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Original article

Supplementing panicum maximum with two medicinal forages in the diet of Djallonke sheep at the Benin national sheep center

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ABSTRACT

Ensuring a better integration of natural resources in the animal feeds remains the main challenge that farmers face most of the time. The present study, conducted in the breeding farm of Betecourou, deals with the nutritional value of two plant species both forage and anthelmintic, notably the Khaya senegalensis (Desr.) A. Juss and the Boerhavia diffusa L. The feeding experiments lasted 120 days and were conducted on seventy-two (72) young sheep Djallonké, 9.00 ± 0.25 month age, with an initial weight of 19.32 ± 0.45 kg. For both the dry and rainy seasons' experiments, the sheep were arranged in a Fisher block-like of three batches of twelve animals each. Lot 1: - green leaves of Panicum maximum C1 from pasture + 800 g of green leaves of B. diffusa for each sheep. Lot 2 - green leaves of Panicum maximum C1 taken from the pasture + 800 g of leaves of K. senegalensis per animal. Lot 3 represents the Control group fed only with forage Panicum maximun C1. For the dry season, animals Average Daily Weight Gain (ADG) for Lots 1 & 2 are higher than those of the control group (0.13 kg / d supplemented with B. diffusa and K. senegalensis versus 0.10 Kg/d for the control group). Experiments during the rainy season yielded higher ADG ($p < 0.05$) even though the feed intake for B. diffusa is the lowest. ADG and total weight gain

induced are respectively 0.18 kg / d and 20.94 kg feeding with B. diffusa versus 0.17 kg / d and 20.0 kg for K. senegalensis and 0.12 kg / d and 14.25 kg for the control group) respectively. Boerhavia diffusa and Khaya senegalensis can be used in the formulation of an intensive sheep fattening ration.

1. Introduction

Livestock is second to crop production in terms of natural resources potentially exploitable and convertible into foreign currencies (MAEP, 2011). However, animal products, including meat, milk and eggs do not provide complete coverage of animal protein needs of the country. Accroding to FAO standards, the demand for meat is 21 kg / capita / year and eggs 1 kg / capita / year while the current average production is 8.41 kg / capita / year for meat and 0.6 kg / capita / year for eggs (MAEP, 2011). Therefore, Benin remains a country heavily dependent on imports of meat and meat products that are marketed on a large scale (Gbangboché et al. 2005). This competes with local production, destroys emerging animal products production sectors, favors money loss and must be restricted. However, Benin must improve the level of its production to meet the needs of its population in animal protein. The government of Benin is currently paying more attention to the development of short-cycle animals. Among the targeted species is the Djallonké sheep, with an annual average growth rate of 3% and a contribution to the total meat production in 2004 estimated to 5% (Gbangboché et al. 2005). Its breeding needs little investment compared to cattle (Tchouamo et al. 2005). Unfortunately, as reported by Gbangboché et al. (2002) the increase in sheep meat production in Benin is intimately based on the herd size and not to individual opulence. . This low productivity is due to the type of farming on one hand and especially to the lack of quality food and the prevalence of various diseases on the other. Indeed feeding sheep turns out to be a limiting factor in livestock development in tropical Africa, especially during dry seasons because essentially based on the use of natural pastures (Kaboré-Zoungrana et al. 2008) which is not available during that period . Therefore, it is of upmost importance to identify natural pasture species capable both to cover the nutritional requirements for sheep and have pharmacological properties for the sheep can fully develop their genetic potential.

