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Research Article

Ingestion and *In vivo* Digestibility of *Pennisetum purpureum* Supplemented with Graded Level of *Arachis glabrata* in Guinea Pigs (Cavia Porcellus)

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Abstract

In order to contribute to a better utilization of *Arachis glabrata* in the diet of the Guinea-pig, 04 levels of this leguminous were incorporated at 10, 15 or 20% into concentrated food in order to evaluate the effect of various levels of *Arachis glabrata* on feed intake and *in vivo* digestibility of *Pennisetum purpureum* and on the level of bacteria of the cæcale flora at those animals. Four iso-nitrogenious diet (16% of proteins) were formulated. An experiment were conducted at the Teaching and Experimental Farm of the Faculty of Agronomy and Agricultural Science of University of Dschang between August and September 2016 on a total of 40 adult Guinea-pigs of local breed comprising 20 females and 20 males aged 4 months and weighing averagely 331g. After 02 weeks of acclimatization at farm then 10 days of adaptation in individual cages of digestibility, animals were allotted randomly in four groups (T_0, T_1, T_2, T_3) of 5 animals each per sex. The T_0 group received 60g of concentrated food without *Arachis glabrata* associated at 250g with *P. purpureum* while groups T_1, T_2 and T_3 were respectively feed on 60g of diet containing 10, 15 or 20% of this leguminous associated at 250g of the graminaceous. During experiment of digestibility which lasted 07 days, each diet was repeated on 10 guinea-pigs (5 males and 5 females). Compared to the control, feed intake of *P. purpureum* (163, 1gMS/g/animal) and nutrients at male and apart from sex, was significantly higher with diet containing *Arachis glabrata*. Females were significantly ingested DM and OM of control food than males from who feed intake of that nutrients in diet containing *A. glabrata* were better. Somewhere else, feed intake of CP and CF in all diet was comparable between the two sexes. The digestive of nutrients was not significantly influenced by the level of *A. glabrata* in the ration. The cæcal level of bacterial flora was remained unchanged ($P > 0.05$) when the level of *Arachis glabrata* in the diet varied. However, the diet containing 20% of *Arachis glabrata* was most favorable to the development of Lactobacilli to the detriment of Entérobactéria.

Keywords: *Pennisetum Purpureum*; *A. Glabrata*; Guinea-Pigs; Ingestion; *In vivo* Digestibility

Introduction

Population growth creates an imbalance between demand and supply of animal protein, leading to malnutrition especially in low-income families [1]. To combat this scourge, the development and popularization of mini-breeding offer an alternative source of protein as much as they would contribute in a global way to the economy of the country through the promotion of employment, exchanges and preservation of biodiversity [2]. Thus, caviaculture is a guarantee of food security for vulnerable populations [3]. Indeed, feasibility studies and experiences from other countries have shown that this traditional breeding is economically profitable and participates effectively in the fight for food security and the preservation of biodiversity [4].

However, the major challenge for the success of caviaculture remains food [5] since it represents more than 70% of production costs [6]. The cost of compound food commonly used as forage protein supplement remains expensive and while raising the cost of production, does not always achieve good productivity. However, when looking for good performance, grasses are associated with compound supplements whose rate can be reduced if forage is legumes [7].

Many inexpensive legumes are used as an alternative source of protein. Thus, *Arachis glabrata*, reputed for its excellent growth potential in tropical Africa, has often been incorporated into the guinea pig diet to improve the ingestion and digestibility of forage grasses [8,9]. On the one hand, few studies have been evaluated on the level of inclusion of *Arachis glabrata* on grass digestibility. On the other hand, the presence of antinutritional factors in legumes may reduce the ability of microorganisms to digest nutrients from which they are made [10].

It is with this in mind that the present study was conducted to evaluate the effect of different levels of *Arachis glabrata* in the diet on the ingestion and *in vivo* digestibility of *Pennisetum purpureum* and

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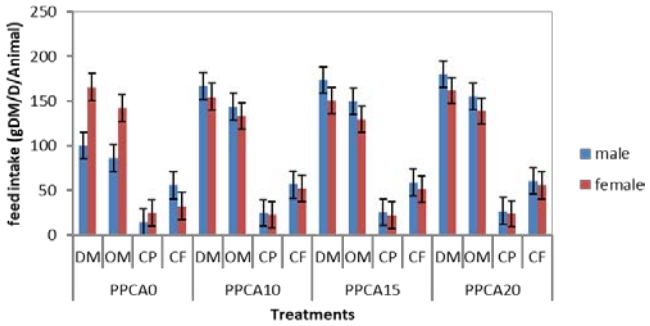

Figure 1: Effect of sex on ingestion of DM, OM, CP, and CF in guinea pigs fed *P. purpureum* with diets containing different levels of *Arachis glabrata*. [a,b]Averages with the same letters for the same parameter are not significantly different at the 5% threshold for the same treatment; PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* + diet containing 20% *A. glabrata*.

on the caecal rate of flora bacterial in guinea pigs.

