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Effects of Graded Levels of Spirulina on Ingestion and *In Vivo* Digestibility of Rice Straw Associated with Molasses in Small Ruminants

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Abstract

The assessment of the effects of spirulina incorporation on ingestion and in vivo digestibility of rice straw was conducted at the Application and Research Farm and at the Animal Nutrition and Feeding Laboratory of Dschang University. The rations were distributed in a completely randomized design comprising three groups of three West African dwarf goats and three groups of three sheeps aged between 18 and 24 months. These animals were housed individually in digestibility cages. Periods of adaptation and data collection were 8 and 6 days, respectively. Each animal received 700g of rice straw per day with 0% spirulina (RS5 + S0) for group 1; 5% spirulina (RS5 + S5) for group 2 and 10% spirulina for group 3 (RS5 + S10). The leftover of each group was evaluated every morning before serving the new ration. A sample of 100g of each ration, faeces and 10 ml of urine was collected for the purpose of carrying out bromatological analyzes and the evaluation of digestibility. The results of this study showed that the addition of spirulina increased digestibility of organic matter and digestible nitrogenous matter of rice straw. The addition of spirulina did not significantly (P> 0.05) influence ingestion of dry matter (DM), organic matter (OM) and cell walls (NDF) in goats. However, the highest intake of DM, OM and cell walls (NDF) was obtained with RS5 + S10 ration (673.06; 541.40; 481.91g DM / day) and the lowest with RS5 + S0 (561.19; 480.61; 457.65g DM / day). On the other hand, in sheep, the addition of Spirulina significantly (P<0.05) influenced intake of rations. Dry matter (DM) intake of RS5 + S0 diet (566.20g DM/day) was comparable (P>0.05) to that of the RS5 + S5 diet (570.39 g DM/day), but significantly (P<0.05) lower than RS5 + S10 diet (603.76g DM/day). The addition of spirulina to rice straw associated with molasses resulted to the best digestive utilization coefficients of DM, OM, cell walls (NDF) and nitrogen in West African dwarf goats. On the other hand, in sheep, the best digestibility coefficients of DM, OM, cell walls and nitrogen were obtained with RS5 + S10 ration. The addition of spirulina to rice straw improved apparent digestibility of nitrogen (P>0.05) in Djallonke ewes. On the other hand, it improved significantly (P<0.05) the apparent digestibility of nitrogen in dwarf goats.

Keywords: Small ruminants; Digestibility; Ingestion; Spirulina; Molasse; Rice straw

Abbreviations: DM: Dry Matter Content; FMU: Forage meat unit; DOM: Digestibility of the Organic Matter; MFU: Milk Forage Unit; DNM: Digestible Nitrogenous Matter; OM: Organic Matter; GML: General Linear Model; CUDa: Coefficients of Apparent Digestive Use; CF: Crude Fiber; TNM: Total Nitrogenous Matter

Introduction

Small ruminant farming occupies a prominent place in many households in sub-Saharan Africa, where it plays an undeniable socio-economic role [1]. These animals are involved in the cultural, traditional and religious rites of different peoples [1,2], and constitute a form of saving and a source of organic fertilizer for many agro-pastoralists [1,3]. Despite this importance, the productivity of these animals remains poor because of health and food constraints; in addition, several authors [2-4] have shown that ruminant husbandry also faces the shrinking of grazing space. Faced with this situation, the integration of livestock production with crop production represents a promising way not only to increasing food supply in a sustained and sustainable way, but also to overcome the quantitative and qualitative forage deficit in ordered to meet the needs of animals during the dry season. This integration would also involve the valorisation of crop residues; notably cereal straw in the diet of small ruminants [5].

Previous studies have shown that the treatment of roughage such as cereal straw with 5% urea improves their nutritional value, ingestion and their digestibility [3,6,7]. Also, the addition of molasses to rations improves their total carbohydrate, mineral and energy content (FMU and MFU) [3,8-10]. These same authors have shown that molasses also improves ingestion and apparent digestibility of nutrients in goats. It increases milk production in cows and maintains a good body condition in heifers fed on corn stubble during the dry season. However, supplementation with biological substances with high protein potential such as spirulina could allow optimal production.

Spirulina (*Arthrospira platensis*) is a blue algae with a crude protein content of 60 and 70% dry matter (Fox, 1999). The addition of 5 to 10% of this fresh seaweed in the diet of some farm animals (poultry, pigs, horses and small ruminants) showed an improvement in acceptability, digestibility and assimilation of rations [11,12]. Other studies have also shown that the use of spirulina in the diet improves microbial mass and reduces the transit time of food particles in the rumen [13] if the energy content in the ration is enough. Thus, the use of molasses could optimize the digestive use of straws when they are associated with spirulina. This work has been initiated with the main objective of contributing to the improvement of knowledge on the valorization of crop residues in the diet of small ruminants.

Materials and Methods

Area of the study

This study was conducted at the Animal Nutrition and Production Research Unit and the Laboratory of Animal Nutrition and Feeding of the Faculty of Agronomy and Agricultural Sciences of the University of Dschang. This locality is located at latitude 5°44'-5°36 'and 5°44'-5°37' north and 10°06'-9°94 'and longitude 10°06'-9°85' east and at an altitude of 1420m. The climate of the region is equatorial, modified by altitude. Temperatures ranges from 10°C (July-August) to 25°C (February).