In this context, selecting forage with high nutritional value and therapeutic properties (nutraceuticals) is fully justified. This will provides farmers with quality animal food that solves all feeding issues they face... Boerhavia diffusa has a pantropical distribution and perhaps native to the tropics of the Old World (Mahesh et al. 2012). Boerhavia diffusa is an herb that is relatively underutilized and neglected in most cases in West Africa in general and Benin in particular but industrially cultivated in India and Nigeria for animal feed. It is also used for medicinal purposes (Najam et al. 2008; Mahesh et al. 2012; Ujowundu et al. 2008). Commonly called 'pork-grass''in southeastern Nigeria its leaves are cooked and eaten as sauce by certain persons. Several researchers have been interested by the extraordinary therapeutic properties of Boerhavia diffusa. Khan et al. (2013) have proven the medicinal properties of Boerhavia diffusa Linn. This plant has the ability to treat diabetes, inflammation, stress, liver disease and heart disease (Khan et al. 2013) and infertility and menstrual pains (Okoli et al. 2007). These properties are due to its bioactive compounds contents such as polyphenols and flavonoids. The leaves are heavily grazed by sheep and cattle during dry season and can also be harvested as forage (Alade et al. 2010). Many researchers have worked on B. diffusa extracts (Okoli et al., 2007; Ujowundu et al., 2008; Jayasri and Anuradha 2012; Khan et al. 2013). Among the compounds isolated from B. diffusa are the punarnavine (alkaloid), the punarnavoside (glucopyranoside), the ursolic acid, the boeravinones (rotenoids) and other minor components (Khan et al. 2013; Ujowundu et al. 2008). Pharmacological compounds content of B. diffusa seem to be geographic region dependent.(Gupta et al. 2012). However, nutritional and therapeutic potentials of B. diffusa in animal feeding is not well reported in the literature. Khaya senegalensis is found where 650-1300 mm of rainfall and a dry season from 4 to 7 months is annually registered (Arbonnier, 2004). Its bark is commonly used in veterinary medicine for its tonic and appetizing effects. It is also used to treat trypanosomiasis, diarrhea and ulcers (Androulakis et al., 2006). Extracts in acetone and methanol of Khaya senegalensis bark are effective against worm eggs, larvae and adult worms of Haemonchus contortus (Chabi China, 2010) and larvae of Hypsipyla grandella (Pérez-Flores et al. 2012). Aqueous extracts of Khaya senegalensis have anti-inflammatory properties (Lompo et al.

2007). It is common to use the leaves as fodder but its nutritional value is low (1.05 FV/kgDM, 171g digestible nitrogen (DiN)) (Neya, 2006). They are solely used towards the end of the dry season or mixed with better forage. Khaya senegalensis is on the IUCN Red list as a vulnerable species due to habitat loss and environmental degradation (Neya, 2006).

It is in the dynamic exploration of scientific nutritional and medicinal resources that this study proposes to determine the effect of supplementation with fresh leaves of Boerhavia diffusa and Khaya senegalensis on weight gain of sheep Djallonké at Benin National Sheep Center. A supplement of 800 g of fresh leaves of Boerhavia diffusa and Khaya senegalensis to young male sheep Djallonke fed in a staling with Panicum maximum var C1 improves their weight gain.

2. Materials and methods

2.1. Study area

This study was conducted at the National Sheep Center (NSC) located in the city of Dassa (2 ° 20 2 ° 27 'east longitude 7 ° 45' and 7 ° 50 'north latitude).

2.2.Supplementation experiments

The feeding experiments was conducted on seventy-two (72) young sheep Djallonké 9.00 ± 0.25 months old with an initial average weight of 19.32 ± 0.45 kg arranged in Fisher-like blocks consisting ofsix batches of twelve animals each.

Table 1
Experimental design.

Block	Basic Diet	Supplemented food	Season
1	P. maximum	800 g B. diffusa	Dry
2	P. maximum	800 g K. senegalensis	Dry
3	P. maximum	P. maximum	Dry
4	P. maximum	800 g B. diffusa	Rainy
5	P. maximum	800 g K. senegalensis	Rainy
6	P. maximum	P. maximum	Rainy

The experiments lasted 120 days during the dry season and the same length during the rainy season. The forages were harvested in the farms. A salt stone was used as a mineral supplement and vitamins. Water and licked stone were available ad libitum. This test consisted of two phases: an adaptation phase for15 days prior to the measurement phase for 120 days during which the animals were weighed in morning before feeding) using a weight's scale of 100.0 ± 0.5 Kg.

The animals were fed twice a day i.e. morning (8 am) and afternoon (5 pm). Animals of experimental groups were supplemented every afternoon (5 pm) with 800 g of fresh green leaves of Khaya senegalensis or Boerhavia diffusa per animal.

During the experiment the animals were under strict health care and veterinary treatments such as the treatment of abscesses, worm internal and external parasites, in accordance with the animal surveillance program established by animal health officials of the NSC.

2.3. Measurements

Weekly weighing of animals using a scale of 100.0 kg ± 0.5 kg was used to follow sheep's growth during the experiments. These weights allowed us to periodically calculate average daily gain (ADG) for each batch of animals following Lhoste et al. (1993):

ADG (g) = (Final Weight - Initial Weight)/Time Experience.

