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In vitro digestibility of *Echinochloa crus pavonis, Pennisetum purpureum* and *Tripsacumlaxum* in dry season in southeastern Gabon

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ABTRACT: A comparative study of the chemical composition and *in vitro* digestibility of *Echinochloa crus pavonis, Pennisetum purpureum* and *Tripsacumlaxum* in the dry season in small ruminants was conducted between August and December 2016 in Franceville. Rumen fluid of both Djallonké sheep and African Dwarf goat were separately collected and incubated with 500 mg of feed sample, as per gas-test method. The parameters of the chemical composition of the fodders used were significantly influenced ($p < 0.05$) by the nature of the fodder. In fact, OM and CF contents obtained with *P. purpureum* (89.26 and 34.90% DM respectively) were significantly lower ($p<0.05$) than those recorded with *T. laxum* and greater ($p<0.05$) than those observed with*E. crus-pavonis*. Ash and CP levels obtained with *P. purpureum* were significantly lower ($p<0.05$) than those recorded with *E. crus pavonis*. On the other hand, they were higher ($p < 0.05$) than those resulting from the analysis of *T. laxum* leaves. The gas and volatile fatty acids productions, *in vitro* organic matter digestibility and metabolisable energy have varied in the same direction from one species to another under the influence of the rumen fluid origin. The highest values have always been obtained with goat rumen fluid for all grasses. Ultimately, *E. crus-pavonis* seems to present better nutrient potential in the dry season compared to the othersfodders.

KEYWORDS: Degradability, nutritional value, sheep, goats, grasses

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I. INTRODUCTION

Livestock remains the principal source of animal protein (meat, eggs and milk) in a world, where hunting and fishing are regulated by an essential need to preserve biodiversity, environment and natural resources. In the tropics, sheep and goats play important sociocultural and economic roles. These animals are not only a source of meat protein for the family, but also a means of hoarding for thousands of breeders, which can mobilize quickly. They are also an important source of organic fertilizers for many farmers [15]. Despite these multiple benefits, production and productivity of small ruminants remains low, due to health and dietary constraints. In sub-Saharan Africa, animals must be covered largely by perennial or annual grasses. The digestive use of this energy is very variable according to the chemical composition of feed [5].

In the region of Franceville (South-East of Gabon), some grasses like *Echinochloa crus-pavonis*, *Pennisetum purpureum* and *Tripsacumlaxum*, which grow in the lowlands and around of marshlands, remain green even in the middle of the dry season. As a result, they are an important source of energy for animals during this difficult period. Thus, the prior knowledge of the nutritional value of these plants could orient the choice of fodder for the policy exploitation and implementation of the pasture areas development in the dry season. Also, the general objective of this study is to contribute to the improvement of the knowledge on the nutritive value of *Echinochloa crus-pavonis*, *Pennisetum purpureum* and *Tripsacumlaxum* under the conditions of southeastern Gabon. It is specifically about:

- Determine the chemical composition of *Echinochloacrus-pavonis*, *Pennisetum purpureum* and *Tripsacumlaxum* during the long dry season;
- compare the *in vitro* digestibility of these grasses with the sheep or goat rumenfluid.

II. MATERIAL AND METHODS

2.1 Presentation of the study area

The present study was conducted between August and December 2016, at the "InstitutNational d'Agronomie et de Biotechnologies (INSAB) of the "Université des Sciences et Techniques de Masuku (USTM), as well as at the Laboratory of Nutrition and Animal Feeding of the Faculty of Agronomy and Agricultural Sciences (FASA) of the University of Dschang (Cameroon). INSAB is located in Franceville south-eastern of Gabon (1°37'15" south latitude and 13°34'58" east longitude). The climate of the region is equatorial type hot and humid, characterized by four seasons: a great rainy season from mid-March to mid-June, a great dry season from mid-June to mid-September, a small rainy season of mid-September to mid-December and a small dry season from mid-December to mid-March. Averages temperatures range from 24.4 to 26.8°C, while annual precipitationranges from 2000 mm to 2 250 mm per year [19].

2.2 Vegetable material

The plant material consisted of leaves of *Echinochloa crus-pavonis*, *Pennisetum purpureum* and *Tripsacumlaxum* harvested in the lowlands around Franceville.

2.3 Animal material

A west-africandwarf goat and a Djallonke ewe, were used in this study. Their age, determined from their dentition, was from 18 to 24 months [4].

2.4 Conduct of the test

The foliage of the three species of grasses mentioned above was harvested on August 15 during the dry season, in three (3) repetitions per species in three districts of the city (Yéné, Mingara and Corniche). The harvested forage was then dried in a Memmert model 800 ventilated oven at 60°C for five days to constant weight; then the fodder was cut, crushed, and then kept in plastic bags in batches of 100g, at a rate of three (3) per species, for subsequent chemical analyzes. A completely randomized two-factor device (forage species and rumen fluid) was used to study *in vitro* digestibility of differentfodders harvested during the dry season.

