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Comparative nutritional evaluation of the two leguminous fodder trees *Prosopis africana* and *Piliostigma thonningii*: effects of different levels of pod-based supplementation on the growth performance of Djallonke sheep

Souleymane OUEDRAOGO[1], Lassina SANOU[2*], Patrice SAVADOGO[3] and Chantal Yvette KABORE-ZOUNGRANA[4]

[1]*Centre National de la Recherche Scientifique et Technologique, INERA, Département Gestion des Ressources Naturelles et Systèmes de Production (GRN/SP), 03 BP 7047, Ouagadougou 03, Burkina Faso.*
[2]*Centre National de la Recherche Scientifique et Technologique, INERA, Département Environnement et Forêts, 03 BP 7047, Ouagadougou 03, Burkina Faso.*
[3]*World Agroforestry (ICRAF), West and Central Africa Regional Office - Sahel Node, BP E5118, Bamako, Mali.*
[4]*Université Nazi Boni, Institut du Développement Rural, BP 1091 Bobo-Dioulasso, Burkina Faso.*
[*] *Corresponding author; E-mail: lassina.sanoulassina@gmail.com*
Tel: +22676072265 or +22672120964

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ABSTRACT

The study aims to provide information on the nutritional value of the pods of the two important fodder species *Piliostigma thonningii* and *Prosopis africana* and their effects, when used as a supplementary feed, on the growth performance of Djallonke sheep. Crushed pods were used as a dietary supplement for growing Djallonke sheep. Comparisons were undertaken on the nutritional values of both fodder species (used as staple foods) and cotton cake, groundnut crop residues, farina of *Mucuna deeringiana* and hay of *Pennisetum pedicellatum*. The results indicated that the pods of the two ligneous plants *P. africana* and *P. thonningii* have a higher content of crude protein compared to compared to the hay of *P. pedicellatum* (12.23% and 18.82%, respectively). The wall content of pods of *P. thonningii* (55.65% NDF, 39.36% ADF and 34.76% ADL) were higher than those of *P. africana* (42.27%, 31.09% and 27.34%, respectively). The average daily gains (ADGs) in growing animals were 78 g, 61 g and 56 g for animals supplemented with farina of *M. deeringiana*, pods of *P. thonningii* and cotton cake, respectively. During the fattening phase of the study, the ADGs were 97 g and 79 g for animals receiving cotton cake and *M. deeringiana* seed meal, respectively. Supplementing feed with pods of *P. thonningii* resulted in increasing growth after 63 days, relative to the other fodders. However, other investigations should be continued to determine the nature and content of tannins that seem to limit the valorization of pods of fodder tree species.

Keywords: Digestibility, feed intake, fodder tree, livestock, nutritive value, Djallonke sheep.

INTRODUCTION

Forest resources play an important role in improving the livelihoods of many people throughout the world. Forests are considered by these people as their granary, pharmacy, pasture and places of religious worship. Indeed, forests are literally supermarkets for millions of people in developing countries

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through the goods and services that they offer (Bognounou et al., 2013; Sanou et al., 2017; Traoré et al., 2011). Among the goods and services provided by forest resources, fodder for animals is considerable in terms of its contribution to reducing costs related to livestock feeding (Larwanou et al., 2010). Many pastoralists are poor and cannot purchase agro-industrial products such as oilcakes of peanut forage and cotton (Ouédraogo et al., 2019; Shelton, 2000). Fodder trees are therefore often used and sought after by pastoralists for livestock. Globally, livestock production systems in semi-arid ecosystems are mainly based on the exploitation of natural pastures characterized by the co-existence of annual grasses, few perennial herbaceous species and scattered fodder tree species (Sanou, 2012; Sanou et al. 2022). The lack of perennial grasses in semi-arid ecosystems as a source of feed is a serious challenge to livestock farming, thus threatening the livelihoods of millions of people (Kassahun et al., 2009). In recent decades, many semi-arid and arid regions of the world including West Africa have experienced high annual and spatial rainfall variability that has negatively affected local livestock production systems due to water insecurity, disease prevalence and low quality of forage (Rojas-Downing et al., 2017). Generally, semi-arid grazing lands often occupy marginal land that is unsuitable for crop production due to the constraints imposed by soil physical and chemical properties, topography (including slopes and waterlogging) and climatic conditions (Rao et al., 2015).

During the dry season, pastures offer grazing animals only low-palatable straws that are sometimes available in insufficient quantities. Fortunately, browse plants can fill the gap as they are characterized by new foliage during this season, with young regrowth and buds and/or flowering and fruiting. Forage trees are one form of browse plant that can supply foliage during dry periods when herbaceous vegetation is senescent and cereal residues are of poor digestibility and low nutritive value. They provide forage that is more palatable and richer in protein, vitamins and minerals, and therefore able to improve livestock diets. Thus, the use of fodder tree species as a supplementary feed source during the dry season is often the only option for poor pastoralists (Ouédraogo-Koné et al., 2009; Shelton, 2000).

Forage trees have high nutritive value for ruminants in terms of their concentration of crude protein (CP) and energy (Lüscher et al., 2014). Feeding foliage from trees, as a supplement or as a sole source of feed, generally results in improved production and health of ruminant animals. Among the woody species that serve as a source of protein supplement for livestock, leguminous trees are often the only option for improving forage diets in arid and semi-arid regions. Tree legumes are a good source of high-quality, protein-rich forage for subsistence and commercial livestock production. Leguminous families contain many highly palatable fodder species such as *Piliostigma thonningii* (DC.) Hochst and *Prosopis africana* (Guill., Perrott. & Rich.) Taub that are dominant in pastures, farmlands and fallows of the semi-arid zone of Burkina Faso in West Africa (Yaméogo et al., 2005). The pods of the woody fodder species *P. thonningii* and *P. africana* are an important source of feed for ruminants grazing in the natural pastures of Burkina Faso. The sale of these species' pods in the country's peri-urban and urban areas also provide substantial income for rural households (Ysuf et al., 2008).

