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Research Article

# *Borassus aethiopum, Desmodium tortuosum, Moringa oleifera* and *Stylosanthes guianensis*-Based Diets for Local Rabbit Does' Nutrition

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## ABSTRACT

**Objectives:** The fibre plays an important role in rabbit diets, and local sources include *Stylosanthes guianensis* (*Sg*), *Desmodium tortuosum* (*Dt*), and many other grasses. This experiment evaluated the lactogenic potential of *Borassus aethiopum* (*Ba*) dried fruit pulp, and *Moringa oleifera* (*Mo*) dried leaves and young stems. Specifically, their effect on local rabbit does litter size and kits' growth were examined. **Materials and Methods:** Six diets were prepared, including a control containing 25%*Sg* and 17% corn (*Zea mays)* (*Sg25%Zm17%*), 20% of *Sg* (*Sg20%*), 20% of *Ba* (*Ba20%*), 20% of *Dt* (*Dt20%*), 10% of *Ba* and 10% of *Mo (Ba10%Mo10%*), and 10% of *Sg* and 10% of *Mo* (*Sg10%Mo10%*). Sixty 4-month-old nulliparous does were divided into 6 groups of 10 each, and each group was fed on one diet. The litter sizes and milk production were recorded, and kits were weighed weekly for a month. **Results:** The mean litter size was 5.13±0.80 ($0.52 \leq p \leq 0.91$). But *Dt20%* diet performed better than other diets and had a litter size of 6 kits. Whereas *Ba20%* was the worst diet with a litter size of 4. For the milk production, *Ba10%*Mo10% diet showed good lactation from day 2 for 75.6 g to day-15 for 72.4 g. Finally, due to its corn, diet *Sg25%Zm17%* produced the best live weight for 450.67 g ($p<0.0001$). **Conclusion:** *Borassus aethiopum* and *Moringa oleifera* combinations can replace *Stylosanthes guianensis* in rabbit diets, as fibre sources.

**Keywords:** *Borassus aethiopum*, Litter size, Rabbit does' Lactation, *Stylosanthes guianensis*.

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## INTRODUCTION

Rabbit farming is an activity accessible to most people and requires little space. It has the potential to contribute significantly to food security and poverty reduction, due to its zootechnical possibilities (Akouango *et al.*, 2014). In Africa, several plants are used for animals' feed and medicinal purposes. Various studies have been conducted to improve nutrition to ensure better productivity and profitability in rabbit farms (Akpo *et al.*, 2015). *Parkia biglobosa* leaves' aqueous extract has demonstrated immunostimulatory activity in rabbits (Yapo *et al.*, 2012). Similarly, Kouakou *et al.* (2016) showed that *Euphorbia heterophylla* and *Ipomoea batatas* leaves can serve as supplements in rabbits and guinea pigs' diets. The leaves and stems of other plants considered weeds, such as *Centrosema pubescens* (Kimsé *et al.*, 2013) and *Tridax procombens* (Adeyemo *et al.*, 2014) promote good digestibility of organic matter, while significantly reducing production costs. Due to the derived animal products nutritional quality, characterized by a high polyunsaturated fatty acids content, a favorable HDL cholesterol level, and strong antioxidant capacity, these species are also valued for their dietary and medicinal properties (Kouakou *et al.*, 2015, 2016; Kouassi *et al.*, 2017). Furthermore, lactogenic plants are commonly used in rural areas to increase breast milk production (Sepehri *et al.*, 2000). So, the experiment hypothesis was that *Desmodium tortuosum, Stylosanthes guianensis, Moringa oleifera* forages, and *Borassus aethiopum* mature fruits can positively influence local rabbit does litter sizes and their lactation performance. The objective was to evaluate these forages effect of rabbit does litter sizes and lactation performance.

## MATERIALS AND METHODS

The experiment was conducted at the graduate school of agriculture experimental farm, at Institut National Polytechnique Félix Houphouët Boigny (INP-HB) at Yamoussoukro in Côte d'Ivoire, from February 5 to May 17, 2025. The pellet feeds were produced at the feed manufacturing plant located within this school.