Materials and Methods

Experimental site

The study took place between August and September 2016 at the Teaching and Experimental Farm of the Faculty of Agronomy and Agricultural Science of University of Dschang. The locality is located between 5°25' and 5°30' Latitude North, 10°00' and 10°05' East Longitude and an altitude of about 1420m west of Cameroon. The climate is equatorial of Cameroonian type, with an average annual temperature of 20°C. The average rainfall is between 1500 and 2000mm, with relative humidity ranging from 40% (in the dry season) to 97% (during the heavy rains). The dry season alternates with the rainy season [11].

Housing and animal sample

The breeding lodges were previously cleaned and then disinfected. The crawl space of two (02) weeks preceded the introduction of forty (40) local adult guinea pigs including 20 females and 20 males of mean age 04 months and means weight 331 ± 42.86g, bought from breeders in the city of Dschang and its surroundings. The guinea pigs were then acclimated to the farm for two (02) weeks in breeding lodges, each equipped with a lighting device, before being introduced into the digestibility cages adapted for this purpose. The animals were raised on litter soil from untreated dry wood chips, males isolated from females. Vitamin C-enriched drinking water at the rate of one 250mg tablet for 1.5 liters was available ad *libitum* and renewed daily.

Plant sample

Pennisetum purpureum was mowed before flowering in the field of forage of the farm the day before and prewashed before being served the next day to the animals. The leaves of *Arachis glabrata* were harvested before flowering, dried, then crushed and incorporated into 10, 15 and 20% feed. After analysis, the chemical composition of the forage used was presented in Table 1.

Conduct of the test

Formulation and composition of different diets: The ingredients, the proportions of which are presented in Table 2, made four (04) iso-nitrogen diets (16% PB). After two (02) weeks

Table 1: Chemical composition of forage used.

Chimical composition	Forages	
	P. purpureum	*A. glabrata*
Dry matter (%)	94 .80	95.29
Organic matter (%DM)	86	87.82
Crude proteine (%DM)	14.9	19.53
Crude fiber (%DM)	34.8	20.94
ash (%DM)	14	12.18

of acclimation of the animals in the breeding lodges, the forty (40) guinea pigs were distributed randomly in the individual digestibility cages and divided into four (04) batches of five (05) animals per sex. The batches numbered T_0, T_1, T_2 and T_3 received in this order the diet containing the increasing levels of *Arachis glabrata*. The animals continued to receive vitamin C in the daily drinking water.

Evaluation of the ingestion: The guinea pigs were first adapted to the digestibility cage and experimental rations for 10 days during which the quantity of food was adjusted to the daily consumption of the animal estimated at 60g.

The evaluation of the ingestion had begun after this phase of adaptation where each guinea pig received every morning between 8 and 9 hours, 250 grams of *Pennisetum purpureum* associated with 60grams of the considered ration (CA0, CA10, CA15 or CA20). Refusals were collected daily and weighed before any new food distribution.

Assessment of digestibility: The digestibility test had begun in conjunction with ingestion and had lasted seven (07) days during which the feces were collected in labeled envelopes and weighed daily in the morning prior to a re-distribution of the diet. After drying at 60°C. in an oven to a constant weight, the faeces were crushed and kept in the plastic bags, of which one hundred (100)g were taken for the evaluation of their Dry Matter Contents (DM) Organic Matter (MO), crude protein (PB) and fiber (CF) according to the method described by AOAC, (1990).

Analysis of caecal flora: At the end of the digestibility test, 03 randomly selected guinea pigs of each sex were sacrificed and the contents of the caecums were taken for evaluation of the composition of the caecal flora (Enterobacteriaceae and Lactobacilli) according to the method described by [12].

Statistical analyzes

Data on dietary intake and nutrient digestibility, as well as on the caecal flora were subjected to the analysis of the 2-factor variance (food ration and sex of the animal) according to the general linear model (MLG). When significant differences existed between treatments, the separation of means was done by the Waller Duncan test at the 5% level [13]. The comparison between the sexes was made by Student's "t" test at the 5% threshold. The statistical analysis software used was SPSS 20.0.