Piliostigma thonningii (Fabaceae-Caesalpinioideae) is a Sahelo-sudanian and Sudanian species that occurs across Africa from Senegal to Mauritania to Sudan. It is a small tree (8–9 m) with an open crown. The leaves are drooping, alternate and conspicuously bi-lobed. The petioles are 1–3.5 cm long and swollen at both ends. The leaf blades are 5–12 cm × 4–18 cm, cordate or rounded at the base, with lobes that are rounded or more or less cuneate, coriaceous, glabrous, greyish-green, and palmately veined with 8–11 basal veins. The species' fruit is an oblong pod 15–30 cm × 2.5–5 cm, straight, undulate or twisted, and many-seeded.

Prosopis africana (Fabaceae–Mimosoideae) is the only native *Prosopis* in Africa, occurring from Senegal to Ethiopia throughout the Sudanian and Guinean ecozones (Bognounou et al., 2013). It is important species for farming and pastoralist communities in the West African Sahel, providing a range of essential products such as wood, fuel, food, fodder and medicines (Weber et al., 2008). *Prosopis africana* is a small to large tree (4–20 m) with an open crown and slightly rounded buttress roots (Laoualia et al., 2014). The leaves are drooping, alternate and bipinnate, with rachis that are 10–15 cm long with 3–6 pairs of opposite pinnae (5–8 cm long); and 9–16 pairs of leaflets that are oblong-lanceolate, 12–30 mm and pubescent. The leaves typically have a gland between pairs of pinnae and leaflets. The calyxes are pubescent, but the petals are glabrous. There are 10 free-standing stamens. The anthers have a small apical gland. The pods are dark brown, cylindrical, thick and hard, shiny, up to 15 × 3 cm, with woody walls that are compartmented; about 10 loose, rattling seeds per pod with a thin, inter-marginal line around the seed (Arbonnier, 2009; Bognounou et al., 2013).

The raising of Djallonke sheep is widespread among rural households in Burkina Faso and these sheep are typically subjected to fattening for market supply. For this fattening process, pastoralists often use supplementary feeds based on agro-industrial products, but the use of these products increases the cost of production and reduces the pastoralist's profit margin. Research investigating cheap, practical and readily-available dry season supplemental feed options for small ruminants like Djallonke sheep is therefore important. Thus, the objectives of this study were to (i) evaluate the nutritional value (chemical composition and digestibility) of the pods of *P. thonningii* and *P. africana*; and (ii) evaluate the effects of different levels of *P. thonningii* and *P. africana* pod-based diets on the growth performance and feed utilization of Djallonke sheep. The findings highlight the value of both of these fodder species' pods as a supplemental feed for pastoralists in arid and semi-arid regions of West Africa. It is hoped this information will encourage the two species' increased cultivation on farms and their conservation through avoided overharvesting in the natural pastures of these regions.

MATERIALS AND METHODS

Study area

The study was carried out in Gampela, Kadiogo Province (12° 25'N; 1°21'W, Figure 1) of Burkina Faso, which is situated in the country's Soudano-Sahelian zone (Fontès and Guinko, 1995). The climate is characterized by two distinct seasons: a dry season from October to May (8 months) and a rainy season from June to September (4 months). The mean (± SE) annual rainfall during the last decade was 712 ±166 mm and the number of rainy days per annum was 22 ±3. Mean daily minimum and maximum temperatures are 22°C and 35°C in January (the coldest month), and 28°C and 42°C in April (the hottest month). Rainfall is variable, both temporally and spatially. The soil at Gampela is classified as a Gleyic-Luvisol and forms structural crusts that restrict infiltration and thus increase runoff (Kagambèga et al., 2011). The rainfall variability and the nature of the soil impact considerably on both herbaceous and fodder species production, and consequently on the efficiency of livestock feeding based only on natural pastures.

The vegetation type at Gampela is characterized by the co-existence of scattered trees and shrubs with a continuous grass layer. The dominant tree species are: *Acacia macrostachya*, *A. nilotica*, *Piliostigma reticulatum*, *P. thonningii*, *Combretum glutinosum*, *C. micranthum*, *C. nigricans*, *P. africana*, *Pteleopsis suberosa*, *Vitellaria paradoxa* and *Ziziphus mauritiana*. The dominant herbaceous species are *Loudetia togoensis*, *Microchloa indica*, *Tripogon minimus*, *Zornia glochidiata*, *Aristida kerstingii*, *Sida alba*, *S. rhombifolia* and

Waltheria indica. Aside from agriculture, which is the occupation of 80% of the area's active population, livestock breeding is the next most important activity for household income generation. At Gampela, two experimental trials (a growth trial and a fattening trial of Djallonke sheep) were conducted using the pods of the fodder tree species *P. thonningii* and *P. africana* as staple foods. These pods were collected in the natural pastures and transported to the Gampela research station of Nazi Boni University hosting the Animal Nutrition Laboratory where the trials were conducted.