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### Rabbit does and Accommodation

The experiment was conducted on nulliparous rabbit does. A total of sixty (60) local breed rabbit does, approximately four (4) months old, were used. These does have 1.56±0.23 kg an average weight. They were placed in individual maternity cages. They were divided into six groups, comprising five experimental groups and one control group. Each group contained ten (10) rabbit does. The maternity cages were in a shared building. Each cage was equipped with a feeder and a water reservoir.

### Feed chemical analyses

The different experimental diets were analysed. These analyses consisted of determining the Dry Matter (DM), ash, fat, crude protein, and crude fibre. Total fibre content was determined using the Fibertec System hot extractor. Furthermore, all analyses were performed according to AOAC standard (2004). In addition, their total carbohydrate content and associated Metabolizable Energy (ME) were determined according to FAO (2003) approach (Table 1).

### Experience

*Borassus* fruits were collected, peeled, and then dried in an oven for 5 days at 70°C. The material was then ground and packaged in bags before use. For *Desmodium, Moringa,* and *Stylosanthes* forages, the leaves were cut and left to dry in the shade in a room for a week. The forages were then ground into a powder and incorporated to the various diets. For the experiment, six diets were manufactured. A control diet consisted in 25% of *S. guianensis* forage and 17% of corn (*Zea mays*) (*Sg25%Zm17%*). While the experimental diets consisted in 20% of *D. tortuosum* (*Dt20%*), 20% of *Borassus aethiopum* mature fruits' dried pulp and peel together (*Ba20%*), 20% of *S. guianensis* (*Sg20%*), 10% *Borassus aethiopum* combined with 10% of *Moringa oleifera parts* (*Ba10%Mo10%*), and 10% of *S. guianensis* combined with 10% of *M. oleifera* (*Sg10%Mo10%*) (Table 1).

One week before the experiment' start, a dietary transition was implemented to facilitate a gradual adaptation of the rabbit does to the different diets. Before the essay began, the animals underwent internal deworming and received preventative antibiotic and vitamin treatment. Drinking water and feed were provided *ad libitum*. To ensure synchronized kindling, all matings were performed within a single week. The rabbit does' health and mortality were monitored daily. The experiment lasted 80 days, including 15 days of adaptation with the dietary transition, 30 days of gestation, and 35 days of lactation until weaning. The rabbit does and kits were weighed weekly. Moreover, the milk production was monitored daily for 35 days. Finally, the litter sizes were recorded at kindling.

### Milk quantity evaluation

The milk quantity was assessed daily throughout the breastfeeding period according to Maertens *et al.* (2006) (Eq. 1). In details, at 6 p.m., the rabbit kits were separated from the rabbit does. The following morning, at 8 a.m., the does were weighed before the rabbit kits nursed, again after the rabbit kits had nursed. The difference between the two weights represented the amount of milk consumed by the rabbit kits.

$$MQ(g) = BW(g) - AW(g) \quad \text{Eq.1}$$

MQ: Milk quantity; BW: Rabbit does' weight before suckling; AW: Rabbit does' weight after suckling.

### Rabbit kits' growth from birth to weaning

Each week, the rabbit kits were weighed, by taking account the diets.

### Litter size

After each birth, the number of rabbit kits was recorded. Diets were also considered.

### Statistical analyses

During the statistical evaluations, an Analysis of Variance (ANOVA) focusing on diet and days was applied, using Tukey's test. Factors such as milk production, rabbit kits' weights, and rabbit does litter sizes were compared within 95% confidence interval.

## RESULTS

The results concern the litter sizes, the overall milk production, the milk production according to the diets and the rabbit kits' growth according to the diets.