The annual insolation is about 1800 hours, the relative humidity varies between 40-97%. The rainfall is between 1500 and 2000mm per year. The dry season runs from mid-November to mid-March and the rainy season from mid-March to mid-November corresponds to the growing season [14].

Animal material

Nine (9) African dwarf goats and nine (9) adult sheep with average weight of 20.11 ± 2.68 and 17.5 ± 1.53kg were purchased from local breeders in Dschang. Their ages, ranging from 18 to 24 months, was determined from their dentition [15].

Animal housing: The animals were housed individually in digestibility cages measuring 1.5m x 0.5m x 1.6m. Each cage was provided with a feeder and a trough. Under the floor of each cage was attached a device use to collect urine and faeces separately.

Health protection: One month before the beginning of the trial, the animals from the different groups were dewormed with 1% ivermectin, a broad-spectrum synthetic anthelmintic active against gastrointestinal and pulmonary nematodes (larvae and adults).

Plant material

The plant material consisted of NERICA 3 rice straw (residues of the plant remaining in the field after rice harvesting).

Collection of rice straw: Two months after threshing at the farm of the Agricultural Research Institute for Development of Santchou, rice straw was collected and transported to the Research and Experimental Farm of the University of Dschang. Rice straw was chopped manually into small pieces of 2 to 5cm and then sun dried for 15 days before being stored in bags.

Spirulina: Spirulina (*Arhtrospira platensis*) that was used in this trial was brought from the Lake Chad region where it grows naturally in alkaline waters. It was purchased in the form of slabs and ground into powder using a 1mm tri-hammer mill, allows completing dissolution in water.

Experimental procedure

Experimental rations: Before serving 700g of rice straw to each animal per day, 5% molasses (based on the weight of the rice straw) was added to all rations. The molasses was diluted in water and the amount of water to be used for dilution was based on the amount of rice straw (250ml water per 600g of straw) [16]. That is 292ml of water for the dilution of the molasses to be added to the daily ration (700g of rice straw). Then 0, 5 or 10% spirulina (based on the weight of the rice straw) previously diluted in the same amount of water as the molasse was added. Three rations were used:

a. RS5 + S0 = Rice straw associated with 5% molasses + 0% spirulina.

b. RS5 + S5 = Rice straw associated with 5% molasses + 5% spirulina.

c. RS5 + S10 = Rice straw associated with 5% molasses + 10% spirulina.

The three ingredients (rice straw, molasses and spirulina) were well mixed before being served to the animals.

Ingestion and *in vivo* digestibility: Two independent ingestion and *in vivo* digestibility tests were performed successively with both species (goat and sheep). In each trial, nine (9) ewes and nine (9) goats were divided into three groups of three animals each of comparable average weight corresponding to the three diets, in a completely randomized design.

Each trial lasted 14 days, made up of an adaptation period of 08 days and a data collection period of 06 days. The purpose of the adaptation period was to allow the animals to become familiar with the digestibility cages and the new diet that will be served

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to them. During the adaptation period, each animal received on the first day 350g of experimental ration and fresh *Pennisetum clandestinum* depending on the group. This quantity was gradually increased until reaching the totality of their ration (700g of fresh material) on the last day of adaptation. During the data collection period, rations were served two (02) times per day, 350g in the morning between 8 and 9 am and 350g in the evening between 4 and 5pm. The water was served ad libitum and renewed daily.

Data collection

Ingestion: The ingestion of each ration were calculated by difference between the quantities served the day before and the refusals collected the next day. Similarly, faeces and urine produced by each animal were collected each morning. The faeces were weighed using a Kitchen scale (SF-400) with a 7000g scale, a sensitivity of 1g and urine measured with a 500ml graduated cylinder.

Digestibility: A sample of 100g of faeces from each animal was taken and dried at 60 °C till constant weight in a ventilated oven, then ground using a tri-hammer mill equipped with a grid of 1mm sieve in diameter and kept in plastic bags for the purposes of bromatological analyzes. Similarly, urine produced each morning per animal was collected in containers in which sulfuric acid (H_2SO_4) diluted at 10% was previously introduced according to the average volume of urine produced by each animal during the adaptation period, in order to stabilize urinary nitrogen. 10ml sample of urine was then pipetted into test tubes, stored at 4°C in a refrigerator in the Laboratory of Animal Production and Feeding of the University of Dschang for the determination of urinary nitrogen.

In addition, a sample of 100g of each ration was taken and dried at 60°C till constant weight in a ventilated oven. After drying, these samples were weighed and crushed using a hammer mill equipped with a grid of 1mm sieve size, then kept in plastic bags for bromatological analyses.

Analysis of samples

Analysis of the chemical composition of the different diets and feces were performed to determine dry matter (DM), ash, organic matter (OM), crude fiber (CF), lipid (F), cell wall (NDF), digestibility of the organic matter (DOM), milk forage unit (MFU); forage meat unit (FMU) and total nitrogenous matter (TNM). Urine nitrogen analysis was also performed. These analyzes were performed according to the methods described by AOAC [17] and Van Soest et al. [6].

Calculated parameters

The following parameters were calculated from the results of the chemical composition as shown below:

a. DOM (% DM) = - 2.10CF (% DM) + 96.8 [18].

b. DNM (g/kgOM) = 0.917TNM (g/kgOM) - 0.0055CF (g/kgOM) - 17.6 [18].

c. Total Carbohydrates = Organic Matter - (Lipids + Raw Proteins).

d. MFU = 121.80 + 0.11TNM - 1.81CF + 1.26F [19].

e. FMU = 124.15 + 0.06 TNM - 2.20CF + 1.22F [19].