Growth trial of Djallonke sheep

A growth trial was conducted involving a total of 29 Djallonke sheep aged 12-18 months that were purchased at a local livestock market. This breed is characterized by a small size, with a live weight varying between 25 and 30 kg for males and 20-25 kg for females. The breed is also adapted to the unfavorable climatic conditions of semi-arid zones (Soubeiga, 2000). Before the growth trial, the sheep were dewormed with Synanthic (internal deworming) and then received an injection of the antibiotic Oxytetracycline 6% to prevent any incubation of diseases during the experiment. After this step, all animals were weighed. The average weights were 21.98 ± 2.36 kg for the animals subject to the *P. thonningii* trial and 14.2 ± 1.3 kg for the animals subject to the *P. africana* trial. For the *P. thonningii* trial, the animals were divided into three lots (Lot 1: 6 animals, Lot 2: 6 animals and Lot 3: 5 animals) and those used for the *P. africana* trial were divided in two lots (Lot 1: 6 animals, Lot 2: 6 animals). For feeding, the animals were grazed for 5 h/day. The dietary supplement was provided to the animals when they returned from the pasture. The supplement amounts were as follows: Lot 1: 400 g of *P. thonningii*/animal/day, Lot 2: 200 g of seed meal of *Mucuna deeringiana*/animal/day, Lot 3: 100 g of cotton seed cake/animal/day (Table 1). These supplements corresponded to 50%, 25% and 13% of the animal's total DM requirements for Lots 1, 2 and 3, respectively. The mineral supply was permanently assured in the sheepfold in the form of a lick stone and the animals also had access to water at will.

To facilitate the distribution of supplements, digestibility cages were used. For the *P. africana* trial, eleven sheep of the same breed were selected. They were divided into two lots, one consisting of five animals fed exclusively on natural pasture (Lot 1) and one consisting of six animals fed on the dietary supplement provided to the animals when they returned from the pasture (Lot 2). The grazing time was also 5 hours/day. The dietary supplement consisted only of crushed pods of *P. africana*. The crushed pods were accessible at will, with a daily adjustment of the rate of refusal between 10 to 15%. Refusals were removed from feeders every morning and weighed to determine the amount of food ingested, calculated using the following equation: $Qi = Qd - Qr$, where Qd and Qr represented the distributed quantities and the refused quantities, respectively. This allowed for the determination of the consumption index (IC). The IC is the ratio of the amount of food ingested (Qi) to weight gain (WG). It reflects the efficiency of the feed valuation by the animals. A low IC value indicates that the feed is well valued by the animals. It reflects the amount of complementary feed (in kg) used to produce one kilogram of growth, and the amount of pasture that has not been evaluated. Thus, it facilitates calculation of the cost of the weight gain of the ration. It is calculated as follows: $IC = \frac{Qi(kg)}{GP(kg)}$ where GP = weight gain. The monitored parameters during this phase were the weight change (weekly weighing) at the beginning and at the end of the trial to assess the sheep's weight change/variation (increasing or decreasing).

Fattening trial of Djallonke sheep

The fattening trial only experimented with the utilization of *P. thonningii* pods because the remaining quantity of the pods and seeds of *P. africana* following completion of the growth trial were heavily infested with insects and were thus unsuitable for conducting the trial. Food rations used for the fattening trial were cotton cake, crushed pods of *P. thonningii*, peanut leaves and seed meal of *M. deeringiana* in different proportions, as shown in Table 2. The combination of foods was to compare the effect of the protein sources of the pods of *P. thonningii* with that of the cotton seed cake and the seed meal of *M. deeringiana* on the fattening of Djallonke sheep. The animals were divided into two lots: one set of eight animals and another set of nine animals. The daily rationing and supply levels of the pods of *P. thonningii* were progressively corrected based on the ingested quantities to keep a total refusal rate of rations between 5% and 15%. On the other hand, the quantities of peanut leaves, the seed meal of *M. deeringiana* and cotton seed cake remained constant. The mineral supply was permanently assured in the sheepfold in the form of a lick stone and the animals also had access to water at will. The formulation of rations was based on the methodology of concentrated feeds because of the richness of ligneous fodder in crude protein (CP) and their relatively low level of intake; which would avoid digestive interactions. The rations were assigned to the animal lots on the basis of 50 g DM/kg $P^{0.75}$ and in two meals separated by 7 hours (8 h and 15 h). These rations would cover the maintenance needs of the animals and support a small amount of production as follows: Lot 1 fed with ration 1 and Lot 2 fed with ration 2 (Table 2).

During the fattening trial, the animals were kept in individual metabolism cages equipped with a feeder, a drinking trough and licking stone (mineral supplement). This allowed for measurement of the exact amounts of offered and refused food as well as excreted faeces. They were subjected to fourteen days (pre-experimental adaptation period) on rations and in metabolism cages. The animals were weighed at the beginning and at the end of each phase to assess their weight variation and determine the readjusted quantities of rations to be distributed. The refusals were removed from the feeders every morning and weighed and accumulated per animal. Faeces were harvested every morning and weighed per animal before distribution of the day's ration.

Bromatological analysis

The bromatological value or chemical composition of a feed is an important parameter in the assessment of its quality. Samples of the different feeds used during the sheep fattening and growth trials (pods of *P. thonningii* and *P. africana*, seed meal of *M. deeringiana*, peanut leaves, cotton seed cakes, hay of *P. pedicellatum*) were analyzed at the above-noted Gampela Animal Nutrition Laboratory Samples of those feeds were taken, dried, crushed and analyzed for the following components: dry matter (DM) by drying at 105°C in an oven for 24 h; total mineral material (MM) or ash by calcination of the DM in a muffle furnace at 550˚C for 3 h; organic matter (OM) by calculating the difference between DM and MM (Vaieretti et al., 2007); and the neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) (Van Soest et al., 1991). This method allows for isolation of the components of the cell walls. The crude protein content (CP) was determined by analyzing the total nitrogen content according to Kjeldahl (1883), then multiplying by 6.25.

Data collection and statistical analyses

The animals were weighed at their entrance to and exit from the cages. Also, weekly weightings were conducted to assess the average daily gain (ADG) of each lot. The quantities of DM offered, ingested and refused were measured daily. At the end of the trial, a sample of the feed offered and their refusals were taken for the bromatological analyses (MM, CP, NDF, ADF and ADL). Statistical analyses included analysis of variance followed by mean separation using SAS software.

