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Zootechnical performances of djallonké sheep supplemented with cocoa bean fragments, fruits, and leaves of *Cajanus cajan* in Côte D'ivoire

Ané François De Paul Atsé*, Jacques Yao Datté, Sidiki Sangaré, Alassane Méïté

Laboratory of Biology and Health, UFR-Biosciences, Félix Houphouët-Boigny University, Abidjan, Côte d'Ivoire

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ABSTRACT

This study was conducted at the Toumodi Sheep Station (SOT), under the authority of the Ministry of Animal and Fishery Resources (MIRAH), using a sample of 30 Djallonké lambs with an average body weight of 8.628 ± 0.2376 kg and an average age of 3 months. The animals were divided into five (5) groups of six (6) animals each. All groups were fed fresh biomass of *Panicum maximum* as the basal diet. Group 1, considered the control group (Te), received no supplementation. Group 2 (So) received the industrial feed "SOGOBALO" as a supplement at a rate of 200 g/day/animal. Group 3 (Br) was supplemented with 450 g/day/animal of cocoa bean shells. Groups 4 (Fr) and 5 (Fe) received 400 g/day/animal of pigeon pea (*Cajanus cajan*) and 600 g/day/animal of *Cajanus cajan* leaves, respectively. After a 10-day adaptation period, the lambs were supplemented for 180 days. The results revealed significant differences ($P < 0.01$) in growth performance among the five groups. The final average weights observed were 19.63 ± 1.90 kg for group Te, 24.18 ± 1.70 kg for group So, 17.32 ± 1.70 kg for group Br, 21.27 ± 1.20 kg for group Fr, and 16.92 ± 1.00 kg for group Fe. The total weight gains were 0,65±0,26 kg, 0,75±0,23 kg, 0,47±0,16 kg, 0,57±0,16 kg, and 0,44±0,08 kg, respectively. The average daily gains were 0,07±0,03 kg, 0,08±0,02 kg, 0,05±0,02 kg, 0,06±0,01 kg, and 0,05±0,01 kg. The specific growth rates were 0,37±0,18, 0,34±0,11, 0,29±0,11, 0,30±0,07 and 0,28±0,06 respectively. These zootechnical results indicate that the animals supplemented with SOGOBALO exhibited the best growth performance, followed by those supplemented with pigeon pea, *Panicum maximum* (control), cocoa bean shells, and finally *Cajanus cajan* leaves.

***Corresponding author:** Ané François De Paul Atsé ✉ atseane@yahoo.fr

INTRODUCTION

Côte d'Ivoire faces a deficit in animal products, being largely dependent on foreign markets to meet the animal protein needs of its population (Sangaré *et al.*, 2022; Kouadio *et al.*, 2019). Livestock productivity remains low, with nearly 45% of its meat requirements being imported (FAO, 2021). This situation places Côte d'Ivoire among the largest importers of ruminants (sheep and cattle) in West Africa (Ouattara *et al.*, 2020). Between 2015 and 2019, Côte d'Ivoire spent an average of 25 to 27 billion FCFA per year on the importation of meat, offal, and derivatives, totaling approximately 55,000 tons/year (FAO, 2021). Despite this significant effort, the state fails to satisfy the demand for animal protein.

The number of sheep increased from 1,161,000 heads in 1991 to 1,487,000 heads in 2001, and was estimated at 1,610,000 heads in 2020, with a concentration in the northern (38%), central (35%), and southern (18%) regions (MINADER, 2021). This livestock is mainly composed of Djallonké sheep. Thanks to their adaptation to the various agricultural and ecological regions of sub-Saharan Africa, Djallonké sheep play a crucial role in achieving food security in animal protein (Traoré *et al.*, 2020).

Nutrition is one of the main determinants of animal production and represents a limiting factor in the development of livestock farming, especially during the dry season. It relies essentially on the use of natural pastures, where herbaceous forage only supports animal growth for a short period of the year (Koné *et al.*, 2018). The leaves and pods of certain woody species offer quality feed for ruminants, the use of which is accentuated during the dry season when other forage resources are limited (Zoungrana *et al.*, 2019). Feed for sheep comes from plant, industrial, or food waste sources, posing challenges regarding their quality and availability. Nevertheless, the diversity of agricultural products in Côte d'Ivoire allows the transformation of numerous by-products, which could be integrated as ingredients in feed formulation or as supplements for fattening in Djallonké sheep farming. However, data concerning these by-products, notably their nature, quantity, and availability, remain fragmented or even non-existent (Kouakou *et al.*, 2023).

