International Journal of Environment, Agriculture and Biotechnology
Vol-6, Issue-1; Jan-Feb, 2021

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Effects of feeding ration incorporating *Piliostigma thonningii* (schum.) pods on growth and gastrointestinal parasites in West African Dwarf goats of Burkina Faso

Safoura Dindané-Ouédraogo[1], Salifou Ouédraogo-Koné[1,2*], Dominique Ouédraogo[1,2], Issouf Ima[2], Bienvenue Zoma-Traoré[2] and Albert Soudre[3]

[1]Laboratoire d'Etudes et de Recherches des Ressources Naturelles et des Sciences de l'Environnement (LERNSE), Université Nazi BONI, 01 BP1091 Bobo-Dioulasso 01, Burkina Faso
[2]Département d'élevage, Institut du Développement Rural (IDR), Université Nazi BONI, 01 BP1091 Bobo-Dioulasso 01, Burkina Faso
[3]Unité de Formation et de Recherche en Sciences et Technologies (UFR/ST), Université Norbert Zongo (UNZ), BP 376, Koudougou, Burkina Faso

Received: 16 Nov 2020; Received in revised form: 11 Jan 2021; Accepted: 19 Jan 2021; Available online: 06 Feb 2021

Abstract— *The objective of this study was to determine the availability and the use of Piliostigma thonningii pods through individual interviews using semi-structured questionnaires, and to evaluate the effect of diet incorporating these pods on growth and parasitic status of goats. The trial consisted in feeding diets to 12 adult West African dwarf goats, divided into three batches of four animals each. Batches 1 and 2 received a diet with 40% Piliostigma thonningii pods, and bamboo charcoal as a zootechnical additive (1g/kg PV) in the diet of batch 2. For batch 3, the animals received a diet without the pods, proportionally replaced by cotton seed cake. The experiment lasted for 78 days including two weeks of adaptation. The Mac-Master technique was used for identification and enumeration of strongyle eggs and coccidia oocysts. The results showed a higher frequency of the use of pods in shredded form (38.18%) compared to crushed (25.45%) and whole (20.00%). The availability of pods was confirmed by 57.1% of the respondents. The ADG obtained with the batches fed diet incorporating the pods were 16.39±4.10 and 24.01±5.97 g/d for batches 1 and 2 respectively, significantly lower than those obtained with the animals in batch 3 that received the cotton seed cake (31.39±5.80 g/d). The level of EPG recorded in animals from batch 1 (50±100) was significantly lower than those obtained with animals from batches 2 and lot 3 (500±455 and 925±736 respectively). The use of Piliostigma thonningii pods could be of great use in goat intensive production improvement programs.*

Keywords— ***Pods, Piliostigma thonningii, Bamboo charcoal, ADG, EPG.***

I. INTRODUCTION

Livestock farming offers many advantages for people in developing countries. First of all, it allows to get a more nutritional and diversified diet, especially in terms of animal proteins. In addition, livestock farming is an important source of income with the sale of animal products such as milk, eggs or wool. Finally, it provides manure, traction services, insurance functions and social status [1]; [2]. Thus, most rural households in Africa combine agriculture with livestock production.

In Burkina Faso, the livestock sector is one of the main sources of rural households' income. It contributes for improving their living standard and consequently to poverty reduction of rural population. Even if this contribution to household income varies significantly depending on the region [3]; [4]. Livestock production remains the primary source of access to basic social services for 38.8% of the population living in rural area. The domestic ruminant stock of the country was estimated to 9.8 M cattle and 24,5 million (M) of small ruminants [5]. The number of livestock is increasing, especially that of goats, which has grown from 10.64 M in 2005 to 13.89 M heads in 2014 [5]. Goats are one of the most important sources of meat in rural areas where it is not common to slaughter cattle during social and ritual events [6].

