**ration 1 (CSS+CCH)**	**ration 2 (Pellet 1 : GSS+GCH)**	**ration 3 (CSS + bran)**	**ration 4 (Pellet 2 : GSS + bran)**
Chopped sorghum straw	257,17	0	212,73	0
Chopped cowpea haulms	334,66	0	0	0
Pellet 1 (GSS + GCH)	0	600,54	0	0
Pellet 2 (GSS + bran)	0	0	0	417,22
Maize bran	0	0	204,49	0
Total intake (g DM/animal/d	570,85[a]	600,54[a]	417,22 [b]	462,18[b]
Total intake (g DM/kg LW)	32,55[a]	36,76[a]	26,76[b]	30,85[b]
Total intake (g DM/kg$^{0.75}$)	68,39[a]	73,69[a]	53,086[b]	60,68[b]

Means in the same line with different letters are different at $p < 5\%$; GSS: ground sorghum straw; GCH: ground cowpea haulms; CSS: chopped sorghum straw; CCH: Chopped cowpea haulms

3.3. Nutrient intake per ration

Table 4 Intake of nutrients according to rations

	Ration 1 (CSS+CCH)	**Ration 2 (pellet 1 : GSS+GCH)**	**Ration 3 (CSS + bran)**	**Ration 4 (pellet 2 : GSS + bran)**
DM	570,85 ± 22,17 [a]	600,54 ± 16,58 [a]	417,22 ± 10,69 [b]	462,18± 21 [b]
OM	516,54±20,10 [a]	543,87±15,01 [a]	389,33±10 [b]	421,11±19,14 [b]
CP	75,26±2,83 [a]	70,15±1,94 [a]	44,66±1,19 [b]	49,43±2,25 [b]
CF	160,87±6,29 [a]	159,33±4,4 [a]	76,63±2 [b]	90,54±4,11 [c]
NDF	304,98±12,13 [a]	346,71±9,57 [a]	223,68±5,61 [b]	245,89±11,17 [b]
ADF	173,89±6,83 [a]	186,59±5,15 [a]	86,65±2,26 [b]	103,14±4,69 [c]

Means in the same line with different letters are different at $p < 5\%$; GSS: ground sorghum straw; GCH: ground cowpea haulms; CSS: chopped sorghum straw; CCH: Chopped cowpea haulms

The results of the consumption of nutrients according to the rations are reported in Table 4. In general, there was no difference in nutrient consumption between the R1 ration and the R2 ration incorporating sorghum straw and cowpea haulm, nor between the R3 ration and the R4 ration containing straw and bran. However, there is a difference between

the two groups of rations for all the nutrients. The highest CP intake value was observed with ration 1 (75g), followed by ration 2 (70g). Ration 3 (44.6g) of chopped sorghum straw with maize bran recorded the lowest CP consumption. High intake of NDF and ADF was obtained with R2.

3.4. Digestibility of the rations

The digestibility of the non-pelletized rations (ration 1 and ration 3) was higher than that of the pelleted rations (ration 2 and ration 4) (Table 5). The highest DM and MO digestibility values are observed with ration 3 (chopped sorghum straw and maize bran), 59% and 63% respectively, followed by ration 1 (55% and 59%). These values are different from those of ration 2 (47% and 44%). There is a decrease in digestibility of about 8 points between the chopped and pelleted fodder rations. Concerning the digestibility of CP, ration 1 (chopped straw and haulms) recorded the highest value from the three other rations that had similar values (58.5 to 58.75%). The digestibility of crude fiber and NDF is higher in diets 1 and 3 consisting of chopped forage than in pellet diets.

Table 5 Digestibility of rations and nutrients (%)

	Ration 1 (CSS+CCH)	**Ration 2 (Pellet 1 : GSS+GCH)**	**Ration 3 (CSS + bran)**	**Ration 4 (Pellet 2 : GSS + bran)**
dDM	54,87±1,6^{ac}	47,09±0,8^{bc}	59,09±1,14^{a}	50,85±1,31^{abc}
dOM	59,41±1,42^{a}	44,15±,96^{bd}	62,87±1,04^{ad}	55,07±1,19^{acd}
dCP	69,87±1,15^{a}	58,66±1,52^{b}	58,51±1,42^{b}	58,75±1,16^{b}
dCF	50,43±1,68^{a}	38,38±1,01^{b}	45,96±1,72^{a}	39,16±1,66^{b}
dNDF	49,88±1,84^{a}	42,99±0,92^{b}	54,54±1,34^{a}	42,81±1,54^{b}
dADF	47,7±1,89^{a}	36,34±1,0^{bc}	39,84±1,9^{bc}	30,71±1,8^{b}

Means in the same line with different letters are different at p < 5%; GSS: ground sorghum straw; GCH: ground cowpea haulms; CSS: chopped sorghum straw; CCH: Chopped cowpea haulms; dDM : Digestibility of dry matter; dOM : Digestibility of organic matter; dCP: Digestibility of crude protein; dCF: Digestibility of crude fiber; dNDF: Digestibility of NDF ; dADF: Digestibility of ADF.