This study aims to provide sheep farmers with dietary supplements for sheep, based on the available cocoa by-products and *Cajanus cajan*. The general objective is to evaluate the zootechnical performances of Djallonké sheep subjected to dietary supplements. More specifically, the study will focus on weight gain, weight gains, average daily gains, and specific growth rates of Djallonké sheep, depending on four types of dietary supplements during the dry season.

MATERIALS AND METHODS

Study area

The Toumodi Sheep Station (SOT), located in Toumodi, a town in the center of Côte d'Ivoire, served as the study site. This farm is located 3 kilometers from the village of Assounvoué, which is situated approximately 10 kilometers from Toumodi. The department of Toumodi is part of the Bélier region and is located approximately 200 km from Abidjan on the Abidjan-Bouaké axis. The SOT, within the framework of the Integrated Ranch and Station Management Project (PROGIRS), includes 4 other stations and a ranch.

This state farm's missions and objectives are to promote and develop sheep and goat farming, to produce ewes and rams, and to make improved breeders available to the National Sheep Breeding Program (PNSO) and other farmers. It also aims to train and retrain farmers and technicians in small ruminant farming. The station has 300 ha of natural pastures.

Animal material

This study was conducted on 30 Djallonké breed lambs, born and raised at the SOT, aged three months and weighing an average of 8.6 ± 0.24 kg. The animals were vaccinated against peste des petits ruminants (PPR), dewormed with albendazole, and subjected to monthly dipping. They were then divided

into five homogeneous groups of six animals after an adaptation period of 10 days.

Feed and distribution method

At the start of the experiment, a double weighing of the lambs was carried out, and they were placed six per pen.

The animals belonging to the same group were identified by medallions of the same color bearing numbers ranging from 1 to 6. After weaning, the lambs were taken to pasture for a daily duration of 8 hours under the supervision of a shepherd. The pasture consisted of *Panicum maximum* variety C1.

Upon returning from pasture, around 3 p.m., the animals were sorted and housed in five pens of 12 m² each, where they received four types of dietary supplements intended to cover their energy and protein needs. The supplementation ration was defined according to the growth and physiological stage of the animals (mating, gestation, lactation), as well as the season. It varied from 200 to 300 g/day/animal and was intended to cover approximately 60% of energy requirements and 40% of protein requirements, in accordance with recent recommendations in small ruminant nutrition (Kebede *et al.*, 2019; FAO, 2021).

The distribution of supplements aimed to satisfy nutritional needs for growth and fattening, targeting an average daily gain (ADG) of 175 g/day, corresponding to an energy density of approximately 2.2 FU/kg of weight gain (Mohammed *et al.*, 2020). The supplementation scheme is summarized in Table 1.

Table 1. Composition and nutritional values of the rations distributed to lambs during the experiment

Lots	Base ration	Dietary supplement (g/day/OU)			
		Socobalo	Cocoa bean fragments	*Cajanus cajan* fruits	*Cajanus cajan* leaves
1 (n= 6)	P. maximum C1				
2 (n=-6)	P. maximum C1	200			
3 ((n=-6°	P. maximum C1		450		
4 (n = 6)	P. maximum C1			400	
5 (n = 6)	P. maximum C1				600
Qty (g/kgDM)		175	394.88	355.2	178.5
GE (FU/Kg)		2.2	2.2	2.2	2.2

(n): number of animals; Qty: quantity; GE: Gross Energy; FU: Feed Unit; Kg: kilogram, g: gram; DM: dry matter; P: *panicum maximum*; g/day/OU: gram per day per ovine unit, OU: Ovine Unit.

Prior to this, the animals were adapted to the different pens and different dietary supplements for a period of 10 days. Lick stones were available at all times, and water was provided *ad libitum*.

During the experiment, the animals benefited from veterinary care and treatments in accordance with the prophylaxis program established by the animal health officials of the Toumodi Sheep Society (SOT). This prophylaxis program included, among other things, deworming, vaccinations, a weekly individual check of the general health status of the sheep, as well as compliance with the hygiene measures in force within the center.