In spite of all these advantages, livestock production is facing food deficit due to the reduction of rangelands resulting to demographic pressure, extensive cropping, bush fires, uncontrolled exploitation and the erratic of rainfall. In addition, the mode of management practiced, essentially based on the exploitation of natural pasture, results in gastrointestinal parasitosis, which is a major constraint to the development of small ruminant productions [7]. Losses induced by digestive pathologies result in mortality and reduced performance [8]. The poor management of crop residues, the high cost of Agro-Industrial By-products and conventional anthelmintics limit livestock production [9]; [10]. All these factors impact negatively animal production systems, which requires an improvement.

Regarding these food and health constraints, the intensification of animal production and the use of browse species with anthelmintic properties are proving to be an alternative to address feed shortage and gastrointestinal parasites. Many authors have already mentioned the relevance of tree fodder and their rational use in animal feed to address physical and economical inaccessibility of agro-industrial by-products [11]; [12]; [13] and [14]. Tree fodder are a significant source of nitrogen during the dry season, when this element is the main limiting factor for animal production [15]. Also, improving goat production must necessarily involve optimizing the use of ligneous fodder, which are an appreciable source of locally available forage and have a significant nitrogen content during the dry season ([9]; [15]. Among browse species, *Piliostigma thonningii* is one of those which pods are used in ruminant nutrition [16] and has anthelmintic properties [17]. Feeding tree fodder, as supplement or as a sole feed, generally results in improved production and health of ruminant animals [18]. The objective of this experiment was therefore to evaluate the effects of feeding diets including pods of *Piliostigma thonningii* on growth rate and gastrointestinal parasites in goats in the sub-humid zone of Burkina Faso, for intensive goat production.

II. MATERIALS AND METHODS

2.1. Study area

The experiment was conducted on farm, in Kiri, a village located at 15 km of Bobo-Dioulasso the second biggest town of Burkina Faso, at about W 4º19' longitude and N 11º19' latitude. The mean altitude is roughly 420 m above sea level. Soils of the study area are mostly hydromorphic on ancient cuirass and are therefore an asset for agricultural activities [19]. The average temperature is 27°C with minima of 20°C in December and maxima of 35°C in April. Compared to the other parts of the country rainfall at Kiri even erratic is relatively abundant. It varies between 900 and 1200 mm per year [19] with an average of 995.15 mm. Relative humidity varies between 21% (January to February) and 82% (August).

2.2. Experimental animals, feeds and management

The animals used were growing males and females of the West African dwarf goats breed, 6 months of age and with a mean initial body weight (bw) of 10.50 kg (sd=0.69), bought from farmers around the research station. Before starting of the experiment, animals were vaccinated against pasteurellosis, trypanosomosis and foot and plague of small ruminants.

The feeds used were crushed pods of *Piliostigma thonningii*; rice straw, maize bran, cotton seed cake and molasses. Cotton seed cake was used in the control group because it is the most available protein supplement in the region. The pods were collected manually from the trees from December to March 2018 and the other feed were purchased from local factories. The pods were sun dried and crushed. Rice straw was hand chopped into pieces of approximately 10 cm before being treated with molasse. The treatment of the rice straw consisted in spreading, and spraying with diluted molasses using a sprayer. The dilution was 250 ml of water per 600 g of chopped rice straw following [20]. The bamboo charcoal is obtained by pyrolysis, i.e. by complete carbonization of traditional woody materials then crushed.

The animals were housed in separated individual pens (1.5 m x 1.5 m) and were fed on cotton seed cake or *Piliostigma thonningii* at 07:00 h and 14:00 h, and on rice straw and maize bran at 10:00 h and 16:00 h. The animals had free access to water and a commercial mineral lick block containing 6% P, 12% Ca, 63% NaCl, 2% Mg, 15% cement as a binding agent, and Fe (2 g/kg), Cu (1.5 g/kg), Mg (0.75 g/kg), Co (0.03 g/kg), Zn (0.9 g/kg) and I (0.1 g/kg).