The chemical composition analyzes were carried out at the Animal Nutrition and FeedingLaboratory of University of Dschang in Cameroon. Percent dry matter (DM) was determined by drying dry fodder samples in an oven at 103°C for 24 hours. The ash contents (total minerals) were evaluated after incineration of dry samples in a muffle furnace at 500°C for 6 hours. Fat contents (MG) were analyzed using the Soxhlet device, while crude protein levels were evaluated by the Kjeldhal method [2]. Crude fiber (CB) was determined according to the method of Weende analysis [1]. The west-africandwarf goat and the Djallonké sheep, were housed, maintained and fed alternately with the three grasses for ten days. At the end of this period, the animals were sacrificed and the rumen fluid of each was recovered and prepared for the *in vitro* digestibility study. The latter was done according to the method described by [9] modified by [7], in three repetitions for each fodder and type of rumen fluid; Thus, 500 mg of sample, weighed using a KERN 770 electrical scale, 210g range and 0.0001 g sensitivity, were introduced into a 100ml syringe. The following day, rumen fluid from the sheep and goat was collected, one after another, just after slaughter. After each collection, the fluid was immediately filtered under a flow of CO_2. 700 ml of inoculum were then taken, introduced into the mother solution and homogenized for 10 mm using a magnetic rod.

For each type of rumen fluid, 40 ml of the inoculum was collected and injected into each syringe using a Fortuna Optifix brand precision dispenser, and then the whole was placed in a water bath to 39°C for incubation. This last operation lasted 24 hours and the volumes of gas produced were recorded after 3, 6, 9, 12, 18 and 24 h. Gas production and *in vitro*organic matter digestibility (IVOMD) were calculated according to the formulas described by [10]; *in vitro*dry matter digestibility (IVDMD) was evaluated according to the formula presented by [20]; production of volatile fatty acids (VFA), metabolisable energy (ME), partitioning factor (FC) and microbial mass (MM) were estimated according to the formulas described by [7].

2.5 Statistical analyzes

In vitro digestibility data were subjected to analysis of variance (ANOVA) using the General Linear Model (MLG), using SPSS 20.0 software. When the differences existed between the samples, the averages were separated by the Duncan test at the 5% significance level. The comparison of the averages between sheep rumen fluid and goat rumen fluid was carried out using the Student test at the 95% confidence interval.

III. RESULTS

3.1 Chemical composition of different fodder species in dry season

Table I presents the parameters of the chemical composition of fodder species studied in the dry season. During this period, the NDF content varied according to the nature of the fodder. The lowest amount (79.15% DM) was obtained with *T. laxum*; while *P. purpureum* had the highest content (87.94% DM). Indeed, thislast was significantly higher (p <0.05) than that observed with *T. laxum.*

Table 1. Chemical composition of different fodder species in the dry season

Espèces fourragères	DM (%)	Ash (%DM)	OM (%DM)	CP (%DM)	CF (%DM)	NDF (%DM)	Lipids (%DM)
E. crus pavonis	97,91^{c}	9,18^{a}	86,68^{c}	16,64^{a}	33,42^{c}	83,94^{ab}	3,97^{a}
P. purpureum	99,11^{a}	8,96^{b}	89,26^{b}	12,72^{b}	34,90^{b}	87,94^{a}	2,17^{c}
T. laxum	98,42^{b}	6,41^{c}	90,45^{a}	8,19^{c}	36,48^{a}	79,15^{b}	3,19^{b}
SEM	0,18	0,44	0,56	1,22	0,49	1,46	0,28
Probability	0,000	0,000	0,000	0,000	0,007	0,014	0,002

a, b, c : means without common subscript in the same column are different at P<0.05. DM : dry matter; OM : organicmatter; CP : crudproteins ; CF : crudfiber, NDF : Neutraldetergentfiber, SEM : standard error of mean.

However, the NDF level obtained with *E. crus-pavonis* was comparable (p> 0.05) to those found with the leaves of *P. purpureum* and *T. laxum*. OM and CF levels obtained with *P. purpureum* were significantly lower (p <0.05) than those found with *T. laxum*, and higher (p <0.05) than those observed in *E. crus-pavonis*. Ash and CP levels obtained with *P. purpureum* were significantly higher (p <0.05) than those observed with *T. laxum*, but lower (p <0.05) than those resulting from analysis of the leaves of *E. crus-pavonis*. DM and lipids levels varied significantly (p <0.05) depending on the nature of the fodder. The highest amount of DM was obtained with *P. purpureum* (99.11% DM), and the lowest with *E. crus-pavonis* (97.91% DM). On the other hand, lipids levels evolved (p <0.05) in the opposite direction.