2.4. Statistical analysis

The response of sheep to food supplement depends on the quality of basic rations. For the appropriate model to explain sheep's growth we used the principle of automatic parsimony with Akaike information criterion

(AIC) using the MASS package (Venables and Ripley, 2002) of R statistical software (R Development Core Team, 2012). The average ranking was made with the procedure of HSD.test of agricolae package (de Mendiburu 2013)

The basic model is:

$$Y_1(\text{Weight}_{kg}) = f\left[\left(\text{Panicum Quantity ingested}_{kg} + \text{Supplement} + \text{Saison}\right)\right]\text{^}2$$

Using the principle of parsimony we obtained the following function:

$$Y_2(\text{Weight}_{kg}) = f\left[\left(\text{Panicum Quantity ingested}_{kg} + \text{Supplement} + \text{Season} + \text{Quantity ingested: Supplement}_{kg} + \text{Quantity ingested: Season} + \text{Supplement: Saison}\right)\right]$$

Table 2
Sum of the squared and degrees of freedom of Y2's variables.

	QI*	Suppl*	Saison	QI: Suppl	QI:Season	Suppl:Saison
Sums of squares	321439.9	218634.0	371.4	6.2	75.7	3807.1
degrees of freedom	1	3	1	1	1	2

QI: Quantity Ingested ; Suppl: Supplement

Table 3
Y2's Residues.

Sums of squared values	**12818.5**
degree of freedom	711
Standard residue error	4.246043

3. Results

3.1. Composition of the two medicinal forages

The values of Table IV showed the chemical composition of leaves of B. diffusa and K. senegalensis. Indeed the result of chemical analysis of these two forages revealed that they are rich in organic matter, dry matter, mineral matter, and in crude protein. Boerhavia diffusa's leaves are also more nutritive than Khaya segalensis's. This may be probably due to organic matter and crude protein level's with B.diffusa.

Table 4
Chemical composition and nutritive value of K. senegalensis and B. diffusa.

Parameters	**Khaya senegalensis (Neya, 2006)**	**Panicum maximum C1 (Kouakou et al. 2010)**	**Boerhavia diffusa (Daodu and Babayemi, 2009)**
DM (%Fresh Matter*)	85.9	34.6	82.6
Total ash (%DM)	17.4	9.3	17.7
OM (%MS)	80.0	90.7	80.4
Crude Protein. CP (%DM)	11.6	10.2	17.7
NDF (%DM)	43.3	32.1	38.9
Ingestibility gDM/kg P0.75*	35.9	128.9	55.3

* FM : Fresh Matter

3.2. Weight gain

In dry season, two periods were observed in the growth curve (Figure 1). The phase 1 run from the first to the 60th day. It's characterized by low weight gain of the three groups. There is a slight difference between the growths of sheep which are supplemented but those animals have higher weight than control's ones. The weight

gain was 2.87 kg for B. diffusa's sheep versus 2.21 kg and 1.03 kg for K. senegalensis's and control's sheep groups ($p< 0.01$).This performance of K. senegalensis block was probably due to the presence in their leaves of tannins.