2.3. Experimental design

A total of 12 adult West African dwarf goats were used for the experiment. They were divided into three batches of 4

ISSN: 2456-1878
https://dx.doi.org/10.22161/ijeab.61.20

animals each. Three treatments (diets) were allocated to the animals. They were fed on the same amount of maize bran and hay from rice straw (Table 1). The treatments were three supplements: cottonseed cake (CSKD), pods of *Piliostigma thonningii* without bamboo treatment (PTD), and pods of *Piliostigma thonningii* with bamboo treatment (PTCD). The molasses-treated rice straw and maize bran were the staple food. Cottonseed cake and pods were used as feed supplements. The addition of bamboo charcoal was done to explore its effects on the improvement of the digestibility. It was incorporated at a dose of 1g/kg PV of the animal. Water and lick stone were administered ad libitum.

Table 1. Centesimal composition of the diet (%)

Feed ingredients	Treatment diets		
	PTD	**PTCD**	**CSKD (control)**
Molasses	5	5	5
Rice straw	20	20	20
Cotton seed cake	-	-	40
Piliostgima thonningii	40	40	-
Maize bran	35	35	35
Bamboo charcoal (g/kg PV)		1	
Mineral lick block		*ad libitum*	
Total	100	100	100

PTD= Piliostigma thonningii Diet; PTCD= Piliostigma thonningii and Charcoal Diet ; CSKD= Cotton seed Cake Diet

2.4. Measurements and chemical analysis

The animals were weighed at the beginning of the experiment and at seven days intervals, always in the morning (06:00 h) before offering the feed, using a 50±0,01 kg electronic scale. Data were used to calculate initial average weights (IW), final average weights (FW), average daily gain (ADG) and feed consumption index (CI). The Average Daily Gain (ADG) obtained according to the formula: ADG (g) = (FW-IW) / (ND), where IW= initial weight, FW= final weight and ND= duration in days. The Consumption Index (CI): was calculated according to the formula: CI= DFC (g)/ADG(g), with DFC = daily food consumption obtained by the difference between the amount of food distributed and the refusal and ADG defined above. The amounts of feeds offered were measured daily and representative samples were taken every week and pooled to monthly samples. Sub-samples of the monthly samples of feed were taken for chemical analysis. The faecal samples were also collected every month directly from the rectum of each animal. Each sample was identified and kept in a cooler containing cooling blocks until conducting the analysis. The parasite EPG (eggs per g faeces) were determined using the modified technique of McMaster [21]. Eggs of nematodes, cestodes and oocystes of coccidia were identified and counted according to [22]. For the survey, sixty-one (61) farmers were interviewed using a semi-structured question guide with the focus to collect information on the availability and the use of patterns of *Piliostigma thonningii*. The sub-samples of feeds offered were analyzed for DM, CP, OM and Ash. The DM (967.03), CP (988.05), and Ash (942.05) were analyzed according to the standard methods of AOAC [23]. The metabolic energy (ME) of the feeds was estimated using: ME (MJ)=0.82 x 19.3 x DOM (kg) derived from the equations given by Devendra and McLeroy (1982): DE (MJ)=19.3 x DOM (kg) and ME (MJ)=0.82 x DE (MJ).

2.5. Statistical analysis

The EXCEL 2013 spreadsheet was used to develop the database and XLSTAT software Version 2015 .5. 01.

22537 was used for statistical analysis of data. The EPG data were submitted logarithmic transformation (log10 x + 1) to approximate normal distribution. For data from trial and EPG recording, the Fisher's test (LSD) was used to separate the averages where analysis of variance reveals significant differences between treatments at the threshold of probability p<5%. For the survey data, a descriptive analysis was conducted using of the SPSS software to determine the percentages.

III. RESULTS

3.1. Measurements and chemical analysis

The nutrient contents of the feeds used are presented in the Table 2.