### Litter size

The different diets effect on rabbit does litter size is illustrated on Figure 1. Some important differences were reported among the diets. For example, *Dt20%* and *Sg10%Mo10%* had 6±0.71 and 5.8±0.45, respectively and were similar ($p$=0.997). Moreover, this leading group performance higher than that of *Ba20%* diet. Of course, *Ba20%* diet poorly performed for 4.2±0.45 rabbit kits per farrowing, and this result was inferior to the leading group output ($0.006 \leq p \leq 0.018$). Between these two groups, *Ba10%Mo10%, Sg20%*, and *Sg25%Zm17%* diets results were 4.8±0.45, 5.33±0.58 and 4.67±1.53, respectively. This transition group was like the leading group, and similar to *Ba20%* diet. It should be mentioned that rabbits fed on *Dt20%* and *Sg10%Mo10%* diets had litter sizes 28.48% and 24.46% larger, respectively, compared to the control *Sg25%Zm17%* diet. Similarly, rabbits fed on *Sg20%* and *Ba10%Mo10%* diets had litter sizes 14.38% and 4.72% larger, respectively, than the control diet.

## Milk production

The different diets effect on the rabbit does' milk production is on Figure 2. Looking at all rabbit does milk production performances; the top productions were reached between the 5th and 12th days (Figure 2a). From day-5 to day-12, the milk productions fluctuated between 64.81±4.44 g and 67.82±4.44 g, respectively. Thereafter, from day-14, the milk production declined and reached 63.06±4.44 g. Whereas, checking the diet effects on the milk productions, at the beginning of lactation, *Ba10%Mo10%, Dt20%*, and *Sg10%Mo10%* diets yielded 75.60, 85, and 56.33 g respectively, compared to 50 g for the control diet (Figure 2b). Diet *Dt20%* reached its maxima milk productions between day-3 for 85 g, and day-12 for 86 g. Alongside *Dt20%* diet performance, *Ba10%Mo10%* reached 82 g on day-6, and 84 g on day-12. The lowest quantities were obtained with *Ba20%* and *Sg20%* diets. Thus, the average quantity of milk produced by rabbits on *Ba10%Mo10%* and *Dt20%* diets differed by 25.6g and 35g, or 51.2% and 70%, respectively, compared to the control diet ($p<0.0001$). On day 12, milk production was higher with the Ba10%Mo10% and Dt20% diets, at 85.6 g and 86 g respectively, representing increases of 17.26% and 17.81%, compared to *Sg25%Zm17%* diet at 73 g. From day 29 onward, there was a general decline in milk production. However, from day-29, does fed on *Sg25%Zm17%* diet ceased producing milk, while those fed on the experimental diets continued to nurse their kits.

## Rabbit kits' weights (g)

During the first week, no significant differences were noted between the diets (Figure 3). Between the second and fifth weeks, significant differences were observed with *Ba10%Mo10%* and *Sg25%Zm17%* diets compared to other diets ($p<0.0001$). Between the fifth and seventh weeks, a large difference was noted, especially with the control diet. The average weight of the rabbit kits fed on *Sg25%Zm17%* diet was 450.67 g, while those feed on *Ba10%Mo10%* diet weighed 344.82 g. From week 5 onward, rabbit kits' weights of the control diet were higher. *Sg25%Zm17%* and *Ba10%Mo10%* diets showed better growth than other diets.