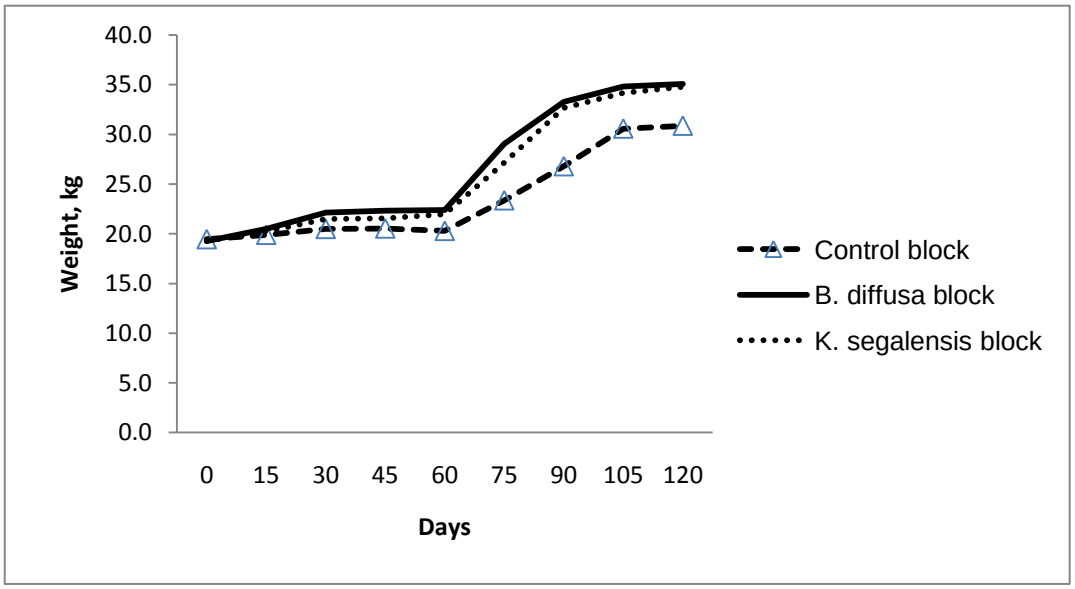

Fig. 1. Sheep's weight evolution of three experimental groups during the dry season.

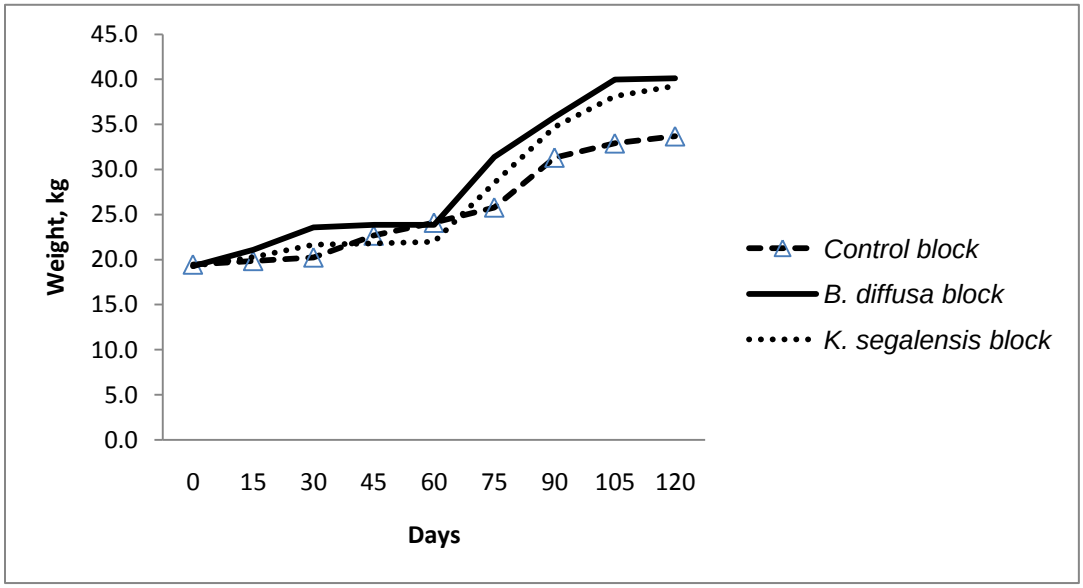

Fig. 2. Sheep's weight evolution of three experimental groups during the rainy season.

The phase 2 runs for the last sixty days. Animals' weights during this phase had remarkably increased. The average weight gain was 12.4 kg, 12.2 kg and 10.3, kg for B. diffusa's K. senegalensis's and control's block respectively ($p <0.01$). From the 105th day of experiment, it can be noticed a slowdown in the weight gain of all sets of sheep. This reflected a loss of efficiency of the dietary supplement.

Regarding the rainy season (Figure 2) we saw the same trend but with much higher body weight gains. We had also 2 phases. The first phase run from the1st to the 60th day as in the dry season case. However it should be noted that B. diffusa's animals weight were higher than those of the batch of K. senegalensis. B. diffusa supplemented animals had greater growth and were heavier than the control group ($p < 0.01$) . Control animals' average weight exceeded the Khaya senegalensis feed ones by 0.9 kg ($p < 0.01$), thus confirming the phenomenon observed during the dry season.