3.2 In vitro digestibility of various fodders species with ovinerumenfluid

Comparison of *in vitro* digestibility parameters of fodder species incubated with ovine rumen fluid (Table II) in the dry season shows that IVOMD, ME and NDIN significantly varied (p<0.05).

Table 2.*In vitro* digestibility parameters of fodders incubated with ovine rumen fluid in the dry season.

Grasses species	PG after 24h (ml/500mg)	IVOMD (%)	ME (MJ/ kgMS)	VFA (mmol/40ml)	IVDMD(%)	PF (mg/ml)	MM (mg)	NDIN
E. crus-pavonis	56,85^{a}	73,50^{a}	10,88^{a}	1,30^{a}	37,51^{a}	1,32^{a}	95,10^{a}	0,59^{a}
P. purpureum	56,31^{b}	71,25^{b}	10,58^{b}	1,29^{a}	37,34^{a}	1,33^{a}	75,12^{b}	0,39^{b}
T. laxum	52,38^{c}	65,55^{c}	9,79^{c}	1,19^{b}	26,72^{b}	0,99^{a}	74,42^{b}	0,23^{c}
SEM	0,76	1,21	0,17	0,02	1,85	0,08	3,43	0,05
Probability	0,003	0,000	0,000	0,002	0,000	0,115	0,000	0,000

a, b, c : means without common subscript in the same column are different at P<0.05.PG : producted gaz; DIVMO : in vitro digestibility of organicmatter; ME: metabolisableenergy; VFA: volatilsfattyacids; DIVMS : in vitro digestibilityof dry matter; PF: partitioning factor; MM : microbial mass; NDIN: neutraldetergentinsoluble nitrogen, SEM : standard error of mean,

The values obtained with *E. crus-pavonis*, were highest regardless of the parameter. However, the VFA and IVDMD obtained with *E. crus-pavonis* and *P. purpureum* were comparable (p> 0.05), and significantly higher (p <0.05) than the values obtained with *T. laxum*. In addition, no significant difference (p> 0.05) was observed between partitioning factors (PC) obtained with the three fodder species in the dry season. Similarly, the quantities of gas produced (PG) by*E. crus-pavonis* and *P. purpureum* were comparable (p> 0.05), but significantly lower (p <0.05) than those produced by *T. laxum*. The microbial mass (MM) recorded with *E. crus-pavonis* was significantly (p <0.05) greater than those observed with *P. purpureum* and *T. laxum* in which they were comparable (p> 0.05).

3.3 In vitro digestibility of various fodders species with caprine rumenfluid

The influence of the nature of fodder species on the evolution of *in vitro* digestibility parameters with goat rumen fluid in the dry season is presented in Table III.

Table 3.*In vitro* digestibility parameters of fodders incubated with goat rumen fluid in the dry season.

Grasses species	PG after 24h (ml/500mg)	IVOMD (%)	ME (MJ/ kgMS)	VFA (mmol/40ml)	IVDMD (%)	PF (mg/ml)	MM (mg)	NDIN
E. crus-pavonis	59,24[a]	67,26[a]	11,21[a]	1,36[a]	33,28[a]	1,12[a]	86,43[a]	0,53[a]
P. purpureum	57,05[b]	71,91[b]	10,68[b]	1,30[b]	31,49[a]	1,10[a]	73,79[b]	0,37[b]
T. laxum	54,31[c]	75,63[c]	10,05[c]	1,24[c]	24,35[b]	0,90[b]	74,93[b]	0,30[c]
ESM	0,74	1,22	0,17	0,02	1,40	0,04	2,14	0,04
Probability	0,000	0,000	0,000	0,000	0,000	0,000	0,001	0,000

a, b, c : means without common subscript in the same column are different at P<0.05. PG : producted gaz; DIVMO : in vitro digestibility of organicmatter; ME: metabolisableenergy; VFA: volatils fattyacids; DIVMS : in vitro digestibility of dry matter; PF: partitioning factor; MM : microbial mass; NDIN: neutraldetergent insoluble nitrogen, SEM : standard error of mean,

This table shows that, the evolution of PG, IVOMD, ME, VFA and NDIN are significantly (p<0.05) influenced by the nature of the fodder. Indeed, the highest values were obtained with *E. crus-pavonis*. The IVDMD and PF obtained with *E. crus-pavonis* and *P. purpureum* were comparable (p> 0.05), and significantly higher (p <0.05) than those reported with *T. laxum*. The values obtained from the analysis of *E. crus-pavonis* and *P. purpureum* are comparable (p> 0.05) for IVDMD and PF. However, these values are significantly (p <0.05) higher than those observed in *T. laxum*. The highest (p <0.05) MM was observed with *E. crus-pavonis*. In fact, the recorded value is significantly (p <0.05) greater than those obtained with *P. purpureum* and *T. laxum* which were comparable with each other (p> 0.05).