Table 2. Chemical composition of the experimental feeds

	DM (%)	g/kg DM		
		CP	OM	Ash
Cotton seed cake	93,15	373,7	922,3	77,7
Pods of *P. thonningii*	94,49	86,9	915,0	85,0
Maize bran	94,95	126,0	911,7	88,3
Rice straw	92,44	59,0	831,0	169,0
Molasses rice straw	90,42	50,9	837,9	162,1
Molasse	77,23	35,4	877,0	123,0

DM= Dry Matter ; CP= Crude Protein; OM= Organic matter

The CP contents of the feeds used differed (Table 2). Cotton seed cake had the highest CP content (373,7 g/kg DM) and the molasse, the lowest (35,4 g/kg DM). The CP contents of the pods of *Piliostigma thonningii* (86,9 g/kg DM) was higher than that of rice straw.

3.2. Feed intake, growth performance and feed conversion ratio

Feed intake, goats Daily Weight Gain (DWG), absolute weight gain and Feed Conversion Ratio (FCR) are shown in Table 3 below.

Table 3. Initial and final weight, average daily gain and feed conversion ratio (LS means and SE)

	Diets		
	PTD	PTCD	CSKD
Total DM (g/day)	304,08±72,93a	309,6±61,1a	371,75±92,63b
Total DM (g/kg $W^{0,75}$)	52,13±66,10	53,08±55,98	63,73±83,96
Initial weight (kg)	9,11±0,52	9,62±0,64	10,56±1,62
Final weight (kg)	10,5±1,14	11,49±1	13,03±1,91
Live weight gain (kg)	1,38±0,77a	1,87±0,52a	2,43±0,78b
Average daily gain (g)	16,39±4,10a	24,01± 5,79a	31,39±5,80 b
Feed conversion ratio			
kg DM/kg BWG	18,06±9,32a	10,83±2,43b	10,3±4b

a,b,c Means within row with different superscripts are significantly different (P<0.05).

ISSN: 2456-1878
https://dx.doi.org/10.22161/ijeab.61.20

DM intake ranged from 304.08±72.93 g to 371.75±92.63 g/animal/d. The highest value 371.75±92.63 g/d was recorded from animals fed control diet and was significantly different from that of animals fed diets with *Piliostigma thonningii*. The animals offered the control diet gained significantly more weight and had a higher ADG (2.43 kg and 31.39 g/day, respectively) than the animals fed pods of *Piliostigma thonningii*. (Table 3). Among the *Piliostigma thonningii* diets, the ADG was not significantly different (p>0.05). The Average Daily Gain (ADG), overall, ranged from 8.01 to 41.73 g/day/animal. The FCR expressed as kg DM per kg BWG, ranged from 10.3 to 18.06. No significant difference was obtained between the diet with *Piliostigma thonningii* treated with bamboo charcoal and the control diet.

3.3. Availability and use of *Piliostigma thonningii* pods

Figure 1 provides information on the availability of *Piliostigma thonningii* pods. The results show that 57% of the farmers confirmed that the pods are fairly available. The cumulative citation frequency of pod availability was 77%.

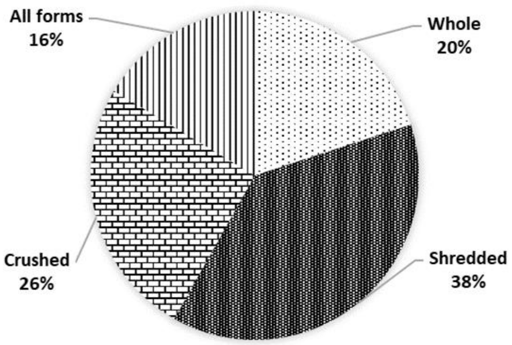

Fig.1: frequency of citation of the availability of Piliostigma thonningii pods.

Figure 2 shows the frequency of citation of the forms in which *Piliostigma thonningii* pods are used by farmers.