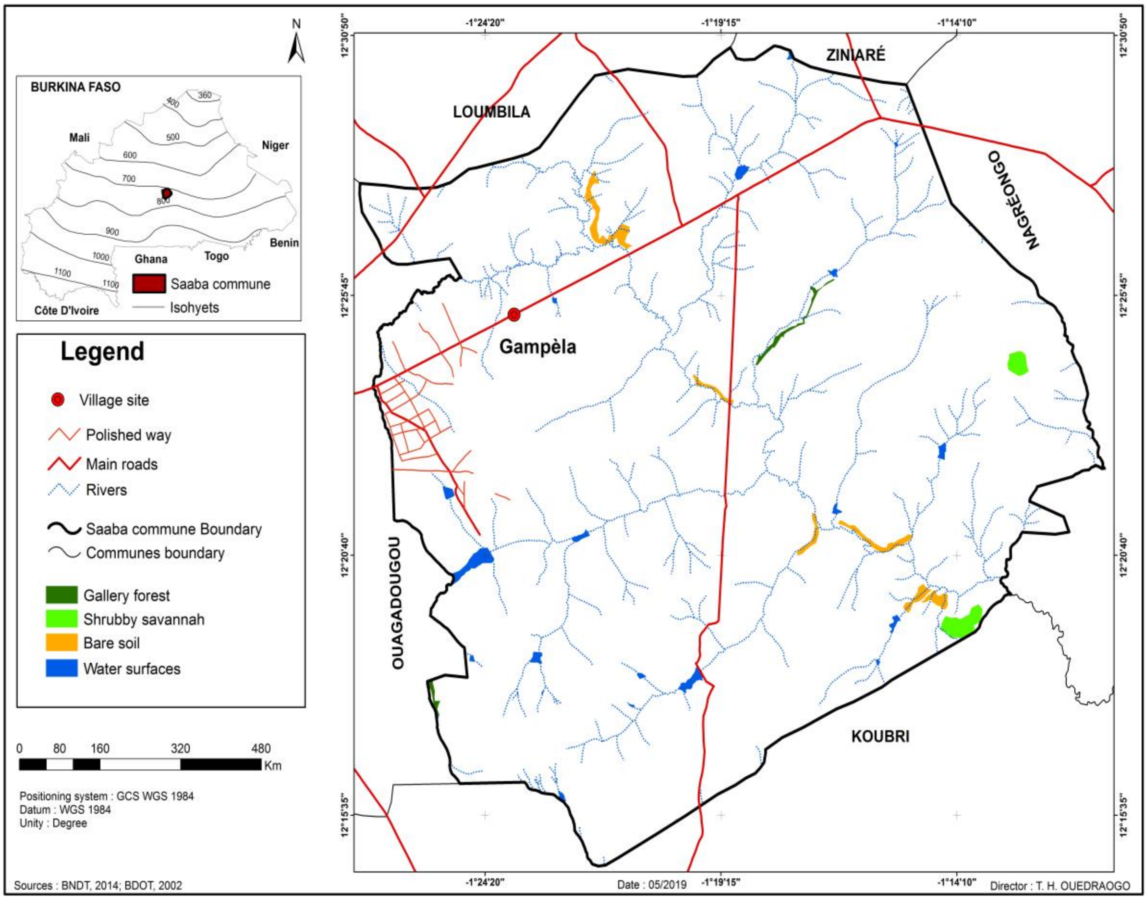

Figure 1: Location of study site.

Table 1: Composition of rations in grams of DM (*P. thonningii*) and percentage (*P. africana*) per animal per day during the growth trial.

Parameters	***P. thonningii***			***P. africana***	
	Lot 1	**Lot 2**	**Lot 3**	**Lot 1**	**Lot 2**
Number of animals	6	6	5	6	6
Pods of *P. thonningii*	400	-	-		
Seed meal of *M. deeringiana*	-	200	-		
Cotton seed cakes	-	-	100		
Pods of *P. africana*				10%	15%
Hay of *P. pedicellatum*				40%	60%
Duration in natural pastures	5 h	5 h	5 h	5 h	5 h
Distribution of water and lick stone	at will	at will	at will	at will	at will

-Signifies that the concerning parameter is not distributed

Table 2: Composition of rations in grams of DM (*P. thonningii*) per animal per day during the fattening trial.

Rations/Lot	Lot 1 (ration 1)	Lot 2 (ration 2)
Number of animals	8	9
Mean live weight (kg)	30.58 ± 0.19	30.27 ± 1.21
Pods of *P. thonningii*	500	500
Peanut leaves	250	250
Cotton seed cakes	200	100
Seed meal of *Mucuna*	200	400
Lick stone	at will	at will
Water	at will	at will
Total (g)	1150	1250
Quantity (g) in % live weight	3.51	3.82