Parameters studied

The zootechnical parameters measured were average weight, weight gain, average daily gain (ADG), and specific growth rate. The evolution of the weight of the lambs was determined by weighing each animal at the start of the experiment, then every 10 days. Weighing's were carried out in the morning on an empty stomach using a scale. These data were used to calculate weight gains, ADGs, and specific growth rates.

Statistical analysis

The data obtained were analyzed with GraphPad and Statistica version 7.1 software. Descriptive statistics of

central tendency and dispersion were used to support the interpretation of the variables. Analysis of variance (ANOVA) was used to determine whether there are statistically significant differences between the groups.

RESULTS

Evolution of average weight as a function of time

The curve below Fig. 1 illustrates the evolution of body weight (kg) in sheep subjected to different diets over a period of 0 to 180 days. The dietary treatments compared are: control, socobalo, cocoa bean fragments, *Cajanus cajan* fruits and leaves.

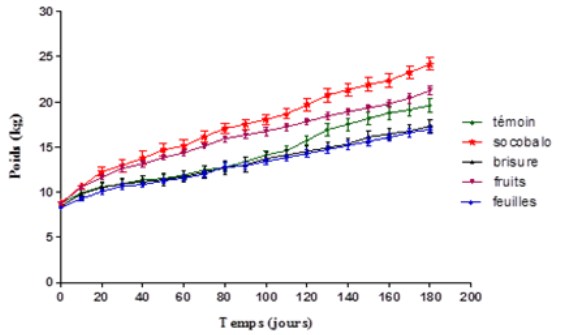

Fig. 1. Variation in body weight of sheep

All the curves show a progressive increase in weight over time, reflecting a continuous weight gain. The evolution is almost linear after the 30th day, with increasing differences between the dietary supplements.

Analysis of the final average weights of the animals at 180 days shows that the Socobalo supplement is the one that induces the best weight gain with a final weight (24.18 ± 1.70 kg), followed by the *Cajanus cajan* Fruits supplement (21.27 ± 1.20 kg). These two diets allowed a growth greater than that of the control (19.63 ± 1.90 kg).

On the other hand, the supplement based on cocoa bean fragments and *Cajanus cajan* leaves gave final weights of 17.32 ± 1.70 kg and (16.92 ± 1.00 kg), resulting in weight performances lower than the control. Graphical analysis confirms that only the Socobalo treatment allows a growth significantly greater than that of the control. The fruits offer an acceptable alternative, while the *Cajanus cajan* leaves and fragments are not effective sources for improving animal weight gain.

Growth performances

The results relating to the growth performances of the different groups, as well as the average weights (AW), weight gains (WG), and average daily gains (ADG) as a function of the periods, are presented in Table 2.

Table 2. Growth parameters of the different groups

	Lots					*p*-value
	Co	So	CBF	CF	CL	
D1 à D60						
AW	10.72±1.02^{abc}	12.61±2.17^{a}	10.57±1.08^{abc}	12.14±1.89^{ab}	10.12±1.16^{c}	0.0002
WG	0.51±0.33^{b}	1.06±0.51^{a}	0.55±0.42^{b}	0.93±0.46^{ab}	0.54±0.20^{b}	0.0024
ADG	0.05±0.03^{b}	0.11±0.05^{a}	0.06±0.04^{b}	0.09±0.05^{ab}	0.06±0.03^{b}	0.0031
D61 à D120						
AW	13.84±1.18^{c}	17.86±1.19^{a}	13.39±0.84^{c}	16.54±0.91^{b}	13.22±0.76^{c}	< 0.0001
WG	0.65±0.28^{ab}	0.76±0.24^{a}	0.47±0.12^{b}	0.58±0.18^{ab}	0.45±0.21^{b}	0.0034
ADG	0.07±0.03^{ab}	0.08±0.02^{a}	0.05±0.01^{b}	0.06±0.02^{ab}	0.05±0.02^{b}	0.0020
D121 à D180						
AW	18.36±0.96^{c}	22.30±1.20^{a}	16.16±0.86^{d}	19.69±0.98^{b}	15.86±0.81^{d}	< 0.0001
WG	0.65±0.26^{ab}	0.75±0.23^{a}	0.47±0.16^{b}	0.57±0.16^{ab}	0.44±0.08^{b}	0.0009
ADG	0.07±0.03^{ab}	0.08±0.02^{a}	0.05±0.02^{b}	0.06±0.01^{ab}	0.05±0.01^{b}	0.0004

Means followed by the same letter in the same column are not significantly different at the probability threshold (< 0.05), according to the TUKEY test. Co: Control, So: Socobalo, CBF: Cocoa Bean Fragments, CF: *Cajanus cajan* Fruits, CL: *Cajanus cajan* Leaves, AW: Average Weight, WG: Weight Gain, ADG: Average Daily Gain.