The second phase, from the 61th to the 120th day was marked by a stronger growth than the dry season. The average body weight gained by animals was 16.1 kg, 16.1 kg, and 8.8 kg respectively for B. diffusa, K. senegalensis and control block ($p < 0.01$). The last two weeks of the experiment all growth curves are flat. In general it appeared that during the rainy season B. diffusa and K. senegalensis supplement has strongly induced growth acceleration. Sheep supplemented with B. diffusa had the best performance with a final weight of 40.11 kg versus 39.27 kg for K. senegalensis supplemented animals and finally 33.68 kg the control ones ($p < 0.05$).

3.3. Effect of season

The average weight of the animals throughout the experiment was higher in rainy season than in the dry season (Figure 3). The average weight gained during the rainy season for comparative type of diet was higher than that of the dry season (28.07 versus 26.01 kg. $p < 0.05$). Also animals supplemented with B. diffusa were heavier than those feed with different diets (28.6 kg against 27.41 and 25.10 kg for animals in the K. senegalensis and those of the control group ($p < 0.05$). These data had confirmed the evolution of average daily gain (ADG) in both seasons (Figure 4 and 5). On the other hand Boerhavia diffusa's ingestibility during the rainy season was lower than in the dry season (0.06 against 0.03 kg DM/LW) while the average final weight of sheep of the same group

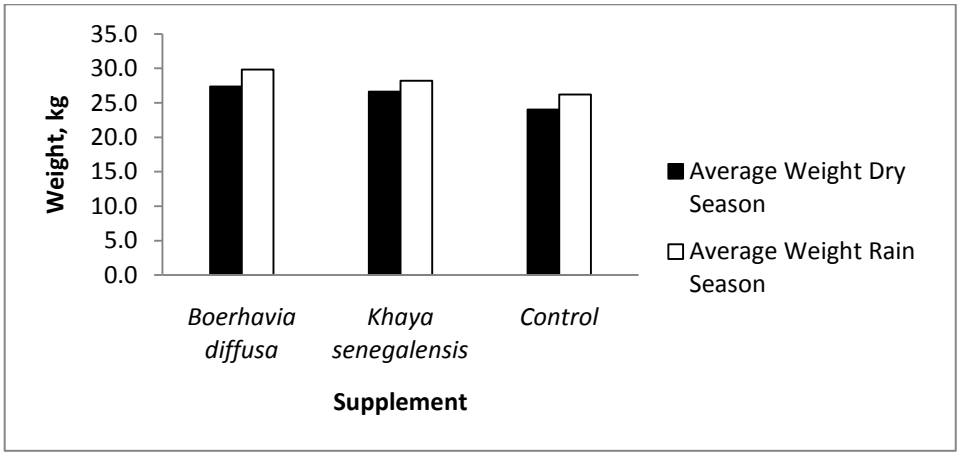

Fig. 3. Evolution of the average weight depending on the season according to the dietary supplementation.

was always higher than that of K. senegalensis fed animals and the control group ($p < 0.05$).

3.4. Evolution of ADG

During the dry season, the ADG trend follows two phases (Figure 4). Phase 1 lasted the first sixty days. It was observed a slight increase in ADG ending on the 30th day followed by a decrease. Even the control group ADG become negative towards the last fortnight of this phase. The phase 2 lasted the second sixty days. Its first part depends on the batch. It lasted only 15 days and ends on the 75th day for B. diffusa'fed sheep. Nevertheless those sheep had the higher ADG. This confirmed animals' weight gain during the dry season. For K. senegalensis fed animals, this stage lasted 30 days and ends on the 90th day. The ADG of these animals were lower than the previous ones. And finally the longest period of time was for the animals of the control group. It lasted 45 days and ended on the 105th day of the experiment. They had the lowest ADG. The duration of this first part induced a variability of the second part of ADG curve following treatments. Indeed B. diffusa supplemented animals ADG decreased for 45 days while the increase phase lasted only 15 days. The ADG of the K. senegalensis fed animals

decreased for 30 days. And finally the animals in control had the shortest duration: 15 days. During this last phase the average daily gain of the control's animals was higher than those of supplemented animals. However for the whole experiment, the overall supplemented animal weight gain was higher than that of control group.