RESULTS

Chemical composition of the distributed feed

The amounts of DM, OM, MM, CP, NDF, ADF and ADL of the distributed feeds are shown in Table 3. The MM and OM content of the pods of the two species are similar, while pods of *P. thonningii* have higher contents of CP (18.82%), NDF (55.65%), ADF (39.36%) and ADL (34.76%) than those of *P. africana* (12.23%; 42.77%; 31.09% and 27.64%, respectively). The pods of *P. africana* are richer in OM and CP than the hay of *P. pedicellatum* harvested at the heading stage (August-September). The contents are 93.36% (OM) and 12.23% (CP) for the pods against 84.38% (OM) and 7.94% (CP) for the hay of *P. pedicellatum* (Table 3). We found that 69.63% and 45.16%) as the contents of contents of the *P. pedicellatum* hay for NDF and ADF, respectively. The contents of 45.89% NDF, 35.91% ADF and 31.66% ADL in the pods of *P. africana* were inferior to those of the pods of *P. thonningii* (57.1% NDF, 46.26% ADF and 33.81% ADL). These values show that the pods of *P. africana* were less lignified than those of *P. thonningii*. The levels of NDF (69.63%), ADF (45.16%) and ADL (39.42%) in the hay of *P. pedicellatum* were higher than those of the pods of *P. africana*. For the *P. africana* pods, the values were 45.89%, 35.91% and 31.66% for NDF, ADF and ADL, respectively. The high ADL content (39.42%) of the hay of *P. pedicellatum* compared to the *P. africana* pods (31.66%) was contradictory to the idea that fodder from ligneous trees is more lignified than herbaceous plants. Table 6 shows that the CP contents of the refused matter are lower than those of the distributed feeds, being 5.79% and 9.36%, compared to 12.23% and 7.94% for the pods of *P. africana* and the hay of *P. pedicellatum*, respectively. Unlike CP, the wall contents (NDF, ADF and ADL) of refusals were higher than those of the distributed feeds. The respective wall content values were 49.42%, 37.72% and 33.43% for refusals against 45.89%, 35.91% and 31.66% for distributed feed for *P. africana*, and 77.07%, 51.10% and 45.02% for refusals against 69.63%, 45.16% and 39.42% for distributed feed for *P. pedicellatum*.

Dry matter intake of the distributed feed

The pods of *P. thonningii* were initially distributed at 500 g/animal/day. This distributed quantity evolved to 1050 g/animal/day for Lot 1 and 902 g/animal/day for Lot 2, corresponding to 1006.11 and 817.80 g of DM per day, respectively, after adjustment (5% to 15% refusal daily) (Table 4). The quantities of DM distributed in Lot 1 were greater than those of Lot 2 (1624.32 g against 1577 g). Depending on the metabolic weight, these quantities were comparable. The amounts of OM distributed and NDF distributed to Lot 1 were slightly higher than those of Lot 2. In contrast, the amounts of CP distributed were almost identical: 235.57 g for Lot 1 and 240.28 g for Lot 2. The refusals consisted solely of *P. thonningii* and amounted to 8.83% and 15% DM for Lot 1 and Lot 2, respectively. The quantities of DM ingested for both lots were significantly different at the 5% level. Ingestion was 1486.81 g DM/head/day for Lot 1 and 1121.42 g DM/head/day for Lot 2. The average consumptions were expressed in kilograms of metabolic weight. They were 103.97 g of DM/kg$^{0.75}$ and 80.68 g of DM/kg$^{0.75}$ for Lots 1 and 2, respectively. The amount of total nitrogen ingested material (TNIM) was 398.65 g and 352.58 g for Lot 1 and Lot 2, respectively.

Weight change of growing animals

Figures 2 & 3 show the weight performances recorded in the animals from the three lots during the growth phase (Lot 1: 400 g/*P. thonningii*/animal/day, Lot 2: 200 g/seed meal of *M. deeringiana*/animal/day, Lot 3: 100 g/cotton cake/animal/day). There were two phases in the weight evolution of the animals. The first phase was a slow weight gain by the animals from the three lots during the first five weeks, followed by a slight decrease in weight in the 5th week. At this time, it was found that the weight gain by animals in the lot 1 receiving the pods of *P. thonningii*, which had an initial average weight slightly higher than that of the animals in Lot 2, was matched by the latter as early as the second week. The second phase was a linear (increasing) trend from the sixth week. In general, all animals in all lots gained weight during the experiment. The weight changes in animals and mean live weight gains (kg) and average daily gains (ADG) are shown in Table 5. For the duration of the growth phase, the average gain in live weight was 9 kg, 11.4 kg and 8.3 kg per animal for the animals in lots 1, 2 and 3, respectively, after 147 days of supplementation. The ADGs averaged 61.2 g, 77.8 g and 56.2 g for lots 1, 2 and 3, respectively. The analysis of variance showed that the ADGs in Lot 2 were high than those of lots 1 and 3 ($P < 0.05$). The ADGs of Lot 1 were comparable to those of Lot 3. The ADGs of Lot 1 (61.2±13.15), consisting of animals supplemented with 400 g *P. thonningii*/day/animal. To better appreciate the effect of the study period on animal growth, ADGs were calculated per one-month period (Figure 2). Analysis of the evolution of the ADGs per month showed an increasing evolution of the ADGs from the first month to the fourth month, where we noted the highest ADG for all three lots. Beyond these periods, the ADG values decreased. The lot 2 that ingested the seed meal of *M. deeringiana* had the highest ADGs during the 21-week period. Throughout the trial period, the lowest ADGs for the three lots were recorded during the first month (August 27 to October 1). This could be explained by the fact that at this time, the animals were not used to the distributed feed. The highest ADGs were observed in November-December. These results are explained by the fact that in September-October, there is an early maturation of annual grasses, which constitute the majority of natural pasture species, leading to a fall in the OM content and digestible nitrogenous matter. However, in November-December, the animals grazed on crop residues on the farmland.