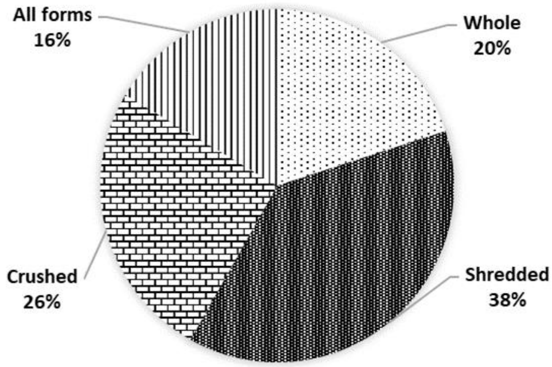

Fig.2: Frequency of citation of Piliostigma thonningii pod usage patterns

The frequency of citation of the use of pods in crushed form is the highest (38,18%). That of the whole pods was the lowest (20%).

The Figure 3 shows the evolution of the EPG of the strongyles.

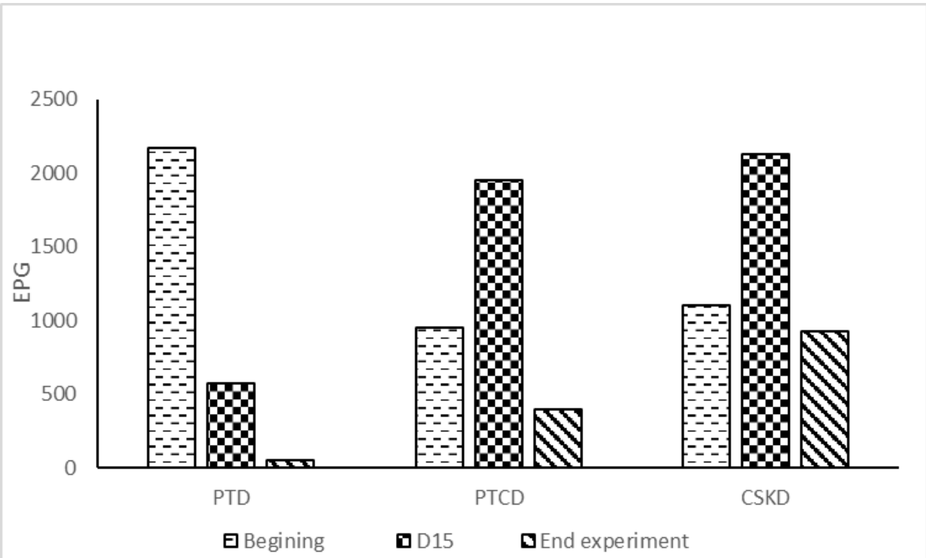

Fig.3: Level and evolution of EPG of strongyles

An overall slight increase in was observed between the period of the beginning of the experiment and the end of the adaptation period, followed by a significant decrease at the end of the trial (78 days after).

The level and evolution of the EPG of the coccidia are presented in table 4.

Table 4. level and evolution of the EPG of the coccidia

Treatment diets	Mean EPG		
	D0	D15	D78
PTD	525±1050 a	129255±12503b	625±299c
PTCD	400±735a	17225±20090b	1025±741b
CSKD	0a	21625±27010b	975±1031b

a,b,c Means within rows with different superscripts are significantly different (P<0.05);

D0= Day 0 (beginning); D15= 15th Day , D78= 78th Day

The results show an increase in EPGs of coccidia between the beginning of the experiment and 15 days after. Between the 15th day and the end of the experiment, a decrease in EPGs has been noted. However, between the beginning and the end, a slight increase was observed.