4. Discussion

4.1. Chemical composition of feed

The high protein content of cowpea haulms compared to sorghum straws is consistent with the families of the two species. Indeed, cowpea being a legume is naturally richer in protein than sorghum belonging to the poaceae family. According to Zoungrana [15], Lawal et al. [16] and Sanon et al. [5], the nutritional value of legumes is higher in protein, energy and vitamins for animal weight growth. The results of the chemical composition of sorghum straw showed a content of 8.04%; which is higher than the maximum content (7%) required for efficient functioning of rumen microorganisms [17]. This content is higher than the values generally reported on sorghum straw that is less than 7% [18,19]. This result could be explained by the dual-purpose variety used confirming this character. Indeed, the particularity of this variety is to keep leaves green, so good quality fodder at the maturity of the grains [20]. Furthermore, the NDF and ADF contents of sorghum straw (62.5% and 32%) are lower than the values reported by Nantoume et al. [19], which were 722 g/kg DM and 464 g/kg DM respectively. Thus, straws of improved variety of sorghum are sufficient to boost microbial activity in the rumen and improve ration degradation. The content obtained is higher than the results (3.96%) of Zampaligré et al. [21] on the same variety. For cowpea haulms, the results obtained on the protein content (15.88%) are similar to that (18,5%) reported by Simian [22], higher than those (10.6%) reported by Azoutane et al. [23], but lower than what Baba et al. [24] obtained (21.3%) with an improved cowpea variety These differences could be explained by the varieties used, but also the conditions for collecting and storage of residues after harvesting the seeds.

4.2. Voluntary intake of rations

The results of voluntary intake show that there is no difference ($p < 0.05$) between pellet rations and those with chopped fodder. However, pelleting seems to improve slightly the intake of feed. Indeed, pelleting did not affect negatively the intake of feed. The difference in consumption could be explained by the size of the chopped and granulated feed. Indeed, the degree of chopping of straws and haulms was around 10 cm, while for granulation, the fodder was first crushed to about 10 mm. Chenost & Kayouli [25] define chopping as being a technique for reducing the size of fairly hard forage,

facilitating its distribution and its prehension by the animal. Furthermore, according to Jarrige et al. [26], with chopped or ground fodder fed to sheep, intake increases as particle size decreases. However, if the grinding is too fine (below 0.75 mm for legumes and 0.50 mm for grasses) the animal's response is reversed. The higher voluntary intake of rations combining sorghum straw and cowpea haulm, whether chopped or granulated, compared to rations combining sorghum straw and maize bran, could be explained by a higher nutrient intake, in particular protein content of cowpea haulms. Several authors have reported the positive effect of supplementation with cowpea haulms [27–29].

4.3. Digestibility

The low level of digestibility of pelleted rations compared to chopped ones could be explained by the grounding that was carried out before pelleting. Fine grounding could lead to an acceleration of digestive transit resulting in a reduction in the residence time in the rumen. This short time is insufficient for rumen microorganisms to act properly to digest feed especially fibrous ones. Azoutane et al. [23] noted that the high proportion of crude fiber and its duration in the rumen influences plant digestibility.

The legume haulms used in this study are rich in nitrogen and have average contents of parietal constituents. Their high intake allows a supply of nitrogen for rumen microorganisms, promoting an increase in cellulolytic activity and therefore improving the digestibility of organic matter and plant walls [19]. Thus, the high digestibility of ration 1 could be explained by the high CP ingestion with this ration. Even though the dMS and dMO of ration 2 are lower, we note a similar dCP with that of rations 3 and 4. This result could be explained by the high consumption of CP with R2 ration.

5. Conclusion

The granulation of crop residues does not have a negative effect on ingestibility. On the contrary, the product is slightly better consumed than chopped fodder. However, the study shows that the digestibility of pelleted rations is low compared to those composed of chopped fodder. The results also show that the rations based on the two crop residues (sorghum straw and cowpea haulm) have a better nutritional value than when the straw is combined with maize bran. Further studies are needed to determine the optimum size for shredding residues before granulation.

Compliance with ethical standards

Acknowledgments

The authors gratefully acknowledge the General Director of the « Centrale des Nouvelles Productions Animales (CNPA)/International Céréales Oléagineux Nutrition Animale (ICONA) » for his support in the production of pellets.

Disclosure of conflict of interest

The authors Toé Arlette, Sanon Hadja Oumou, Kaboré Michel, Somé/Sanou Sita and Bougouma Valérie M.C. declare that they have no conflict of interest.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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