For the period from D1 to D60, the AW, WG, and ADG of sheep supplemented with SOCOBALO and *Cajanus cajan* fruits were found to be higher than those of the control group and those of sheep having received cocoa bean fragments and *Cajanus cajan* leaves. Analysis of variance demonstrated that the different dietary supplements exert a significant effect ($p < 0.05$) on the AW, WG, and ADG of the sheep in the different groups.
For the period from D61 to D120, the AW, WG, and ADG of sheep supplemented with SOCOBALO and *Cajanus cajan* fruits were, once again, higher compared to the control group and those having received cocoa bean fragments as well as *Cajanus cajan* leaves. Analysis of variance confirmed that the different dietary supplements have significant effects ($p < 0.05$) on weight gains, WG, and ADG of the sheep in the different groups.

Finally, for the period from D120 to D180, the average weights (AW), WG, and ADG of sheep supplemented with SOCOBALO and *Cajanus cajan* fruits remained higher than those of the control group and those of sheep having received cocoa bean fragments and *Cajanus cajan* leaves. Analysis of variance revealed that the different dietary supplements have significant effects ($p < 0.05$) on weight gain (AW), WG, and ADG of the sheep in the different groups. It was observed that the AW, WG, and ADG were significantly ($p < 0.05$) higher in sheep having received SOCOBALO and *Cajanus cajan* fruits, while they were lower in those having been fed with cocoa bean fragments and *Cajanus cajan* leaves.

The dietary parameters of the different groups are presented in Table 3. For the period from D1 to D60, the level of feed intake and the consumption index were significantly different ($p < 0.05$) according to the type of dietary supplement. Regarding the ingestion of dietary supplements, the animals in the CL and CF groups consumed 2.57 ± 0.37 kg and 2.25 ± 0.10 kg of *Cajanus cajan* leaves and fruits, respectively, significantly ($p < 0.05$) more than the animals in the CBF and So groups, which were supplemented with cocoa bean fragments and socobalo. The animals in the CL group had a consumption index of 6.88 ± 4.86 kg of *Cajanus cajan* leaves, which is significantly ($p < 0.05$) higher than that of the So, CBF, and CF groups, which had received socobalo, cocoa bean fragments, and *Cajanus cajan* fruits supplements. No significant difference ($p > 0.05$) was observed between the specific conversion rates (SCR) of the animals in the different groups. Thus, despite the variations in the quantities of feed consumed, the animals in the different groups show similar specific growth rates.

Table 3. Dietary parameters of the different groups

	Lots					*p*-value
	Co	So	CBF	CF	CL	
D1 à D60						
FI		1,08±0,07^{b}	1,41±0,09^{c}	2,25±0,10^{b}	2,57±0,37^{a}	< 0.0001
CI		1,29±0,67^{b}	3,77±1,84^{b}	2,95±1,23^{b}	6,88±4,86^{a}	< 0.0001
SCR	0,50±0,37^{a}	0,90±0,58^{a}	0,55±0,48^{a}	0,83±0,53^{a}	0,55±0,35^{a}	0,1323
D61 à D120						
FI		1,11±0,08^{c}	1,85±0,21^{b}	1,86±0,68^{b}	2,64±0,15^{a}	< 0.0001
CI		1,61±0,60^{b}	4,15±0,95^{b}	3,29±1,45^{b}	8,28±7,30^{a}	0,0004
SCR	0,47±0,18^{a}	0,44±0,15^{a}	0,36±0,10^{a}	0,36±0,13^{a}	0,35±0,17^{a}	0,1462
D121 à D180						
FI		1,18±0,03^{d}	1,64±0,35^{c}	2,28±0,08^{b}	2,95±0,20^{a}	< 0.0001
CI		1,72±0,53^{c}	3,84±1,26^{b}	4,20±0,89^{b}	7,03±2,13^{a}	< 0.0001
SCR	0,37±0,18^{a}	0,34±0,11^{a}	0,29±0,11^{a}	0,30±0,07^{a}	0,28±0,06^{a}	0,2849

Means followed by the same letter in the same column are not significantly different at the probability threshold (< 0.05), according to the TUKEY test. Co: Control, So: Socobalo, CBF: Cocoa Bean Fragments, CF: *Cajanus cajan* Fruits, CL: *Cajanus cajan* Leaves, FI: Feed Intake, CI: Consumption Index, SCR: Specific Conversion Rates.