IV. DISCUSSION

4.1. Chemical composition

Apart from cotton seed cake, the CP contents of the ingredients analyzed are relatively low, compared to those reported by [16] and [24] who found values ranged between 10.53 and 9.51% DM for the pods of and *Piliostigma thonningii* and *Piliostigma reticulatum*, respectively. Values founded in the present investigation are higher than those obtained by [25] with *Pilisotigma. reticulatum* pods (5.06% MS). These variations would be related to the species, climate, soil types, state of maturity and shelf life. The CP content of the corn bran used (12.60% of DM) is lower than the levels found by [26] and [27] which obtained values of 13.28 and 17.49% of DM, respectively. However, the CP content of maize bran recorded was higher than that of [28]. Moreover, it is above the limiting level (6 to 8% of DM) below which appetite and forage intake are depressed [29].

4.2. Feed intake, growth performance and feed conversion ratio

The results showed variations between the mean intake values obtained from the three groups of animals. The high value obtained with the animals fed on control ration, could be attributed to the high CP content of the cotton seed cake contained in the diet (CSKD). The slight increase in feed intake value even non-significant obtained with animals fed on ration incorporating *Piliostigma thonningii* and bamboo charcoal could be related to the action of the charcoal. The charcoal would be able to complex the secondary compounds and thus increase the digestibility of the constituents. This result could be due to an improvement in the digestibility of the ration having incorporated bamboo charcoal. Values found herein are similar to those of [25] with substitution of cotton seed cake by *Piliostigma reticulatum* pods and recorded 390.83; 386.35; 384.25g and 362.48g/d with rations incorporating the crushed pods at 20%, 50%, 30% and 0%, respectively. However, our results are higher than 278.5 g; 125.6 g/day, obtained respectively with sheeps and goats by [30]. Our values are lower than 449.5 g/d and 549.2 g/d reported by [31] who worked on animals subjected to rations incorporating 20% *Piliostigma reticulatum* pods. According to [32], an increase in the level of nitrogen through supplementation in a ration stimulates rumen function and consequently leads to an increase in the level of intake in sheep. Another important factor such as protein quality (solubility) could explain the higher intake recorded with the control group.

The ADG of animals fed diets incorporating *Piliostigma thonningii* pods do not differ significantly, but are significantly lower than those of the control group. The results obtained are in line with those of [25] with the partial substitution of crushed *Piliostigma reticulatum* pods and reported ADG of 13.20 to 22.06 g/d with Maradi goats and that of 25g/d reported by [24] with Djallonké sheep led to pasture and receiving as a supplement of the *Piliostigma reticulatum* pods associated with maize bran. However, they are lower than those obtained by [31] using Maradi goats fed with densified feed (50.9 to 78.3g/d). Similarly, they are also lower than those obtained by [16] who, with growing sheep, obtained ADG values of 78 g, 61 g and 56 g respectively for animals supplemented with Mucuna meal, *Piliostigma thonningii* pods and cotton cake. These differences could be related to animal species, initial average weight and age of the animals, the study environment and the composition of the rations used.

The weight gain observed with rations incorporating *Piliostigma thonningii* pods is explained by the fact that the condensed tannins would allow an increase in the flow of assimilable proteins and animate acids in the intestine by protecting dietary proteins from degradation in the rumen. According to Min and [33], at moderate doses (20 to 40 g/kg dry matter), condensed tannins bind to proteins, prevent their degradation in the rumen and thus increase the intake of amino acids in the small intestine, thus improving the nutritional status of the animal. In addition, *Piliostigma thonningii* pods with a CP content of 8.99% DM would allow a better digestion or even a high ingestion. This level of weight gain recorded with rations incorporating *Piliostigma thonningii* pods is online with [16].

The Feed Conversion Ratio (FCR) translates the efficiency of the transformation of the feed into meat and therefore into weight gain. The best FCR was obtained with animals in the CSKD group (10.3±4) and was significantly higher than those in PTD and PTCD groups ($p<0.05$). The values obtained with our work are comparable to those of [25] who recorded 12.76±3.72; 8.42±3.89; 7.65±6.23 and 4.17±4.91, with Maradi goats fed diets incorporating different proportions of *Piliostigma reticulatum* pods. Our values are similar to those of [31] who obtained values ranging from 7.1 to 10.6.