In sum, the ADGs were interesting for all the lots. The supplementation helps avoid weight loss, as seen in animals grazing on natural pastures only, and supports the fattening of animals to a good size and shape in a short time. Figure 4 illustrates the weight change in the lot 1 which animals received the pods of *P. africana* compared to a control lot. The curves show two phases of weight evolution in the animals: a growth phase during the first two weeks for both lots of animals, followed by a weight loss at the third week in each lot; and a slight weight gain is then observed in animals fed the supplementary *P. africana* pods, while those in the control group continued to lose weight. These results could be explained by the low nutritional value of pastures during the period from March to May (dry season). At this time, pastures are strongly dominated by woody species, from which only a small part of the available forage is directly accessible to small ruminants, particularly sheep. Thus, the dietary needs of animals fed solely on natural pasture are difficult to cover, and without supplementation these animals will suffer from weight loss. In nine weeks (63 days), the control group lost 0.3 kg, a negative ADG of -4.8 g, while the feed supplementation lot (lot 1) gained 1.8 kg with an ADG of 28.6 g (Table 5). Indeed, the chemical analysis revealed that our supplementary feed contains 94.80% DM of OM and 8.81% DM of CP, while cottonseed cake, for example, contains 94.98% DM of OM and 29.69% DM of CP.

Table 3: Chemical composition of pods of *P. africana* and *P. thonningii* and hay of *P. pedicellatum* (in % DM).

Components	**Chemical constituants**						
	DM	**MM**	**OM**	**CP**	**NDF**	**ADF**	**ADL**
Pods of *P. africana*	94.54	6.64	93.36	12.23	42.77	31.09	27.34
Pods of *P. thonningii*	95.21	6.68	93.32	18.82	55.65	39.36	34.76
Hay of *P. pedicellatum*	95.17	15.62	84.38	7.94	69.63	45.16	39.42

DM = Dry matter, MM = Mineral materials, OM = Organic matter, CP = Crude protein
NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent lignin

Table 4: Nutrient composition of distributed feed during the fattening trial (g DM/animal/day).

Feed	***Lot 1***				***Lot 2***			
	DM	**OM**	**CP**	**NDF**	**DM**	**OM**	**CP**	**NDF**
Pods of *P. thonningii*	1006.11	951.98	95.68	613.73	864.30	817.80	82.19	527.22
Peanut forage	229.47	209.29	34.47	96.29	229.47	209.29	34.47	96.29
M. deeringiana	192.86	184.78	47.27	26.02	385.73	369.56	94.54	52.04
Cotton seed cakes	195.87	186.03	58.16	98.91	97.94	93.02	29.08	49.46

DM = Dry matter, OM = Organic matter, CP = Crude protein, NDF = Neutral detergent fiber

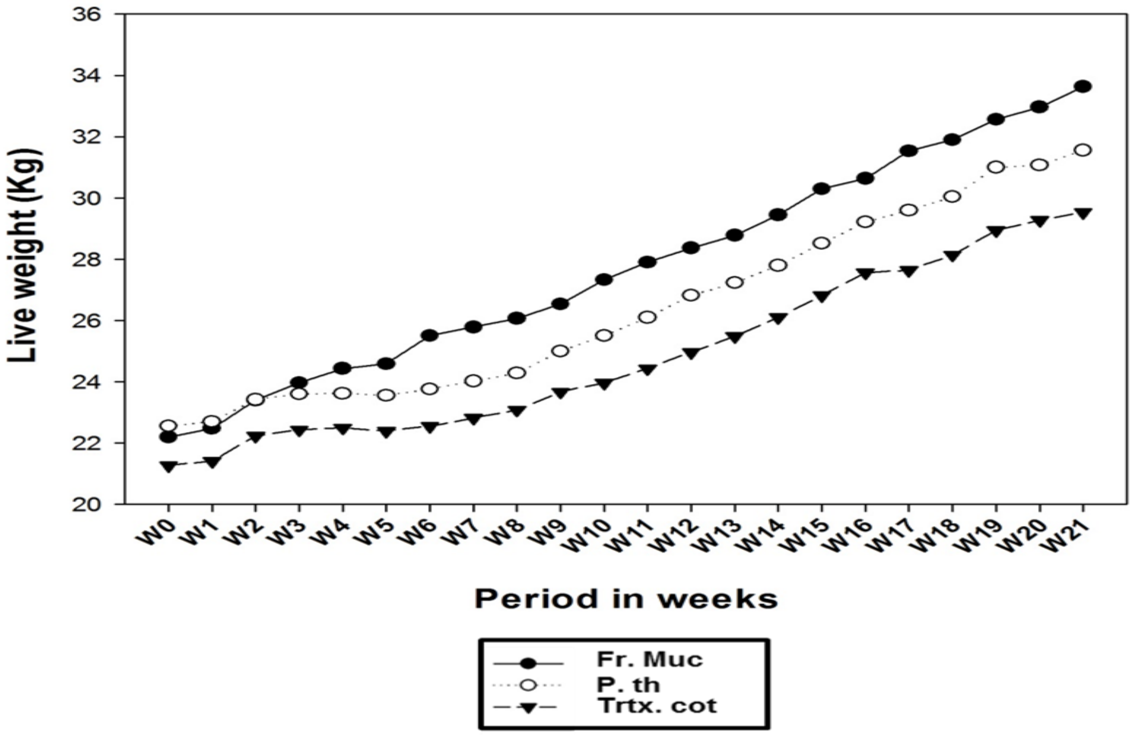

Figure 2: Weight change of animals supplemented with the pods of *P. thonningii* (P.th), farina of *M. deeringiana* (Fr. Muc) and cotton seed cakes (Trtx Cot).