The collected data also made it possible to calculate the ingestion of rations and nutrients as well as the coefficients of apparent digestive use (CUDa) of the DM, OM, NDF and nitrogen according to the formulas below described by Roberge & Toutain [20]:

a. Ingestion = Ration day N – Refusal day N+1.

b. CUDaDM (%) = (DM ingested – DM excreted) × 100/DM ingested.

c. CUDaOM (%) = (OM ingested – OM excreted) × 100/OM ingested.

d. CUDaNDF (%) = (NDF ingested – NDF excreted) × 100/NDF ingested.

e. CUDa Nitrogen (%) = (Nitrogen ingested – Nitrogen excreted) × 100Nitrogen ingested.

f. Digestibility of Nitrogen (%) = (Nitrogen ingested – Nitrogen (fecal + urinary) × 100/Nitrogen ingested.

Statistical analysis

Ingestion and *in vivo* digestibility data were subjected to a one-way analysis of variance using the General Linear Model (GML); the statistical software SPSS 20.0 was also used. The statistical model was as follows:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where:

Y_{ij} = observation on the animal i having received rations i.

μ = general average.

α_i = effect of ration i.

e_{ij} = residual error on the animal i having received ration i.

When differences existed between different treatments, the means were separated by the Waller Dunkan test at the 5% threshold [21]. *In vivo* ingestion and digestibility data were compared between the two species (sheep and goats) using the Student's "t" test at 5% threshold.

Results and Discussion

Results

Nutritional value of rice straws associated with molasses and different levels of spirulina: The dry matter (DM) content of the various diets did not varied significantly with the level of incorporation of Spirulina (Table 1). Cell wall (NDF), organic matter (OM), crude cellulose and total carbohydrate levels decreased with increasing level of spirulina incorporated in the different diets. On

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the other hand, the contents of total nitrogenous matter (TNM), ashe and lipids increased with the level of addition of spirulina. The digestible nitrogenous matter (DNM) and the digestibility of organic matter (DOM) increased with the level of incorporation of spirulina in the rations. Forage meat unit (FMU) and milk forage unit (MFU) increased with Spirulina level of diets.

Table 1: Nutritional value of the different rations.

Chemical Composition	Rations		
	RS5+S0	RS5+S5	RS5+S10
DM (%)	98.61	99.12	98.14
Ash (%DM)	14.36	15.08	19.56
Organic Matter (%DM)	85.64	84.92	80.44
Total Nitrogen Content (% DM)	3.08	5.12	7.17
Cell Walls (% DM)	83.8	80.8	71.6
Crude Fiber (% DM)	45.29	40.51	30.73
Lipids (%DM)	2.03	2.02	1.93
Nutritional Values			
Total Carbohydrates (%DM)	80.53	77.78	71.34
NMD (g/kgOM)	0.81	2.71	4.64
DOM (% DM)	1.69	11.72	32.26
MFU/kg of Dry Matter	0.42	0.51	0.69
FMU/kg of Dry Matter	0.27	0.37	0.59

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina; DNM = digestible Nitrogenous matter; DOM = Digestibility of Organic Matter; MFU = Milk Forage Unit; FMU = Forage Meat Unit.

Effects of graded levels of spirulina on intake and digestibility of rice straw associated with molasses in sheep

Ingestion of DM, OM and cell walls (NDF) of sheep fed with graded levels of spirulina: The addition of spirulina in the diets of sheep had no significant effects (P>0.05) on dry matter, organic matter, cell wall (NDF) ingestion (Table 2).

Table 2: Ingestion of DM, OM and cell walls (NDF) of sheep fed with graded level of spitulina.

Ingestion (g/day)	Rations			SEM	P
	RS5+S0	RS5+S5	RS5+S10		
Dry Matter	566.2	570.39	603.77	9.77	0.251
Organic Matter	484.9	484.34	485.66	6.61	0.998
Cell Wall	474.47	460.87	432.29	2.96	0.135

PR5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; PR5 + S5 = rice straw associated with 5% molasses + 5% spirulina; PR5 + S10 = rice straw associated with 5% molasses + 10% spirulina. P = probability, SEM = standard error of mean.

Digestibility of DM, OM and cell walls (NDF) of sheep fed with graded levels of spirulina: The incorporation of spirulina in the diets had no significant effects (P>0.05) on digestibility of the dry matter and the cell walls of the different diets (Table 3). The digestibility of OM of sheep fed with RS5 + S5 and RS5 + S10 were comparable (P>0.05) but significantly (P<0.05) higher than those of sheep fed with control diet (RS5 + S0).

Table 3: Digestibility of DM, OM and cell walls (NDF) of sheep fed with graded level of spirulina.

Constituents (%DM)	Rations			SEM	P
	RS5+S0	RS5+S5	RS5+S10		
Dry Matter	56.54[a]	60.05[a]	67.28[a]	2.14	0.094
Organic Matter	32.74[b]	42.43[a]	42.74[a]	1.79	0.04
Cell Walls	65.41[a]	67.09[a]	71.79[a]	0.66	0.458

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina. P = probability, SEM = standard error of mean.

a and b: averages with the same letter on the same line are statistically comparable to the 5% threshold.