4.3. Availability and use of *Piliostigma thonningii* pods

The results of our study showed that *Piliostigma thonningii* pods are available. Several factors can influence this availability: demand, the seasonal production period [28] and infestation [16]. Indeed, the consumption of tree fodder becomes more important when herbaceous forage becomes scarce and especially low in nitrogen, hence its higher proportion in the hot dry season found by [34]. The availability of *Piliostigma thonningii* pods found during the surveys could indicate the renewed interest in tree fodder. This would also be an indicator of the difficulties in accessing available herbaceous pasture or their drastic reduction due to several factors mainly anthropogenic. The surveys have shown that pods are most commonly used in crushed form. Grinding and crushing are practiced to reduce the size of the pods to make them easier to grip, because the pods contain a certain lignin content which makes the pod rigid and therefore reduces its ingestion. The low use of whole pods would be due to the extensive nature of the farms. The relatively low level of treatment reveals the extensive character of these farms because in these types of breeding, complementation is insignificant or absent and the methods which make it possible to increase the ingestion are not practiced.

4.4. Parasites infestation

Strongyles eggs decreased significantly towards the end of the experiment (78 days after the start of the experiment) for all animals, but at different rates. The lowest levels at the end of the treatment were observed with animals on the PTD ration. In our study goats were not bleached prior to the trial and parasite species were not isolated and identified. The decrease in EPG could be due to the direct or indirect anthelmintic effect of pods on the strongyles. The direct effect could be explained by the action of tannins on the cuticle of the strongyles or by disrupting nutrition and reproduction. The indirect effect by the improvement of the immune system due to the protein contribution [35]. In the context of this study, if we refer to the interpretation grid or severity scales of [36] based on OPGs, we could say that at the beginning, the infestations were high (> 1,000 OPGs), average (500 - 1,000 OPGs) for lot 1, lot 2 and lot 3 respectively, although the animals were not de-infested at the beginning of the trial. At the end of the trial, lot 1, lot 2 and lot 3 showed low and medium infestation respectively.

The lowest value coccidia EPG was found in the faeces of goats fed with PTD without charcoal treatment. The difference between the number of coccidia oocysts in the faeces of goats fed on diets incorporating *Piliostigma thonningii* pods, and that of goats fed on concentrate support the presence of anti-nutritional factors in tree pods able to control the development of gastrointestinal parasites [37]. This could be explained by the fact that the tree fodder used has anthelmintic properties. It appears that the incorporation of the pods allows to reduce the level of excretion of coccidia eggs. The presence of gastrointestinal parasites in animals can result in a requirement for extra nutrients to repair or replace damaged tissue and express immunity. The significantly lower number of coccidian oocysts in goats fed diet incorporating *Piliostigma thonningii* pods without charcoal treatment could be due to some feed characteristics of pods, regarding the low level of CP content of the diet compare to that of others. The

EPG obtained in our experiment, were similar to 1123±467 reported by [38] in sheep.

V. CONCLUSION

Finaly, the results indicate that *Piliostigma thonningii* pods have a potential value and can be adequately used to address the negative effects of feed scarcity on the performance of goats. It would appear as an alternative that could help in parasite control and animal feeding; but still needs further and longer investigation. The results obtained should make it possible to create a craze for its use by breeders in view of the ever-increasing difficulties in animal feeding. Livestock farmers can easily protect wild trees and collect pods on the fields to prevent their disappearance and to increase the availability of feed for animals. The results will enable the technical and research services to consider strategies for the management of locally available tree fodder resources for sustainable exploitation. Thus, we can suggest to farmers the incorporation of *Piliostigma thonningii* pods in animal diets as a protein supplement. Specific treatments such as grinding and addition of bamboo charcoal can improve their nutritional value.

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