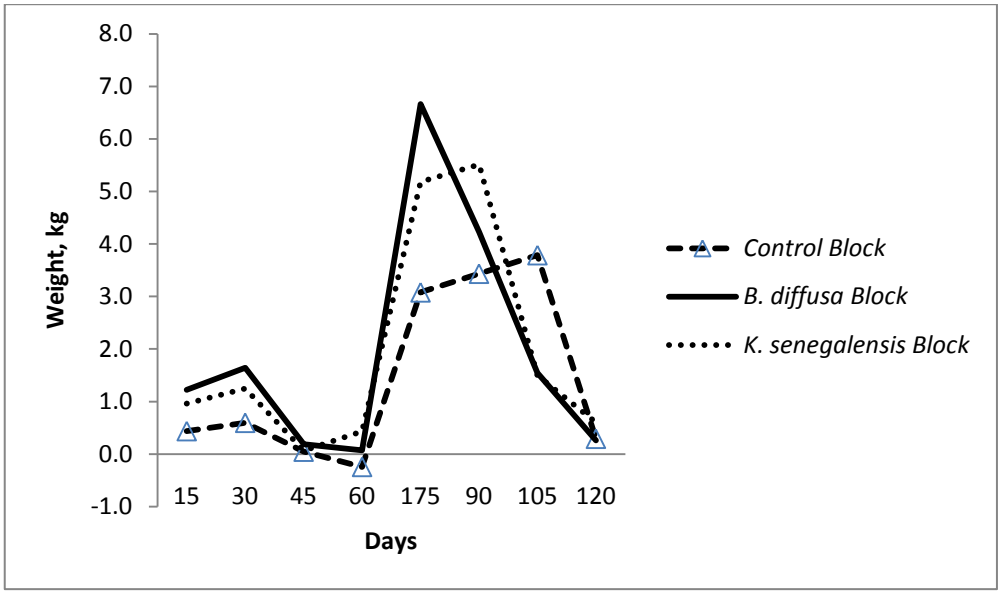

Fig. 4. Average daily gain during the dry season.

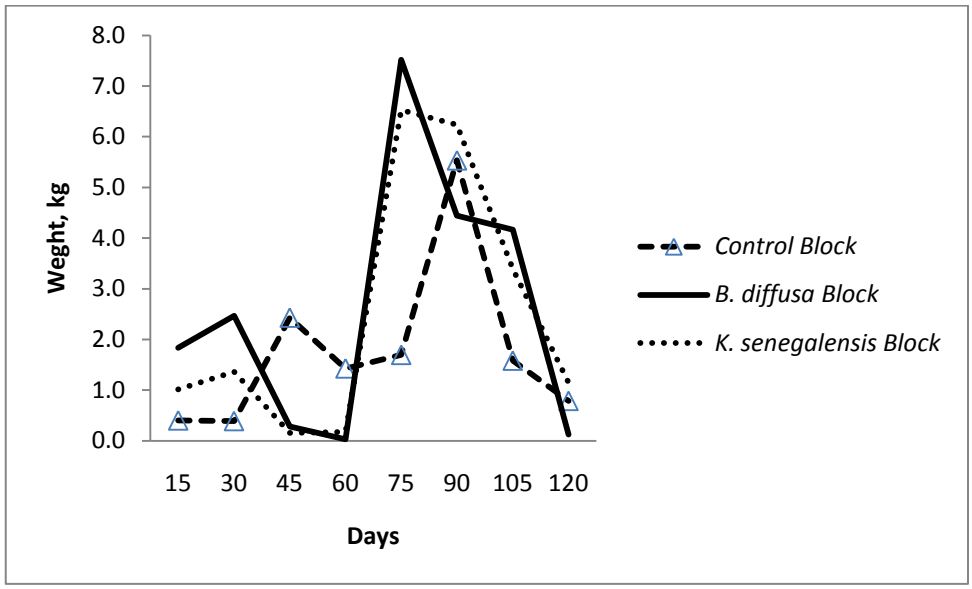

Fig. 4. Average daily gain during the rainy season.