Digestive utilization of nitrogen from rice straws associated with molasses in sheep: The ingestion and digestibility of nitrogen in sheep fed with graded level of spirulina shows no significant effects (P>0.05) on the amount of fecal and urinary nitrogen (Table 4). In contrast, nitrogen ingested, nitrogen retained, the apparent digestibility coefficient and nitrogen digestion significantly increased with the increasing level of spirulina in the ration.

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Table 4: Nitrogen Ingestion and Digestibility of Rice Straws Associated with Molasses in Sheep feed with different levels of spirulina.

Nitrogen Balance	Rations			SEM	P
	RS5+ S0	RS5+ S5	RS5+ S10		
Ingested Nitrogen (g / d)	2.79[c]	4.67[b]	6.92[a]	0.6	0
Fecal Nitrogen (g / d)	1.14[a]	1.15[a]	1.19[a]	0.03	0.842
Urinary Nitrogen (g / d)	1.17[a]	1.43[a]	1,75[a]	0.11	0,079
Nitrogen Retained (%)	0.46[c]	2.08[b]	3.97[a]	0.51	0,000
CUDa N (%)	58.90[c]	75.25[b]	82.77[a]	3.63	0
Nitrogen Digestion (%)	16.90[c]	44.44[b]	57.41[a]	6.14	0

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina. P = probability, SEM = standard error of mean.

a, b and c: averages with the same letter on the same line are statistically comparable to the 5% threshold, CUDa= apparent digestive use of nitrogen.

Effects of graded levels of spirulina on intake and digestibility of rice straws associated with molasses in goat

Ingestion of DM, OM and NDF of goat fed with graded level of spirulina: Ingestion of dry matter and organic matter from different diets increased with the increasing level of spirulina (Table 5). Intake of dry matter and organic matter from RS5 + S10 diet was significantly ($P<0.05$) higher than that of RS5 + S5 and RS5 + S0 diets which were otherwise comparable ($P>0.05$) between them. In contrast, the addition of increasing spirulina levels in the diet had no significant effect ($P>0.05$) on ingestion of cell walls.

Table 5: Ingestion of DM, OM and cell walls (NDF) of goat fed with graded levels of spirulina.

Constituents (%DM)	Rations			SEM	P
	RS5+S0	RS5+S5	RS5+S10		
Dry Matter	561.19[b]	566.39[b]	673.06[a]	18.76	0
Organic Matter	480.61[b]	480.95[b]	541.40[a]	10.78	0.002
Cell Wall	470.27[a]	457.65[a]	481.91[a]	1.67	0.134

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina. P = probability, SEM = Standard error of the mean.

a and b: averages with the same letter on the same line are statistically comparable to the 5% threshold.

Digestibility of DM, OM and cell wall (NDF) of goat fed with graded levels of spirulina: The effect of different levels of spirulina on the apparent digestibility of DM, OM and cell wall (NDF) of rations in the dwarf Guinea goat showed that the addition of spirulina in the different diets had no significant effects ($P>0.05$) on digestibility of DM dry matter, organic matter OM and cell walls (Table 6).

Table 6: Digestibility of DM, OM and cell wall (NDF) rations of goat fed with graded levels of spirulina.

Constituents (%MS)	Rations			SEM	P
	RS5+S0	RS5+S5	RS5+S10		
Dry Matter	69.59	71.29	76.1	1.41	0.148
Organic Matter	74.09	74.48	80.31	1.28	0.06
Cell Wall	75.1	75.35	75.88	0.29	0.951

Effects of graded level of spirulina on the digestive utilization of nitrogen in goats: The amount of nitrogen excreted in the faeces was comparable ($P>0.05$) between the different diets (Table 7). In contrast, the ingested nitrogen, the retained nitrogen, the apparent digestive utilization coefficient and the nitrogen digested were significantly ($P<0.05$) increased with the graded level of spirulina in the diets. The urinary nitrogen of RS5 + S0 and RS5 + S5 rations were comparable ($P> 0.05$) and significantly lower ($P <0.05$) than that of RS5 + S10 diet.

Table 7: Ingestion and digestibility of nitrogen of goat fed with graded levels of spirulina.

Nitrogen Balance	Rations			SEM	P
	RS5+ S0	RS5+ S5	RS5+ S10		
Ingested Nitrogen (g / d)	2.76c	4.64b	7.72a	0.72	0
Fecal Nitrogen (g / d)	1.52a	1.69a	1.28a	0.09	0.188
Urinary Nitrogen (g / d)	0.74b	0.84b	1.90a	0.2	0.004
Nitrogen Retained (%)	0.49c	2.10b	4.53a	0.59	0
CUDa N (%)	44.75c	63.33b	83.42a	5.95	0.002
Nitrogen Digestion (%)	17.99c	45.12b	58.71a	6.11	0

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina. P = probability, SEM = Standard Error of the Average.

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a, b and c averages with the same letter on the same line are statistically comparable to the 5% threshold, CUDa= apparent digestive use of nitrogen.