Results

Chemical composition of forages and different diets

Arachis glabrata had higher levels of dry matter, organic matter, and crude protein than *Pennisetum purpureum* (Table 1). On the

Table 2: Formulation of different diet.

Ingredients (%)	Differents diets			
	CA0	CA10	CA15	CA20
Middlings	31	27.5	26.5	25
Corn	30	27	25,5	24
Cotton cake	5	4.5	4	4
Palm kernel cake	25	22.5	21	20
Soybean meal	2	2	2	1.5
Fish meal	3	2.5	2.5	2.5
Shell powder	2	2	1.5	1.5
Prémix	1	1	1	1
Cooking salt	1	1	1	1
Arachis glabrata	0	10	15	20
TOTAL	**100**	**100**	**100**	**100**
Dry matter (%)	97.82	97.28	97.68	97.54
Organic matter (%DM)	86.06	87.76	88.44	87.45
Crude protein (% DM)	16.02	16.43	16.55	16.67
Fat (% DM)	8.74	4.8	4.65	4.3
Crude fiber (% DM)	15.8	17.93	17.8	17.46
Ash (% DM)	13.94	12.24	11.56	12.55
Digestible energy (kcal/kg ingested food)	2690	2640	2625	2595

other hand, the crude fiber and ash content of this legume was low compared to that of the grass. It can be seen from Table 2 that dry matter, organic matter, crude protein, digestible energy and ash contents varied very little between the different diets. In contrast, the lipid content of the control diet was higher (8.74% DM) than the mean value of that obtained with diets containing *Arachis glabrata* (4.58% DM). The crude fiber content of the legume-free diet was lower than the values obtained with other diets.

Effect of inclusion level of *Arachis glabrata* in the diet on ingestion of *Pennisetum purpureum* in guinea pigs

Ingestion of *P. purpureum*, total dry matter (DM), organic matter (OM), crude protein (PB) and crude fiber (CF) in males and regardless of sex was comparable (P> 0.05) between diets containing *A. glabrata* and significantly (P <0.05) higher than that of the control diet (Table 3). In contrast, ingestion of *P. purpureum* and nutrients in females was comparable (P> 0.05) for all diets. No significant difference (P> 0.05) was, however, recorded on the ingestion of the compound feed, regardless of diet and sex. The highest ingestion of DM (170.9 gDM / animal / day), MB (147.1 gDM / animal / day), BP (25.5 gDM / animal / day) and CF (58.1 gDM / animal / day) was obtained with the diet containing 20% *A. glabrata*.

Effect of sex on nutrient ingestion in guinea pigs fed *P. purpureum* associated with diets containing different levels of *Arachis glabrata*

Females had significantly (P <0.05) better ingested DM and OM than males with the control diet (Figure 1). In contrast, ingestion of these nutrients (DM and OM) with other diets was better (P <0.05) in males. In addition, sex did not significantly influence (P> 0.05) ingestion of CP and CF of different diets.

Table 3: Ingestion of *Pennisetum purpureum* in guinea pigs based on inclusion levels of *Arachis glabrata* in the diet.

Ingestions	Treatments				SEM	P
(g DM/D/animal)	PPCA0	PPCA10	PPCA15	PPCA20		
Experimental food						
Pennisetum purpureum (PP)						
♂(5)	87.0^{b}	158.3^{a}	165.7^{a}	168.6^{a}	3.13	0.01
♀(5)	155.3^{a}	144.28^{a}	142.2^{a}	157.6^{a}	3.07	0.36
♂♀(10)	121.1^{b}	151.1^{a}	153.9^{a}	163.1^{a}	4.47	0.01
Compound food (AC)						
♂(5)	13.1^{a}	8.6^{a}	8.0^{a}	11.6^{a}	1.24	0.5
♀(5)	9.9^{a}	10.5^{a}	8.6^{a}	4.0^{a}	0.94	0.15
♂♀(10)	11.5^{a}	9.6^{a}	8.3^{a}	7.8^{a}	0.86	0.45
Nutrients						
Total dry matter (DM)						
♂(5)	100.1^{b}	166.9^{a}	173.8^{a}	180.3^{a}	3.78	0.01
♀(5)	165.1^{a}	154.8^{a}	150.7^{a}	161.6^{a}	3.41	0.56
♂♀(10)	132.7^{b}	160.8^{a}	162.3^{a}	170.9^{a}	4.47	0.01
Organic matter (OM)						
♂(5)	86.1^{b}	143.7^{a}	149.7^{a}	155.2^{a}	3.27	0.01
♀(5)	142.0^{a}	133.3^{a}	129.8^{a}	139.0^{a}	2.95	0.58
♂♀(10)	114.1^{b}	138.5^{a}	139.7^{a}	147.1^{a}	3.85	0.01
Crude protein (CP)						
♂(5)	14.7^{b}	24.6^{a}	25.7^{a}	26.9^{a}	0.55	0.01
♀(5)	24.4^{a}	22.7^{a}	22.3^{a}	24.1^{a}	0.49	0.47
♂♀(10)	19.5^{b}	23.6^{a}	24.0^{a}	25.5^{a}	0.66	0.01
Crude fiber (CF)						
♂(5)	55.6^{b}	56.5^{a}	59.1^{a}	60.7^{a}	1.19	0.01
♀(5)	32.4^{a}	52.0^{a}	51.0^{a}	55.5^{a}	1.11	0.48
♂♀(10)	44.0^{b}	54.3^{a}	55.0^{a}	58.1^{a}	1.55	0.01