During the rainy season, ADG trend had followed two phases (Figure 5). Phase 1 lasted the first sixty days. We had a slight increase in ADG which ended by the 30th day. From that point all ADG decreased except the control group and this contrary to the dry season period experiments. Control group ADG was the double of the ADG B. diffusa's and K. senegalensis'fed animals during the last fortnight of this phase. The phase 2 lasted the second sixty days. Its first part depended on the batch. It lasted only 15 days and ended on the 75th day for B. diffusa

supplemented sheep. Nevertheless those sheep had the higher ADG. This confirmed animals weight gain during the rainy season. For K. senegalensis supplemented sheep this stage lasted also 15 days and ended on the 75th day. The ADG of these animals were lower than those of the previous ones. And finally the longest period was for the animals of the control group. It lasted 30 days with the lowest ADG. The duration of this first part induced a variability of the second part of ADG curve following treatments. Indeed B. diffusa fed animals ADG decreased for 45 days while the increase phase lasted only 15 days. K. senegalensis supplemented animals group ADG decreased for 45 days. And finally the animals in control group had the shortest duration: 15 days. However on the whole experiment, the overallweight gain by supplemented animals was higher than that of control group.

3.5. Statistical model

To explain animal ADG we used the statistical model Y2. The analysis of variance yielded the following table:

Table 5
Analysis of variance.

	df	Sum of Squares	Mean Squares	F	Pr (>F)	
Quantity ingested	1	321440	321440	17829.17	<2e-16	***
Supplement	3	218634	72878	4042.29	<2e-16	***
Season	1	371	371	20.6	7e-06	***
Quantity ingested: Supplement	1	6	6	0.34	0.55	
Quantity ingested: Season	1	76	76	4.2	0.04	*
Supplement: Season	2	3807	1904	105.6	<2e-16	***
Residues	711	12819	18			

Signify. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

From the analysis of these data, it turns out that the differences observed for the different intakes, dietary supplement, season and the interaction between type of supplement and season were highly significant (P <0.001). The interaction between the amount ingested and the season was significant at 5% (p <0.05). On the other hand the interaction between the ingested quantity and the type of supplement was only significant at 0.1% (p> 0.05).

Table 6
Linear performance weight.

	Coefficient	Standard error	t_value	Pr(>|t|)	
Quantity ingested	4.8	0.3	17.7	<2e-16	***
Supplement: B. diffusa	18.0	0.7	27.3	<2e-16	***
Supplement: K. senegalensis	21.5	0.6	33.7	<2e-16	***
Base diet	24.0	0.4	61.9	<2e-16	***
Rainy season	3.9	0.9	4.6	0.0	***
Quantity ingested K. senegalensis	-0.1	0.5	-0.2	0.8	
Quantity ingested: Rainy Season	1.9	0.5	4.1	0.0	***
K. senegalensis: Rainy season	-12.3	0.9	-14.0	<2e-16	***
Control: Rainy season	-1.7	1.0	-1.7	0.1	
Residual error standard: 4.25 with 711 as degrees of freedom					
Multiple R2: 0.98, Adjusted R2 : 0.98					
F –statistic: 3355 with 9 and 711, p-value: < 2.2e-16					

Signify. Codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.'** 0.1 ' ' 1.

Variables that affect most the animals increase were the basic diet (24.0 %), supplements namely Khaya senegalensis (21.5 %) and Boerhavia diffusa (18.0 %). The contribution of K. senegalensis in the sheep's ADG was offset by intake's coefficient of this plant (-0.1 %) and the contribution of the intake of this supplement in the rainy

season (-12.3 %). This confirmed the decrease in the weight of K. senegalensis supplemented sheep during the phase 2 of the growth curve in both two seasons. The regression coefficient R2 of this model was 0.98. That means that 98 % percent of total weight recorded are explained by that model

4. Discussion

Weight increase is influenced by important parameters such as protein substances' digestibility, nitrogen retention and overall animal health. The presence of tannins in the leaves of Khaya senegalensis (Ketzis et al. 2006) and bioactive molecules in Boerhavia diffusa's leaves (Khan et al. 2013) could explain the absorption of amino acids and increased nitrogen retention. Also, the chemical composition of both plants shows real potential for animal nutrient. The study of the nutritional value of Khaya senegalensis and Boerhavia diffusa highlighted some characteristics of these two species. Bromatological analysis of these two forage species reveals that they are rich in dry matter, organic matter, mineral matter, metabolizable energy. They are also rich in crude protein. Boerhavia diffusa's leaves are more nutritive than Khaya segalensis's. The energy digestibility of B. diffusa which is 67.81% (Milis and Liamadis, 2007) is greater than that of K. senegalensis which is 44.58% (Kaboré-Zoungrana et al. 2008). Also, Boerhavia diffusa's leaves intake and digestibility coefficients are greater than those of Khaya senegalensis's. K. senegalensis's food value is certainly very low due to the low digestibility of organic matter and also its low nitrogen content (Kaboré-Zoungrana et al. 2008). As a matter of fact the energy level of a given food is according to its level in digestible nitrogen (Milis and Liamadis, 2007). The results of the average weight of sheep experiments show that supplement of basic diet with 800 g of green leaves of each plant regardless of the season would have led to an improvement in weight gain (Average Final Weight : 28. 6 kg for B. diffusa > 27.41 kg for K. senegalensis > 25.1 kg of control group, $p < 0.01$).