Comparative effect of graded levels of spirulina on ingestion and in vivo Digestibility in goats and sheeps

Ingestion of DM, OM and cell walls (NDF) of goat fed with graded level of spirulina: The comparative effect of the addition of spirulina on the intake of dry matter, organic matter and cell walls in goat and sheep diet showed that the ingestion of dry matter and organic matter for RS5 + S0 and RS5 + S5 diets was significantly (P<0.05) higher in sheep (Figure 1). In contrast, ingestion of RS5 + S10 diet was comparable (P>0.05) between goats and sheeps. The same observation was made for the cell walls of RS5 + S0 and RS5 + S5 rations.

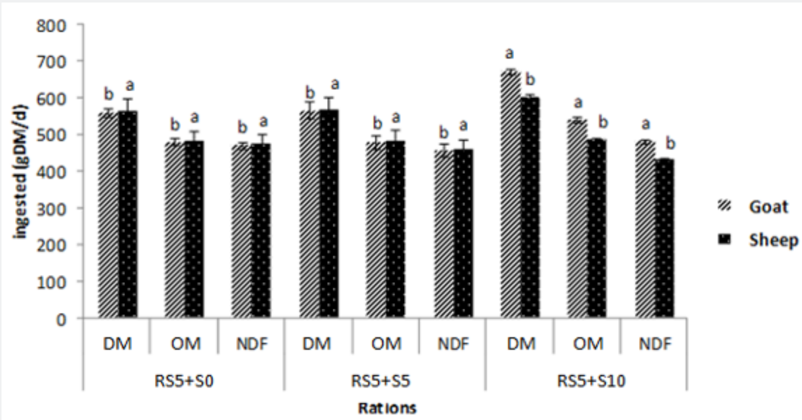

Figure 1: Comparative ingestion of dry matter, organic matter and cell walls in goats and sheeps fed with graded level of spirulina.

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw combined with 5% molasses + 10% spirulina DM = dry matter; OM = organic matter; NDF = cell walls.

a, b: bars with different letters are statistically significant at the 5% threshold.

Apparent digestive coefficient of DM, OM and cell walls (NDF) in goats and sheeps fed with graded levels of spirulina: Apparent digestive utilization coefficients of dry matter (DM), organic matter (OM) and cell walls (NDF) were significantly (P<0.05) higher in goats for RS5 + S0 diets and RS5 + S5, except the apparent digestive utilization coefficient of the cell wall of RS5 + S5 diet (Figure 2). In contrast, the apparent digestive utilization coefficient of dry matter, organic matter and cell wall of RS5 + S10 rations was comparable (P>0.05) between goats and sheeps.

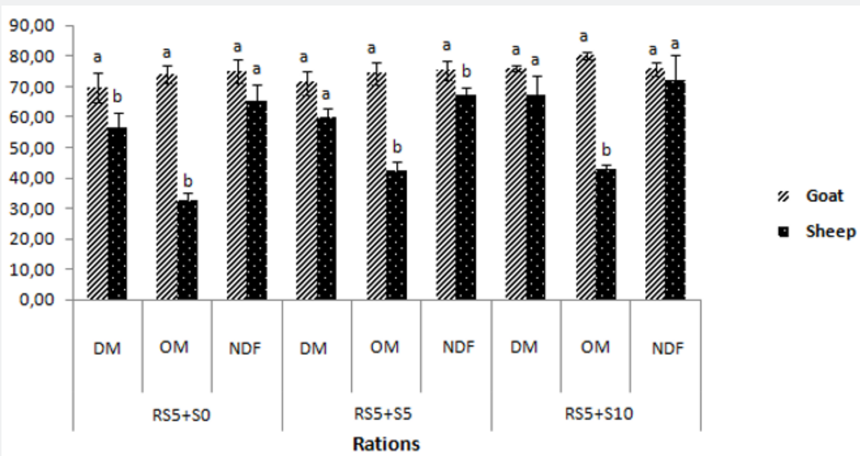

Figure 2: Comparative apparent digestive utilization coefficients of dry matter (DM), organic matter (OM) and cell walls (NDF) of goats and sheeps fed with graded level of spirulina.

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw associated with 5% molasses + 10% spirulina; CUDaDM = apparent digestive utilization coefficients of dry matter; CUDaOM = apparent digestive utilization coefficients of organic matter; CUDaNDF = apparent digestive utilization coefficients cell walls.

a, b: bars with different letters are statistically significant at the 5% threshold.

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Digestive utilization of the nitrogen of goats and the sheeps fed with graded levels of spirulina: The comparative effects of the inclusion level of spirulina on digestive utilization of nitrogen rations in goats and sheeps shows that, the ingested nitrogen of RS5 + S10 diet was significantly high (P<0.05) in goats, whereas those in the RS5 + S0 and RS5 + S5 rations were comparable (P>0.05) in both species (Figure 3). Nitrogen excreted in faeces by goats was higher than that excreted in the feces by sheep receiving RS5 + S0 and RS5 + S5. Urinary nitrogen was significantly (P<0.05) higher in sheep fed with RS5 + S0 and RS5 + S5 rations; but the reverse trend was observed with RS5 + S10 rations in goats. The nitrogen retained was significantly (P<0.05) higher in goats regardless of the ration considered.

The comparison of the digestive utilization of nitrogen between goats and sheep shows that, goats used nitrogen better than sheep (Figure 4). In fact, the CUDa of sheep was significantly higher (P<0.05) with RS5 + S0 and RS5 + S5 rations compare to goats.