3.4 Comparative effect of the rumenfluid source on the in vitro digestibility parameters of grasses

Table IV shows the effect of rumen fluid source on,*in vitro* digestibility parameters of *E. crus-pavonis*, *P. purpureum* and *T. laxum*.

Table 4. Comparison of the parameters of the in vitro digestibility of the three grasses according to the rumen fluid source.

Grasses species	Rumen fluid	PG after 24h (ml/500mg)	IVOMD (%)	ME (MJ/ kgMS)	VFA (mmol/40ml)	IVDMD (%)	PF (mg/ml)	MM (mg)	NDIN
E. crus-pavonis	Ovin	56,85[b]	73,50[b]	10,88[b]	1,30[b]	37,51[a]	1,32[a]	95,10[a]	0,59[a]
	Caprin	59,24[a]	75,63[a]	11,20[a]	1,35[a]	33,28[a]	1,12[a]	86,43[b]	0,53[a]
P. purpureum	Ovin	56,31[a]	71,25[a]	10,58[a]	1,29[a]	37,34[a]	1,33[a]	75,12[a]	0,39[a]
	Caprin	57,05[a]	71,91[a]	10,68[a]	1,30[a]	31,49[b]	1,10[b]	73,79[a]	0,37[b]
T. laxum	Ovin	52,38[a]	65,55[a]	9,79[a]	1,19[a]	26,72[a]	0,99[a]	74,42[a]	0,23[a]
	Caprin	54,31[a]	67,26[a]	10,05[a]	1,24[a]	24,35[a]	0,90[a]	74,92[a]	0,30[a]

a, b : means without common subscript in the same column are different at P<0.05. PG : producted gaz; DIVMO : in vitro digestibility of organicmatter; ME: metabolisableenergy; VFA: volatils fattyacids; DIVMS : in vitro digestibility of dry matter; PF: partitioning factor; MM : microbial mass; NDIN: neutraldetergent insoluble nitrogen.

The comparative effect of the rumen fluid source on the *in vitro digestibility* parameters of the three grasses in the dry season, shows that with *T. laxum* and for all the parameters studied, no significant difference was observed between the liquid of sheep and goat rumen. However, gas production, IVOMD, ME, and VFA obtained with *E. crus-pavonis* were significantly (p <0.05) higher with goat rumen fluid. For the same parameters, no significant difference (p> 0.05) was observed with *P. purpureum*. Similarly, no significant influence (p> 0.05) was observed for IVDMD, PF and NDIN with *E. crus-pavonis*. In contrast, the microbial mass obtained with *E. crus-pavonis* incubated with goat rumen fluid was significantly (p <0.05) lower than that recorded with ovine rumen liquid.

IV. DISCUSSION

The DM content obtained with *E. crus-pavonis* (97.91%) is different from that reported by [17] which was 94.44%. Similarly, for *P. purpureum*, the DM content recorded (99.11%) is rather different from that of

91.96 and 94.8% DM respectively obtained by [13], and [11]. On the other hand, the ash, CP, CF and lipids contents obtained with *P. purpureum* are close to those obtained by [11]. The leaves of *T. laxum* showed values in ash and OM, similar to those obtained by [3], while the content of CPapproaches to the 9% DM reported by [18], but very low compared to the 16.95 % DM recorded by [16]. These differences in chemical composition would be related to the influence of certain factors such as the type of soil, the part of the plant (leaf, stemand pod), the age of the plant, the season of harvest [12], the state of hydration and the rhythm of precipitation [14]. In addition, the comparison of the chemical composition of the three grasses shows significant variations ($p < 0.05$), these would probably be related to the intrinsic characteristics of each fodder species, influenced by the edaphic and climatic conditions of the harvesting medium [6].

The parameters of *in vitro* digestibility have evolved in a variable way. Indeed, whatever the origin of the rumen fluid, the results of PG, IVOMD, ME, VFA, MM and NDIN obtained with *E. crus-pavonis* were higher than those recorded with the other grasses. These results suggest that *E. crus-pavonis* is more digestible than *P. purpureum* and *T. laxum*. In addition, the parameters of the *in vitro* digestibility of the different grasses, with the goat and sheep rumen fluid are very close. This finding is similar to that of [8] which obtained comparable *in vitro* digestibility results with rumen fluid from sheep and goats that ingested the same ration.

V. CONCLUSION

In short, *Echinochloa crus-pavonis*, *Pennisetum purpureum* and *Tripsacumlaxum* could constitute basic fodder for feeding small ruminants in the dry season. However, *Echinochloa crus-pavonis* appeared to show better abilities to meet the nutritional needs of animals in the dry season compared to the other two grasses.

The results of this study could be confirmed by studying the palatability and *in vivo* digestibility of those grasses in small ruminants in reproduction, growth or maintenance during the dry season.

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