For the period from D61 to D120, the level of feed intake and the consumption indices were also significantly different ($p < 0.05$) according to the type of dietary supplement. The animals in the CL group consumed 2.64 ± 0.15 kg of *Cajanus cajan* leaves, a significantly higher quantity ($p < 0.05$) than that of the animals in the CBF, So, and CF groups, which were supplemented with cocoa bean fragments, socobalo, and *Cajanus cajan* fruits. In addition, the animals in the CL group showed a consumption index of 8.28 ± 7.30 kg of *Cajanus cajan* leaves, which is significantly higher ($p < 0.05$) than that of the other groups.

No significant difference ($p > 0.05$) was observed between the SCRs of the animals in the different groups. Thus, the animals in the different groups once again showed comparable specific growth rates despite the dietary supplements.

For the period from D121 to D180, the level of feed intake and the consumption index continued to show significant differences ($p < 0.05$) according to the type of dietary supplement. The animals in the CL and CF groups consumed 2.95 ± 0.20 kg and 2.28 ± 0.08 kg of *Cajanus cajan* leaves and fruits, respectively, in a significantly ($p < 0.05$) higher quantity than the animals in the CBF and So groups which were supplemented with cocoa bean fragments and socobalo. The animals in the CL group, supplemented with *Cajanus cajan* leaves, had a consumption index of 7.03 ± 2.13 kg, significantly ($p < 0.05$) higher than those of the So, CBF, and CF groups having received the socobalo, cocoa bean fragments, and *Cajanus cajan* fruits supplements. As before, no significant difference ($p > 0.05$) was observed between the SCRs of the animals in the different groups, indicating that the specific growth rates remain identical despite the differences in dietary supplements.

DISCUSSION

The values of the initial average weights of the lambs at weaning are lower than the value of 10.04 kg obtained by Kouadio *et al.* (2018) and the value of 10.56 kg obtained by Yao *et al.* (2020). This is due to the lack of pasture for the sheep and the breeding conditions. The absence of a significant difference ($p \leq 0.05$) between the initial average weights shows that the animals were selected under the same experimental conditions. Sanogo *et al.* (2016) reported that the live body weight at weaning of lambs improves with the age of the ewe and that several factors act on the growth of sheep. Among the environmental factors that influence growth, nutrition and parasitism are by far the most important (Traoré *et al.*, 2017; N'Dri *et al.*, 2022).

At the end of the 180 days of experimentation, the sheep that received socobalo and *Cajanus cajan* fruits as dietary supplements have an increase in body weight while those that received cocoa bean fragments and *Cajanus cajan* leaves have a loss of body weight compared to the control group. In this experiment, the characteristics of growth such as the AW, the WG and the ADG over the 3 periods are significantly different ($p \leq 0.05$) between the different groups of sheep having received the dietary supplements. These different parameters were higher in the sheep having received the socobalo followed by those who received the fruits of *Cajanus cajan* than the control group and the animals having received the cocoa bean fragments and the leaves of *Cajanus cajan*.

Over the period of 180 days of experimentation, the highest final average weights (24.18 ± 0.69 kg; 21.27 ± 0.50 kg) and average daily gains (ADG) (85 ± 4.28 g/day; 68.33 ± 1.67 g/day) were obtained with the animals having received the socobalo and *Cajanus cajan* fruits.