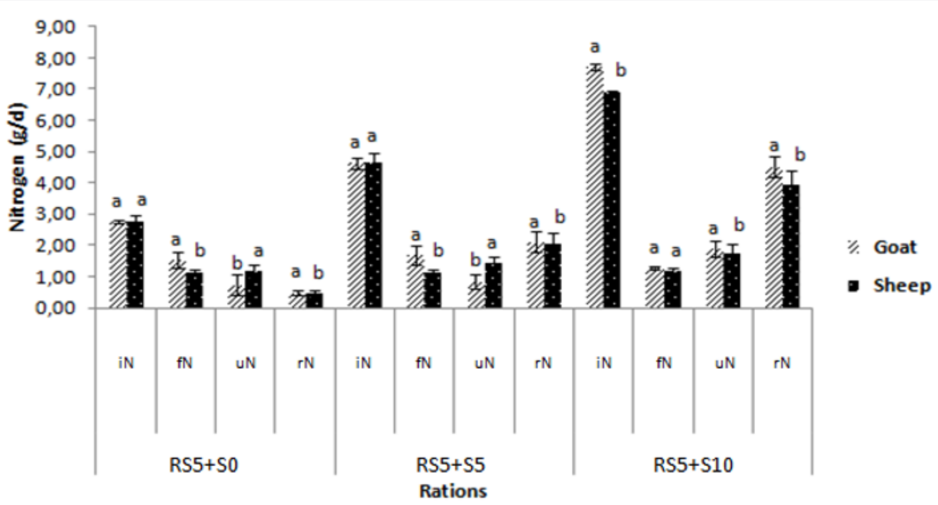

Figure 3: Effects of graded levels of spirulina on the comparative digestive utilization of nitrogen in goats and sheeps.

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 = rice straw with 5% molasses + 10% spirulina.,iN= ingested nitrogen, fN= fecal nitrogen;uN= urinary nitrogen, rN= retained nitrogen.

a, b: bars with different letters are statistically significant at the 5% threshold.

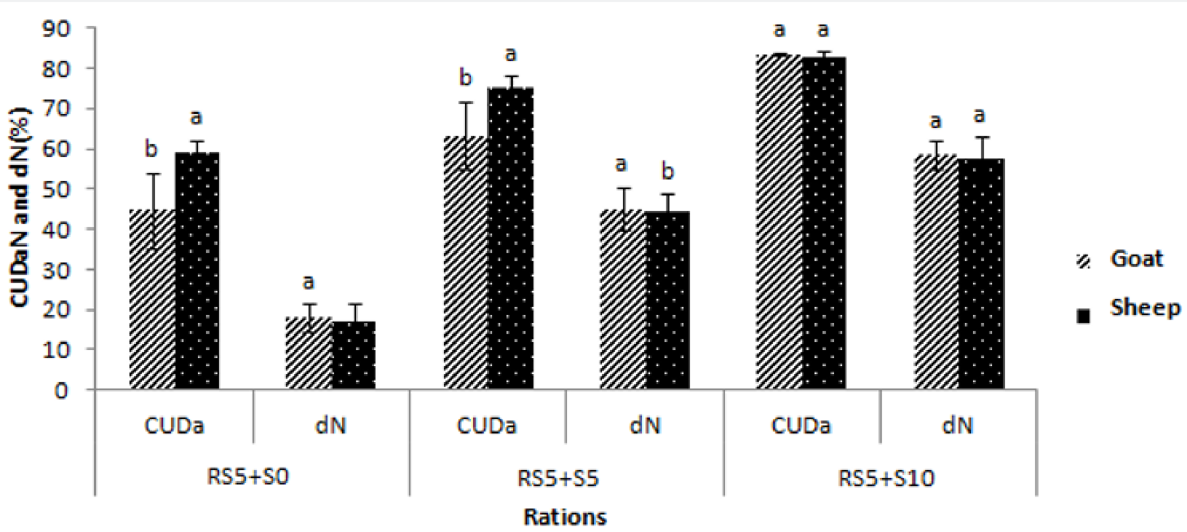

Figure 4: Comparative digestive utilization coefficients and digestibility of dietary nitrogen between goats and sheeps.

RS5 + S0 (control) = rice straw associated with 5% molasses + 0% spirulina; RS5 + S5 = rice straw associated with 5% molasses + 5% spirulina; RS5 + S10 rice straw with 5% molasses + 10% spirulina. CUDa= apparent digestive use of nitrogen. dN = digestibility of nitrogen.

a, b: bars with different letters are statistically significant at the 5% threshold.

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Discussion

The values of the chemical composition of the different diets were close to those reported by Boka et al. [22] and Attokoku [23]. The dry matter content (DM) of the different diets was close to that reported by Gongnet et al. [5]; Attokoku [23] but higher than that obtained by Sooden-Karamath & Youssef [24] (60.1% DM) and Boka et al. [22] (91.38% DM). The TNM content of the diets was close to that reported by Boka [22] and Attokoku [23] and lower than that obtained by Sooden-Karamath & Youssef [24] (18.8% DM); Boka [22] (12.17% DM); whereas, ash contents were close to those obtained by Sooden-Karamath & Youssef [24] (17.0% DM); Hue et al. [25] (13.4% DM) and Boka [22] (16.02% DM). Cell wall contents (NDF) were higher than those reported by Hue et al. [25] and Boka [22].