^{a,b}Averages with the same letters on the same line are not significantly different at the 5% level; SEM: Standard Error on the Average; P: Probability; PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* + diet containing 20% *A. glabrata*.

Effect of the inclusion level of *Arachis glabrata* in the ration on apparent digestibility coefficients (ADC) nutrients in guinea pigs fed with *P. purpureum*

The inclusion level of *Arachis glabrata* in the ration did not significantly (P> 0.05) affect the digestive utilization of nutrients in both males and females, and even sex-independent, when rations were associated with *P. purpureum* (Table 4). The highest ADC values of DM (84.2 gDM/ animal / d), OM (85.0 gDM / animal / d), CP (90.5 gDM/ animal / d) and CF (83.9 gDM / animal / day) were obtained with the control diet.

Effect of sex on the digestive utilization of nutrients in guinea pigs fed with *P. purpureum* associated with diets containing different levels of *Arachis glabrata*

Figure 2 shows that sex did not significantly (P> 0.05) influence the digestive utilization of nutrients in guinea pigs fed with *P. purpureum*

Table 4: Apparent digestibility coefficients (ADC) of nutrients in guinea pigs fed with *P. purpureum* based on inclusion level of *A. glabrata* in the diet.

ADC (%) Sexe	Treatements				SEM	P
	PPCA0	PPCA10	PPCA15	PPCA20		
ADC MS						
♂(5)	87,6[a]	82,0[a]	85,0[a]	78,8[a]	1,18	0,12
♀(5)	80,9[a]	80,7[a]	76,1[a]	79,3[a]	1,28	0,55
♂♀(10)	84,2[a]	81,4[a]	80,1[a]	79,1[a]	0,95	0,26
ADC MO						
♂(5)	88,2[a]	82,9[a]	85,4[a]	79,9[a]	1,19	0,13
♀(5)	81,8[a]	81,7[a]	77,1[a]	80,3[a]	1,24	0,54
♂♀(10)	85,0[a]	82,3[a]	81,3[a]	80,1[a]	0,94	0,30
ADC PB						
♂(5)	92,7[a]	92,6[a]	92,1[a]	90,8[a]	0,71	0,76
♀(5)	88,2[a]	87,8[a]	82,6[a]	81,1[a]	1,20	0,21
♂♀(10)	90,5[a]	90,3[a]	87,3[a]	85,9[a]	0,89	0,40
ADC CB						
♂(5)	87,6[a]	82,8[a]	81,4[a]	81,0[a]	1,14	0,31
♀(5)	80,3[a]	80,2[a]	72,0[a]	71,1[a]	1,38	0,13
♂♀(10)	83,9[a]	81,5[a]	76,7[a]	76,1[a]	1,09	0,11

[a]Averages with the same letters on the same line are not significantly different at the 5% level; SEM: Standard Error on the Average; P: Probability; ADC: apparent digestibility coefficient; PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* +diet containing 20% *A. glabrata.*