Over the 3 periods of experimentation, the AW, the WG and ADG of the animals having received the socobalo and *Cajanus cajan* fruits supplements have higher values than the control animals and those having received the cocoa bean fragments and the *Cajanus cajan* leaves. The final average weights (FW) obtained of 19.63 ± 1.90 kg, 24.18 ± 1.70 kg, 17.32 ± 1.70 kg, 21.27 ± 1.20 kg, 16.92 ± 1.00 kg for the Co,

So, CBF, CF and CL groups during these tests are higher than those obtained by Yao *et al.* (2020). These authors report that the weights obtained by Djallonké sheep at 12 months of age are 19 kg for males and 17 kg for females. Those obtained by the animals having the socobalo and the fruits of *Cajanus cajan* are comparable to the values obtained by Koné *et al.* (2017) and Yao *et al.* (2020). These authors obtained FW that oscillate between 20 to 22 kg for the adult weight of the Djallonké. This observation suggests that the dietary supplements have induced an improvement in weight evolution and that the high weight performances in the animals having received the socobalo and the fruits of *Cajanus cajan* are due to their high nutritional value. Indeed, according to Kouamé *et al.* (2019), the growth rate varies according to the dietary program adopted, especially according to the nature and quality of the forages distributed and the level of supplementation. The weight masses of these authors compared to the results obtained in this study are largely lower. The work of Koné *et al.* (2017) has shown that the implementation of elementary prophylactic and zootechnical measures reduces losses and ensures that the animals grow to reach the live body weight of 20 to 22 kg in six or eight months that they could only have after two or three years in traditional farming.

In the Sahelian regions, mineral supplementation of animals is always essential in the dry season (Konaté *et al.*, 2018; Ouattara *et al.*, 2020) and this is all the more beneficial if the latter have a supply of easily degradable organic matter (Soro *et al.*, 2019; Tapsoba *et al.*, 2021). When this supplementation is well chosen, it undoubtedly leads to significant effects on weight gains (Sanou *et al.*, 2017; Yéo *et al.*, 2023). Indeed, with a protein supplementation regime after weaning, the Djallonké sheep can gain up to 110 g/day (Yapi *et al.*, 2019; Kaboré *et al.*, 2021). These authors report that body gain is an indicator of feed efficiency and that nutrients are physiologically deposited in the body. A decrease in body mass may be due to a low efficiency of the feed ingredient.

The ADG obtained with the different supplements during the 180 days (60.00 ± 10.95 g; 85.00 ± 10.49 g; 46.67 ± 8.16 g; 68.33 ± 4.08 g; 48.33 ± 7.53 g) are higher than those reported by Lawani *et al.* (2017) in Benin, in Djallonké sheep subjected on the one hand to *Panicum maximum* only (ADG of 22 g/day) and on the other hand to *Panicum maximum* supplemented by *Chamaecrista rotundifolia* or *Aeschynomene histrix* (19 and 23 g/day).

The ADG of the animals having received the cocoa bean fragments and the *Cajanus cajan* leaves in this experimentation are comparable to the values between 43 g and 51 g reported by Kouamé *et al.* (2018) during the supplementation of Djallonké sheep with *Pterocarpus* or *Bridelia*. These ADG compared to those of the control animals are largely lower. Indeed, the growth of the Djallonké lamb after weaning remains low (Tiemoko *et al.*, 2020). Even with supplemented feed, the average daily gain is often between 65 g and 80 g for the period from 1 to 5 months of age, and rarely exceeds 90 g with a balanced diet (Zinsou *et al.*, 2022).

However, the ADG obtained by the animals having received the socobalo and the fruits of *Cajanus cajan* in the tests are higher than those reported by Koulibaly *et al.* (2016) and Diarra *et al.* (2021), but comparable to those of the control. These authors obtained ADG of 66.37 g/day with a supplementation based on cottonseed, wheat bran and *Leucaena* in Togo, and of 64.1 g with a feed based on local ingredients.

The results obtained by Adégbidi *et al.* (2019) in Benin, by supplementing *Panicum maximum* with cottonseed hulls and cottonseed cake, are higher than the ADG obtained with the fruits of *Cajanus cajan* but comparable to the ADG obtained with the socobalo in this study. The latter obtained ADG ranging between 82.5 to 90 g/day with these types of supplements.

These differences in results could be explained on the one hand by the nutritional values of the different dietary supplements used during the experimentation, and on the other hand by the farming climate and the experimental conditions. The ADG of the animals having

received the socobalo is higher than the values obtained by Kaboré *et al.* (2017), who report a value of 78.4 g in sheep of the same breed in semi-intensive management (free grazing in the rainy season and supplementation at 25% of the DM requirements with a mixture of 50% cottonseed cake and 50% wheat bran). Indeed, Zoundi *et al.* (2018) report, under these conditions, ADG of 33 g/day for Mossi sheep aged 5 to 18 months.