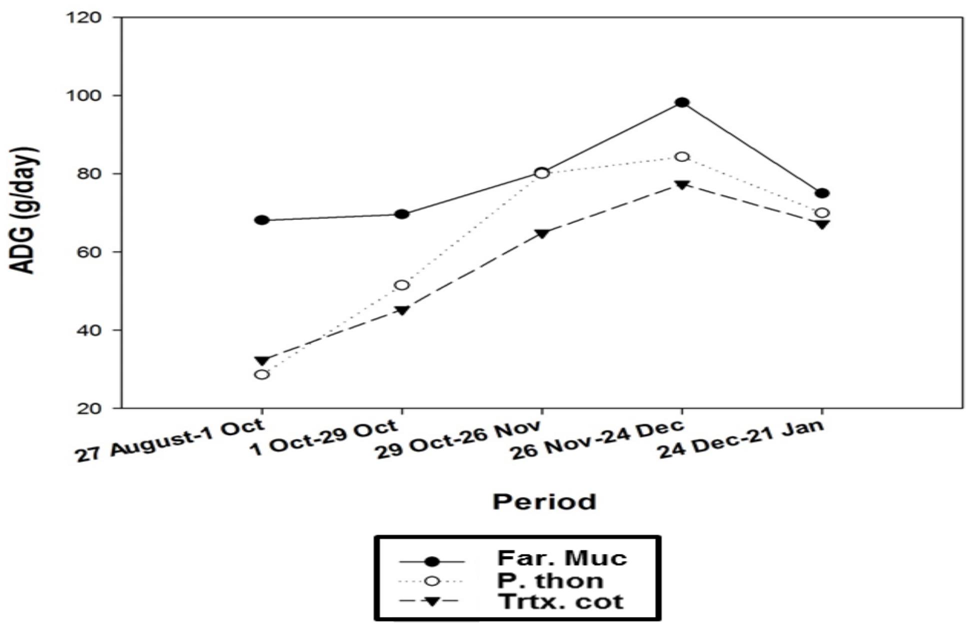

Figure 3: Evolution of average daily weight gain of growing animals.

Table 5: Weight characteristics of growing animals.

Parameters	*P. thonningii*			*P. africana*	
	Lot 1 (pods of *P. thonningii)*	Lot 2 (farina of *Mucuna)*	Lot 3 (cotton cake)	Diet 1	Diet 2
Initial weight (kg)	22.6±2.40a	22.2±2.40a	21.3±2.60a	14.10±2a	14.2±1.30a
Final weight (kg)	31.6±1.60a	33.6±2.30a	29.5±2.40a	13.80a	16±1.14a
Live Weight Gain (kg)	9	11.40	8.30	-0.30	1.80
ADG (g)	61.2±13.15b	77.8±7.83a	56.2±9.35b	-4.80±7.34ab	28.6±4.73a

ADG = average daily gain. For each parameter, the means with the different letters are significantly ($P<0.05$) different based on Tukey's HSD test.

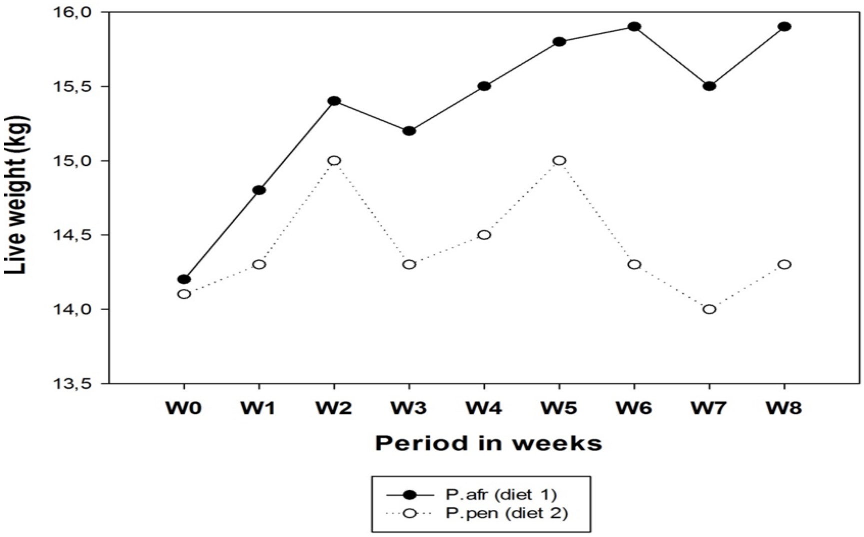

Figure 4: Weight evolution of animals fed with *P. africana* and *P. pedicellatum.*

Table 6: Chemical composition of the distributed, refused and ingested rations (grams of DM/animal/ day and grams/kgP$^{0.75}$/ day).

Feed parameters	Lot 1				Lot 2			
	DM	OM	CP	NDF	DM	OM	CP	NDF
Distributed (g DM)	1624.32	1532.08	235.57	834.96	1577.43	1489.66	240.28	725.01
Distributed (g/kgP$^{0.75}$)	113.59	107.14	16.47	58.39	113.48	107.17	17.29	52.16
Refused	143.51	135.78	13.65	87.54	236.42	223.7	22.48	144.22
Refused (%)	8.83	8.86	5.79	10.48	14.99	15.02	9.36	19.89
Ingested (g DM)	1486.81[a]	1401.97	398.65	751.08	1121.42[b]	1066.02	352.58	490.53
Ingested (g/kgP$^{0.75}$)	103.97	98.04	27.88	52.52	80.68	76.69	25.37	35.29

DM = Dry matter, OM = Organic matter, CP = Crude Protein, NDF = Neutral detergent fiber