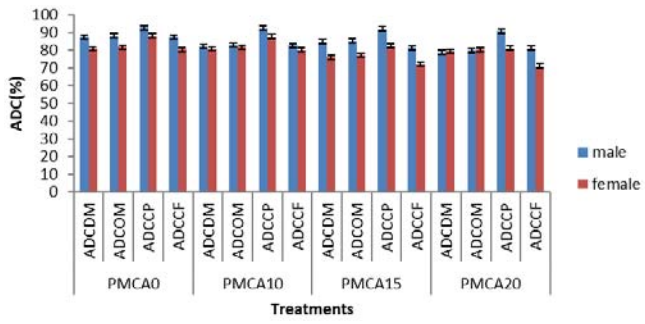

Figure 2: Effect of sex on the digestive use of MS, MB, PB and CB in guinea pigs fed *P. purpureum* associated with diets containing different levels of *A. glabrata.*

[a,b]Averages with the same letters on the same line are not significantly different at the 5% level; SEM: Standard Error on the Average; P: Probability; ADC: Apparent Digestibility Coefficient; PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* +diet containing 20% *A. glabrata*.

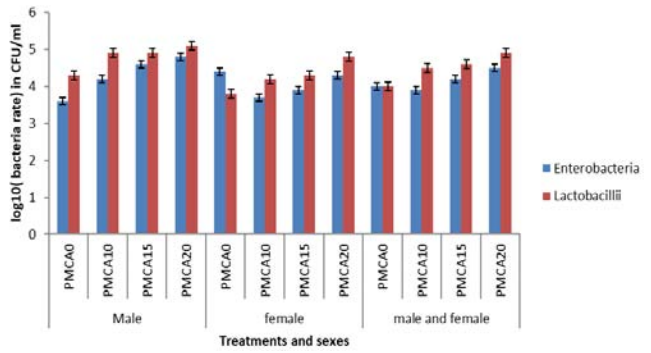

Figure 3: Effect of the inclusion level of *Arachis glabrata* in the diet on the variation of the level of Enterobacteria and Lactobacilli in guinea pigs fed with *P. purpureum.*

PPCA0: *P. purpureum* +diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* +diet containing 20% *A. glabrata*.

associated with diets containing different levels of *A. glabrata.*

Effect of the inclusion level of *Arachis glabrata* in the diet on the cecal rate of Enterobacteria or Lactobacillus bacterial flora in guinea pigs fed with *P. purpureum*

Table 5 shows that in male guinea pigs, the rate of enterobacteria was comparable (P> 0.05) between the *A. glabrata* containing diets and significantly higher (P <0.05) than that obtained with the control diet. However, no significant differences were observed between diet containing *A. glabrata* as much for females as for sex, no difference was observed between treatments. On the other hand, the lactobacilli rate did not significantly vary with the rations. The highest rate of Enterobacteria (4.5 CFU/ml) and Lactobacilli (4.9 CFU/ml) was obtained with the 20% *A. glabrata* diet.

The comparison between the levels of Enterobacteria and Lactobacilli in guinea pigs fed *P. purpureum* associated with different diets (Figure 3) shows that the levels of these microorganisms were comparable (P> 0.05) whatever the diet. However, the level of Lactobacilli was higher than that of Enterobacteriaceae. In addition, the rate of these bacteria was not significantly (P> 0.05) modified by sex, although the highest values were recorded in males with rations containing *Arachis glabrata* (Figure 4).

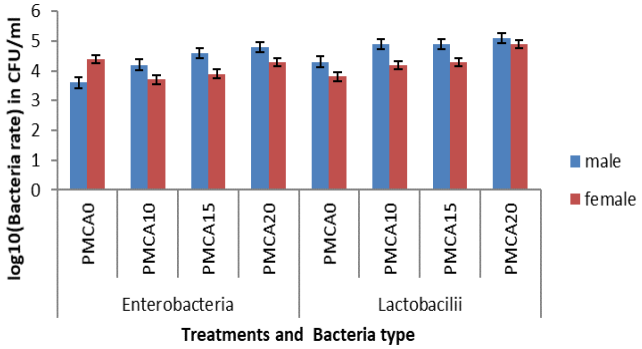

Figure 4: Variations in the level of Enterobacteria and Lactobacilli in guinea pigs fed with *P. purpureum* associated with diets containing different levels of *Arachis glabrata.*
PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* + diet containing 20% *A. glabrata*.

Discussion

Effect of inclusion level of *Arachis glabrata* in the diet on ingestion of *Pennisetum purpureum* in guinea pigs

Compared to the legume-free diet, ingestion of *P. purpureum* (163.1gMS / animal / d) was significantly higher with *A. glabrata*-containing diets. This shows that the protein intake of this legume improve thus de-cluttering the caecum with the consequent increase in food intake [7,14,15].