A test feed of 55 days conducted in New Zealand showed that sheep fed with plant rich in nutrients leads to an improvement in weight gain, reproduction and wool production (Min et al., 1999). The analysis of the plasma of these animals showed that those observations were due to an increase in essential amino acid. It is essential to note that in this experiment the induction of performance improvement is not related to the increase in voluntary intake, which fully justifies B. diffusa's voluntary intake in the rainy season. Indeed, during this season this supplement induces higher weight gain and lowest voluntary intake (0.03 versus 0.07 for Khaya senegalensis, $p < 0.05$). Indeed Boerhavia diffusa's herb and roots are rich in proteins and fats. The herb contains 15 amino acids, including 6 essential amino acids, while the root contains 14 amino acids, including 7 essential amino acids (Chopra and al. 1923). Also, based on the work of Ramirez-Restrepo et al. (2005) tannins would be responsible for tannins' forage performance improvement such Khaya senegalensis.

The difference in performance improvement of the two dietary supplements may be due to the difference observed in the energy digestibility (Ramirez-Restrepo and Barry, 2005). Indeed B. diffusa is richer in energy than Khaya senegalensis and the latter richer in tannins. This would explain the high weight gain induced by the first supplement and the average results of the second.

The intake of the two species B. diffusa and K. senegalensis obtained in our experiment during the dry season as in the rainy season (0.06 and 0.03 kgDM/LW respectively for B. diffusa and K. senegalensis in the dry season and 0.03 and 0.07 kgDM/LW respectively for B. diffusa and K. senegalensis in the rainy season), is consistent with the daily intake of dry matter (1.25 kg DM / d) conventionally accepted for tropical sheep maintenance but slightly lower than intake obtained by Babatoundé et al. (2008) in studying the eating habits and weight changes of sheep Djallonké grazing on forages grown in mixture (Andropogon gayanus + Aeschynomene histrix and Panicum maximum var. C1 + Aeschynomene histrix) which is 55 gDM / LW.

Whatever the season experiment, ADG of control group is always lower than supplemented animals (14.3 in the control group versus 19.8 and 19.4 g/day in the dry season for B. diffusa and Khaya senegalensis's sheep. respectively ($p < 0.01$) and 17.78 versus 26.10 and 25.0 g/day during the rainy season for B. diffusa and Khaya senegalensis's sheep respectively ($p < 0.01$)). The live weight gain would be explained by the supplying of bio active molecule and nitrogen's matter (Karigar et al., 2010; Khan et al., 2013) appropriate for biological process and metabolic functioning. ADG obtained with animals supplemented during the dry season are higher than average ADG reported by Gbangboché et al. (2002) for the traditional sheep farming (12 g/day). However they are less than Ouedraogo's ADG (2006) obtained with Sahelian sheep which is 25 g/day. Our experiment's ADG are also lower than those of Kaboré-Zoungrana et al. (2008) which are 116 g/day with Sahelian sheep feed with leaves of Balanites aegyptiaca associated with Pennisetum pedicellatum in the proportions 60/40 for 8 weeks.

5. Conclusion

The overall results of our study showed that in dry season, supplementing sheep's diet with leaves of K. senegalensis and B. diffusa significantly improves their weight gain. Meanwhile, B. diffusa effects on sheep weight gain are more prominent than those of K. senegalensis. However, during the rainy season, as though supplement with green leaves of B. diffusa is the most effective, voluntary intake of this plant is down by half compared to the one in dry season and is lower than K. senegalensis's intake.

If the mechanism of the actions of these plants in the process of weight gain is well established, it could contribute to standardizing the organic biological technique pertaining to weight increase in sheep.

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