This allows us to say that the socobalo induces the best growth performance, followed by the fruits of *Cajanus cajan*, the control, then the cocoa bean fragments, and finally the leaves of *Cajanus cajan*. These observations, in relation to the results obtained, suggest that the differences in weight performance and the classification of the dietary supplements tested are linked to the nutritional values, which determine the growth performances.

The feed intakes over the three periods of experimentation varied according to the type of dietary supplement. The FI and CI values of the socobalo (SO group) were lower compared to those of the animals having received the cocoa bean fragments, the fruits and the leaves of *Cajanus cajan*. The socobalo induced higher average weights (AW), weight gains (WG) and ADG than the other supplements. It proved to be the most palatable and the richest in nutritional elements supplement.

The FI and CI of the animals supplemented with the leaves of *Cajanus cajan* presented high values, proof of their good palatability. Despite this, the animals showed low AW, WG and ADG, with high CI. Indeed, although rich in proteins, the leaves of *Cajanus cajan* have a high fiber content, which limits the availability of nutrients for digestion (Dossa *et al.*, 2019; Osei-Amponsah *et al.*, 2020; Da Silva *et al.*, 2021). It has been shown that the leaves of *Cajanus cajan* increase the consumption of coarse forages, which can result in a higher live weight (Oduro *et al.*, 2020).

After the animals supplemented with the leaves, those having received the fruits of *Cajanus cajan* presented the highest FI and CI. These animals also recorded AW, WG and ADG higher than those of the animals receiving the cocoa bean fragments, the leaves of *Cajanus cajan* and the control. This reveals that the fruits of *Cajanus cajan* have been palatable and constitute an important source of proteins (Yapo *et al.*, 2018; Adjolohoun *et al.*, 2021). For ruminants, the fruits *Cajanus cajan* can provide a high-quality feed, usable as a basic forage or as a dietary supplement. The plant produces a large quantity of biomass (Adjei *et al.*, 2020; Okello *et al.*, 2017; Shahzad *et al.*, 2019).

The low intake of cocoa bean fragments by sheep could be attributed to its low palatability, probably due to the presence of theobromine, an alkaloid toxic to animals, as well as its form of presentation (fragments). This observation is consistent with the findings of Oduro *et al.* (2021), who note low digestibility of cocoa in monogastric animals due to its high cellulose content (18%), theobromine (3%), and caffeine (1.5%).

The dry matter (DM) feed conversion ratios (FCR) obtained in this fattening trial are comparable to some results from studies conducted on sheep. Using a basal diet of Brachiaria supplemented with various by-products, Mensah *et al.* (2019) reported FCRs ranging from 6.9 to 21.3 kg DM/kg. Sanogo *et al.* (2016) reported FCRs ranging between 7.76 and 11.34 kg DM per kg. The FCRs in our trial are lower than those found by Kpara *et al.* (2017) when supplementing Panicum maximum with cottonseed hulls and cottonseed cake in Djallonké sheep in Benin. They are also lower than those reported by Adjayi *et al.* (2020) on Djallonké rams in Togo. This difference could be explained by the diet, the rearing method, and especially the age of the animals. This last hypothesis seems plausible because our animals were selected after weaning, while those cited by Adjayi *et al.* (2020) were between 15 and 18 months old. Indeed, several authors indicate that FCR increases with the age of the animals (Traoré *et al.*, 2018). For the age groups of 3-8, 9-12, 12-18, and over 18 months, they established increasing FCRs of 8.6, 10.7, and 13.9 kg DM/kg of weight gain, respectively.

Regarding the specific conversion rates (SCR) over the three trial periods, there were variations between the different feed supplements, with no significant difference between the groups.

CONCLUSION

The different feed supplements had significant effects on the growth performance of the sheep. In particular, *socobalo* and *Cajanus cajan* fruits resulted in the best growth performance in the sheep during the trials.

However, during the growth phase, the live weight of the animals decreased significantly in those receiving cocoa bean fragments and *Cajanus cajan* leaves. *Cajanus cajan* fruit is the best supplement after *socobalo* and can be proposed in rural areas for fattening and to reach maturity in sheep.

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