These differences in the bromatological composition of the rations was due to the different varieties of rice, the type of soil, the harvest period, the time between harvesting and utilization of the rice straw, fertilization with various sources of nitrogen (urea or chicken faeces); the heterogeneous level of incorporation of molasses into the different experimental rations [4,23,26]. These results are consistent with those obtained by many authors [3,27] who suggested that, the addition of molasses would have a dilution effect on the composition of the plant [27]. The digestible nitrogenous matter (DM) and the digestibility of the organic matter (DOM) increased with the addition of spirulina in the rations. The addition of Spirulina improved the MFU and FMU contents of rice straws associated with molasses. Molasses with the importance of its mineral function and its high sugar content improved MFU and FMU contents of rice straws by adding different spirulina levels associated with 5% molasses [27]. This difference is also related to the lipid content of spirulina [28,29].

The inclusion of spirulina influenced ingestion of rice straws associated with molasses. Ingestion of DM, OM and cell wall (NDF) were low with RS5 + S0 diet regardless of the species. This can be explained by the absence of spirulina which, in the diet improves the microbial mass and reduces the transit time of food particles in the rumen [13]. The addition of 10% Spirulina induced a higher intake of DM, OM and cell walls (NDF) in sheep. These results corroborate those obtained by Sooden-Karamath & Youssef [24]; Matumuini et al. [27] and can be attributed to the high rate of passage of digesta in the digestive tract of sheep compared to goats [24].

Ingestion of cell walls was higher than that obtained by Fotna [12] when the rations consisted of corn stalks mixed with 5 and 10% spirulina combined with 5% molasses. Indeed, spirulina is concentrating of protein rich in minerals and vitamins, which would have helped to improve the palatability and digestibility of different rations [8].

The addition of spirulina to rice straw associated with 5% molasses improved digestibility of DM, OM and cell walls in both species and the values were comparable (P>0.05) irrespective to the species. CUDa of DM, OM and cell walls of the diet containing 10% spirulina corroborate the results obtained by Fotna [12] when 10% spirulina was included in corn stubble associated with 5% molasses. On the other hand, these values were superior to those obtained by Chouna [30] and Tendonkeng et al. [1] using rice straw treated with 5% urea with the addition of molasses in goats. This difference could be explained by the nitrogen sources used by these authors. Also, molasses would probably have neutralized ammonia resulting from the action of urea and would have contributed to reducing the degree of lignin-hemicellulose-cellulose linkage breakdown of the ration [3]. The level of spirulina influenced (p<0.05) nitrogen intake, the amounts of fecal and urinary nitrogen in goats. The lowest ingestions and excretions were obtained with the RS5 + S0 diet in goats, while in sheep the lowest excretions were obtained with the RS5 + S10 diet. Urinary nitrogen was not influenced by the addition of spirulina to rice straws associated with 5% molasses in goats. This difference could be related to the addition of molasses which would promote the proliferation of fibrolytic rumen bacteria resulting in a good degradation of rice straws and the absorption of nutrients which varies with the animal species [3].

Conclusion

The effects of graded level of spirulina on ingestion and in vivo digestibility of rice straw associated with molasses in small ruminants improved total nitrogen matter, digestibility of organic matter and t nitrogenous digestible matter content of rice straw.

Ingestion of rice straw varied irrespective of the animal species with the inclusion level of spirulina. However, ingestions of dry matter, organic matter and cell walls of different diets were significantly (P<0.05) higher in goats compared to sheep. The RS5 + S10 diet had the best digestive utilization coefficients of DM, OM, cell wall and nitrogen in both species. On the other hand, goats used nitrogen better than sheep regardless of the ration considered. The CUDa of sheep was significantly higher (P<0.05) with RS5 + S0 and RS5 + S5 rations compare to goats.

In view of the results obtained, the addition of 10% spirulina to rice straw associated with molasses proved to be an alternative forage resource for small ruminants during the periods of food shortages. For a good evaluation of this residue associated with 10% of spirulina, it would be desirable to conduct a feeding trial to assess the effect of the level of inclusion of spirulina associated to molasses and rice straw on the performance of goats and sheeps.

References

1. Tendonkeng F, Pamo TE, Boukila B, Defang FH, Nijki EW, et al. (2013) Socio-économic and technical characteristic of small ruminant rearing in south region of Cameroon: Case of Mvilla Division. Livestock Research for rural development 25(4).

2. Pamo TE, Boukila B, Fonteh FA, Tendonkeng F, Kana JR (2007) Nutritive values of some basic grasses and leguminous tree foliage of the Central region of Africa. Animal Feed Sciences and Technology 135(3-4): 273-282.

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3. Lemoufouet J, Tendonkeng F, Soumo NS, Mbainaissem B, Miégoué E, et al. (2014) Ingestion et digestibilité chez le mouton des chaumes de maïs traitées à urée associées à la mélasse. Livestock Research for Rural Development 26(2): 1-6.

4. Tendonkeng F, Boukila B, Pamo ET, Mboko AV, Fogang ZB, et al. (2011) Effets direct et résiduel de différents niveaux de fertilisation azotée sur la composition chimique de Brachiaria ruziziensis à la floraison à l'Ouest Cameroun. International Journal of Biological and Chemical Sciences 5(2): 570-585.

5. Gongnet GP, Fadiga S, Cisse M (1997) Amelioration de la valeur alimentaire de la paille de riz par le traitement à l'urée et la complementation en céréales chez le mouton Peulh sénégalais. Tropicultura 15(4): 163-168.