The best intake of total Dry Matter (DM) and Organic Matter (OM) from diet containing *A. glabrata* in male guinea pigs compared to females could be explained by the fact that in adulthood, males have a higher weight and are therefore more vigorous. They could therefore better ingest food because the food intake is very often correlated to the weight of the animal. According to many authors, dietary intake in male guinea pigs is better than that of females [1,8].

Effect of the level of inclusion of *Arachis glabrata* in the diet, on the digestibility of *Pennisetum purpureum* in guinea pigs

The apparent digestibility coefficient (ADC) of nutrients did not follow the same trend as their ingestion. The lack of a significant difference in dietary intakes for *Pennisetum purpureum* in guinea pigs could be explained by the fact that digestive use is more affected by food than by diet. Animal indeed, according to [16], diet is the factor that has the strongest influence on digestibility. Similarly [17], also reported that one of the environmental factors that seems most likely to modify the bacterial colonization process of the gastrointestinal tract is the food ingested by the gold host. In this study, the rations used were iso-nitrogenous. Digestibility will therefore be affected by the quality and physical state of the ration, that is to say the form in which the food is presented to the animal as much as its chemical composition. These factors condition the action of the microbial flora and digestive juices. The rations used in this test were in powder form, which promoted both ingestion and digestive utilization of the nutrients.

Table 5: Effect of inclusion level of *Arachis glabrata* in diet on the variation of Enterobacteria and Lactobacilli levels in guinea pigs fed *Pennisetum purpureum*.

Genus	Treatments				ESM	P
Bacterial	PPCA0	PPCA10	PPCA15	PPCA20		
LOG10 (Entérobacteria) (CFU/ml)						
♂(5)	3.6^{b}	4.2^{a}	4.6^{a}	4.8^{a}	0.08	0.03
♀(5)	4.4^{a}	3.7^{a}	3.9^{a}	4.3^{a}	0.09	0.13
♂♀(10)	4.0^{a}	3 .9^{a}	4.2^{a}	4.5^{a}	0.08	0.7
LOG10 (Lactobacillii) (CFU/ml)						
♂(5)	4.3^{a}	4.9^{a}	4.9^{a}	5.1^{a}	0.07	0.1
♀(5)	3.8^{a}	4.2^{a}	4.3^{a}	4.8^{a}	0.06	0.6
♂♀(10)	4.0^{a}	4.5^{a}	4.6^{a}	4.9^{a}	0.09	0.44

^{a,b}Averages with the same letters on the same line are not significantly different at the 5% level; SEM: Standard Error on the Average; P: Probability; PPCA0: *P. purpureum* + diet containing 0% *A. glabrata*; PPCA10: *P. purpureum* + diet containing 10% *A. glabrata*; PPCA15: *P. purpureum* + diet containing 15% *A. glabrata*; PPCA20: *P. purpureum* + diet containing 20% *A. glabrata*.

Effect of the inclusion level of *Arachis glabrata* in rations on the cecal rate of Enterobacteria or Lactobacillus bacterial flora in guinea pigs fed *P. purpureum*

The significant increase in Enterobacteria in male guinea pigs fed *P. purpureum* shows that the inclusion of *Arachis glabrata* in the diet may influence the equilibrium of the caecal flora in these animals. Indeed, one of the factors of the environment that seems most likely to modify the bacterial colonization process of the gastrointestinal tract is the food ingested by the host [17]; any imbalance of intestinal microbial flora that may lead to enteropathies. Compared with the rate of Enterobacteria (Gram-), Lactobacilli (Gram+) were the most numerous. This result reflects the quality of the experimental foods. In fact, according to [18-20], the microbial population is predominantly composed of Gram (+) and anaerobic organisms, Gram (-) being present in a smaller quantity.

Conclusion

Evaluation of the effect of different levels of supplementation with *Arachis glabrata* on the *in vivo* digestibility of *Pennisetum purpureum* in guinea pigs showed that:

- Ingestion of *P. purpureum* by guinea pigs was higher when combined with the diet containing 20% of *A. glabrata*. Males had better ingested DM and OM of rations containing this legume than females. The ADC of DM, OM, CP, and CF in guinea pigs fed with legume rations were comparable to those in the control group.

- Inclusion of 20% of *Arachis glabrata* in the diet of guinea pigs had significantly increased the level of Enterobacteriaceae (Gram-) in males.

From the above, it appears that the inclusion of *A. glabrata* in the guinea pig diet had improved ingestion and digestive utilization of *P. purpureum*. For a better valorization of these grasses in guinea pig food, the inclusion of a minimum of 20% of *A. glabrata* in the ration can be interesting.

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