DISCUSSION

Composition of the distributed feed

The actual CP content of the pods of *P. thonningii* and *P. africana* pods (18.82% and 12.33%, respectively) are similar to that of the pods of *Acacia raddiana* (13.4%), *Bauhinia rufescens* (10.36%), *Dichrostachys cinerea* (8.79%) and *Piliostigma reticulatum* (9.55%) (Sanou, 2005; Sawadogo, 2000; Yanra, 2006). This CP content of *P. africana* is comparable with those of peanut and dolichos vines (11.1% and 11.9%, respectively) (Nantoume et al., 2000) that are usually used as a supplement to cereal straws and grass hay. Despite the high CP content in many fodder tree species, the amount of tannins considerably limits their nutritional value Shenkute et al. (2012). The levels of OM and CP of the hay of *P. pedicellatum* are low compared to those found by Ouédraogo (2006) in hay from the same species and harvested at the same phenological stage. Indeed, this author noted levels of 85.25% OM and 8.37% CP in the *P. pedicellatum* hay. The NDF and ADF contents of the *P. pedicellatum* hay were also lower than those obtained by Ouédraogo (2006), who found values of 76.54% and 47.68% for NDF and ADF, respectively. These differences could be attributed to the storage of the *P. pedicellatum* hay because the contents of certain chemical elements (NM, NDF, ADF, EB) vary according to the storage mode of the forage (Arrigo, 2004). The CP level of 8.81% found in the pods distributed as feed is considerably lower than the CP values found in the pods harvested at Gampela (12.33%). This difference could be explained by the fact that the pods distributed as feed were harvested one year before commencement of the experiment. This storage time could have affected the nutritional value of the pods. The low levels of CP rejection, associated with high levels of fiber, showed that the animals perform a sorting of feed. In general, the refusals consisted of stems of *P. pedicellatum* and pod shells of *P. africana*.

Dry matter intake of the distributed feed

These quantities of ingested DM were comparable to those of Nantoume et al. (2006) who studied "Moorish" sheep in Mali with four rations composed of 43.5% to 54% cotton cakes and 56.5% to 46% fodder (bush straw, peanut leaves, sorghum straw, corn straw). These authors obtained levels of ingestion ranging from 1114 to 1492 g DM/animal /day. Similar results were obtained from previous studies with sheep of the same breed as in our study (Yanra, 2006). In contrast, the levels of ingestion in our study were higher than those of "mossi" sheep (Bougouma-Yaméogo et al., 2002). These authors obtained amounts of DM ingested (DMI) ranging from 774 g to 845 g DM/animal/day on the "mossi" sheep receiving nitrogen supplements between 25% and 48% of cotton cake. The difference in DM intake levels could be related to the amount of CP in each ration, even though the difference in CP for both diets was small. Olorunnisomo et al. (2006) reported an increase in the level of nitrogen through dietary supplementation and added that it stimulates the functions of the rumen and consequently leads to an increase in the level of DMI in sheep. Protein quality (solubility) is another important factor that could explain the greater ingestion of ration 1.

Weight change of growing animals

The ADGs of Lot 1 were comparable to those of Lot 3. The ADGs of Lot 1 are of the same order as those obtained by (Ouédraogo, 2006) in a study on Djallonke sheep supplemented with pods of *P. reticulatum* under the same conditions as the present study. Also, Somda (2001) found that metis lambs grew faster than the Djallonke lambs. The ADG values obtained in the Lot 2 sheep were comparable to those obtained by the previous studies. Thus, the ADG values are lower than the ADGs found by Toleba et al. (2001) in a study in Benin on the Djallonke breed exclusively fed on artificial pasture (fodder composed of either local *Panicum maximum* or *Brachiara ruziziensis*) then supplemented with ad libitum cottonseed. The difference in ADG observed between Lot 2 and lots 1 and 3 could be explained by the higher quantities of CPI. The CP contents of the distributed rations were different to those found by Yanra (2006) who provided sheep with supplementary cotton seed cake. The strong variation of the CP content of the commercial cake induced an imbalance of the CPI between the 3 rations. Nevertheless, we recognize that *Mucuna* is a good supplement for growing animals on pasture. The ADG of 28.6 g observed at the end of the supplementary feeding is lower than the 57.14 g ADG recorded by Ouédraogo (2006) in nine weeks in the same breed of animals supplemented with pods of *Piliostigma reticulatum*. The low ADG recorded (28.6 g) compared to those in the above-noted studies would be partly due to the low nutritional value of the supplementary feed ingested by sheep in the present study, compared to the feed used in the other studies. The ADG of -4.8 g recorded at the level of the control group is lower than the ADGs noted by Zoundi et al. (2002), which were -38.1 g for animals whose *Kibsa* feed was partially supplemented with pods of *P. reticulatum* + Urea, and -49.2 g for animals whose *Kibsa* feed was completely substituted by cottonseed cake + pods of *P. reticulatum* + Urea. It is also low compared to the value of -10.04 g recorded by Ouédraogo (2006) for animals fed exclusively on natural pastures at the same experimental station.

Conclusion

This study sought to provide information on the nutritional value of pods of two fodder tree species (*P. thonningii* and *P. africana*) that could be better utilized in livestock production in semi-arid regions of West Africa. The analysis of the chemical composition of the pods showed that they contain relatively high levels of CP that can alleviate the nutritional deficiencies of livestock during the dry season. In addition, feed supplementation with the pods of both fodder species can, in a short time, result in an ADG of 29 g with a low consumption index (1.1). These results indicate a valuation of the pods of both species by the animals used in the trials. Dry season feed supplementation with pods of *P. thonningii* and *P. africana* can support substantial ADGs in grazing animals, meaning these are two important fodder tree species that can help maintain acceptable levels of animal production during challenging dry seasons. Moreover, the rational use of these fodder trees would help to reduce farmers' animal production costs, particularly given the high costs of agro-industrial products often used for animal feed. However, studies to improve animal intake of *P. thonningii* and *P. africana* pods should be considered, including to assess measures such as crushing + wetting, or crushing + addition of substances such as salt, urea and molasses. Indeed, digestibility aspects of the pods should be also investigated to identify the best rates of their incorporation into rations.

COMPETING INTERESTS

The authors declare that there are no competing interests.

AUTHORS' CONTRIBUTIONS

SO and LS conceived the research idea, collected the data, analyzed the data and wrote the draft. PS and CYKZ made valuable comments on the manuscript.

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