6. Van Soest PJ (2006) Review. Rice straw, the role of silica and treatments to improve quality. Animal Feed Science and Technology 130(3-4): 137-171.

7. Vadiveloo J, Nurfariza B, Fadel JG (2009) Nutritional improvement of rice husks. Animal Feed Science and Technology 151(3-4): 299-305.

8. Aregheore EM, Perera D (2004) Effect of supplementation of a basal diet of maize stover with Erythrina variegate, Gliricidia sepuim or Leucaena Leucocephala on feed intake and digestibility by goats. Trop Anim Health Prod 36(2): 175-189.

9. Broderick GA, Radloff JW (2004) Effect of molasses supplementation on the production of lactating dairy cows fed diets based on alfafa and corn silage. J Dairy Sci 87(9): 2997-3009.

10. Dawit A, Ajebu N, Sandip B (2013) Effects of molasses level in a concentrate mixture on performances of crossbred heifer calves fed a basal diet of maize. Journal of Cell and Animal Biology 7(1): 1-8.

11. Marie-Christine B, Jonathan Boudreau (2005) Parabolic Index: Weather Insurance for Crops.

12. Fotna A (2016) Effet du niveau de spiruline sur l'ingestion et la digestibilité in vivo de chaumes de maïs associés à 5% de mélasse chez les petits ruminants. Thèse de Master a l'universiré de Dschang.

13. Quigley SP, Poppi DP, McLennan SR (2009) Strategies to increase growth of weaned Bali calves. Project Report. ACIAR.

14. Pamo TE, Tendonkeng F, kana JR, Loyem PK, Tchapga E, et al. (2004) Effet de différents niveaux de supplémentation avec Leucaena leucocephala sur la croissance pondérale chez la chèvre naine de Guinée. Revue d'Elevage et de Médecine Vétérinaire 57(1-2): 107-112.

15. Corcy JC (1991) La chèvre. La maison rustique. Paris, pp. 273.

16. Chenost M, Kayouli C (1997) Roughage utilization in warm climates.

17. AOAC (Association of Official Analytical Chemist) (2000) Official method of analysis, (15th edn), Washington D.C.

18. Jarrige R, Ruckebusch Y, Demarquilly C, Farce HM, Journet M (1995) Nutrition des ruminants domestiques ingestion et digestion. Chapitre I: les herbivores ruminants. Edition Quae, Paris Amazon France, pp. 921.

19. Sauvant D, Bas P (2001) La digestion des lipides dans le rumen. INRA Prod Ani 14(5): 303-310.

20. Roberge G, Toutain B (1999) Choix des plantes fourragères. In: Cultures fourragères tropicales. Montpellier France, pp. 321-357.

21. Steel, Torrie (1960) Principles and procedures of statistics. p. 481.

22. Boka OM (1993) Contribution à l'étude de l'influence du traitement à l'urée et de la complémentation en carbonate de calcium de la paille de riz, sur la consommation alimentaire, la digestibilité et le métabolisme azote chez le mouton peulh. Mémoire présenté en vue de l'obtention du diplôme d'études approfondies en productions animales (DEA-PA). Universite Cheikh Anta Diop de Dakar Ecole Inter-etats des Sciences et Medecine Veterinaires (E.I.S.M.V.). p. 92.

23. Attoh-Kotoku V (2011) Feeding two NERICA rice straw varieties to sheep: Effect of supplement with leguminous follages on digestibility, nutrient utilisation and growth performance. PhD thesis Department of Animal Science, Faculty of Agriculture, College of Agriculture and Natural Ressources, KWAME Nkrumah University of Science and Technology. pp. 168.

24. Sooden-Karamath S, Youssef FG (1999) Effect of monensin, avoparcin and grass supplementation on utilization of urea-treated rice straw by sheep and goats. Small Ruminant Research 33(3): 201-211.

25. Hue NV, Craddock GR, Adams F (1986) Effect of Organic Acids on Aluminum Toxicity in Subsoils. Soil Science Society of America Journal 50(1): 28-34.

26. Drake JD, Nader G, Forero L (2002) Feeding rice straw to cattle. Review. University of California Division of agriculture and natural resources. Publication 8079. pp. 1-18.

27. Matumuini NEF, Tendonkeng F, Mboko AV, Zougou TG, Boukila B, et al. (2013) Ingestion et digestibilité in vivo des chaumes de maïs associés aux feuilles de Tithonia diversifolia traitées à la mélasse chez la brebis Djallonké (Ovis aries). Livestock Research for Rural Development 25(8).

28. Costa C, Maria Paola Germanò, Rita De Pasquale, Valeria D'Angelo, Stefania Catania, et al. (2002) Evaluation of Extracts and Isolated Fraction from Capparis spinosa L. Buds as an Antioxidant Source. J Agric Food Chem 50(5): 1168-1171.

29. Pierlovisi C, Xavier Cachet (2007) L' homme et la spiruline, un avenir commun?: composition chimique, intérêts alimentaires et activités biologiques. Paris V- René Descartes, Faculté des Sciences Pharmaceutiques et Biologiques, Paris, p. 162.

30. Chouna A (2015) Effet du niveau de mélasse sur l'ingestion et la digestibilité in vivo de la paille de riz traitée à l'urée chez les petits ruminants, Thèse de Master Université.

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