**Table 1: Experiment diets.**

| Ingredients | Diets | | | | | |
|---|---|---|---|---|---|---|
| | Sg25%Zm17% | Ba20% | Dt20% | Sg20% | Ba10%Mo10% | Sg10%Mo10% |
| Stylosanthes guianensis | 25 | | | 20 | - | 10 |
| Rice bran | 20 | 20 | 20 | 20 | 20 | 20 |
| Corn | 17 | - | - | - | - | - |
| Soybean meal | 10 | 10 | 10 | 10 | 10 | 10 |
| Copra cake | 15 | 15 | 15 | 15 | 15 | 15 |
| Cottonseed cake | 8 | 7 | 7 | 7 | 7 | 7 |
| Sugar cane molasses | 2 | 2 | 2 | 2 | 2 | 2 |
| Wheat bran | - | 23 | 23 | 23 | 23 | 23 |
| Borassus aethiopum | - | 20 | - | - | 10 | - |
| Desmodium tortuosum | - | - | 20 | - | - | - |
| Moringa oleifera | - | - | - | - | 10 | 10 |
| Salt (NaCl) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Egg shell | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Totals | 100 | 100 | 100 | 100 | 100 | 100 |
| Analyses | | | | | | |
| Dry Matter (DM) | 92.46 | 95.11 | 91.21 | 91.3 | 92.75 | 93.3 |
| Fat (%DM) | 8.75 | 7.85 | 8.35 | 8.4 | 9.5 | 9.63 |
| Ash (%DM) | 8.84 | 8.13 | 8.41 | 8.5 | 8.35 | 8.64 |
| Crude Protein (%DM) | 15 | 16 | 17 | 15 | 17 | 16 |
| ADF (%DM) | 14.84 | 19.34 | 15.65 | 13.5 | 18.6 | 10.66 |
| NDF (%DM) | 10.66 | 24.32 | 22.72 | 14.4 | 22.36 | 19.76 |
| Total carbohydrates (%DM) | 60 | 63.13 | 57.45 | 59.4 | 58 | 59.03 |
| ME (kcal/kg DM) | 3378.43 | 3448.34 | 3321.07 | 3330.18 | 3437.00 | 3450.97 |

Total Carbohydrates (Tot_Carb) = 100 - (proteins + lipids + + ash) /% (FAO, 2003).ME (kcal/kg DM) = [3.36×Protein + 8.37×Fat + 3.57×Total_Carbohydrate] ×10 (FAO, 2003).

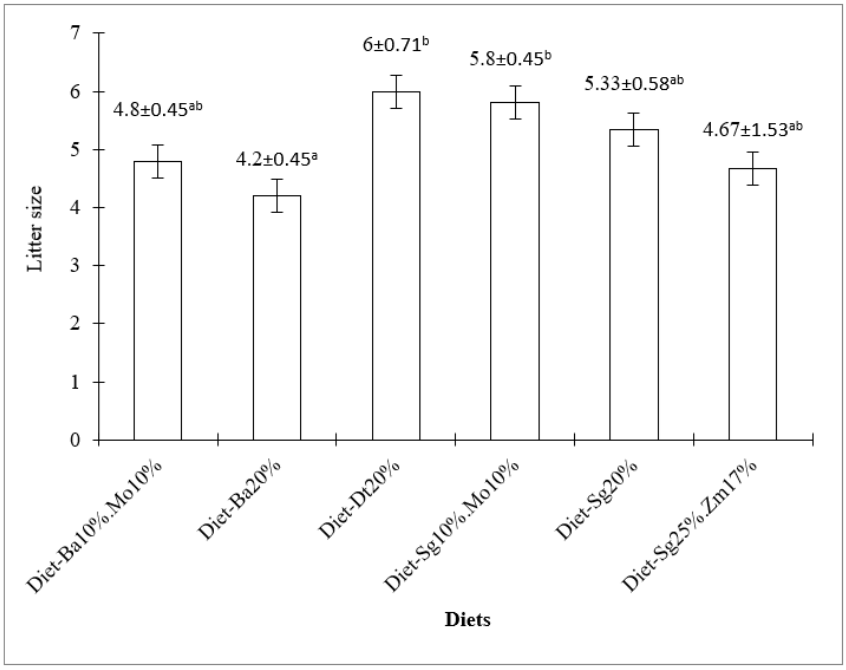



**Figure 1:** Rabbit does' litter size. n(*Ba10%Mo10%*)=45, n(*Ba20%*)=37, n(*Dt20%*)=52, n(*Sg10%Mo10%*)=53, n(*Sg20%*)=49, n(*Sg25%Zm17%*)=48; n=number of rabbit does fed on the diet.

These results indicate that *Sg25%Zm17%* and *Ba10%Mo10%* diets promoted to optimal growth for the rabbit kits.

## DISCUSSION

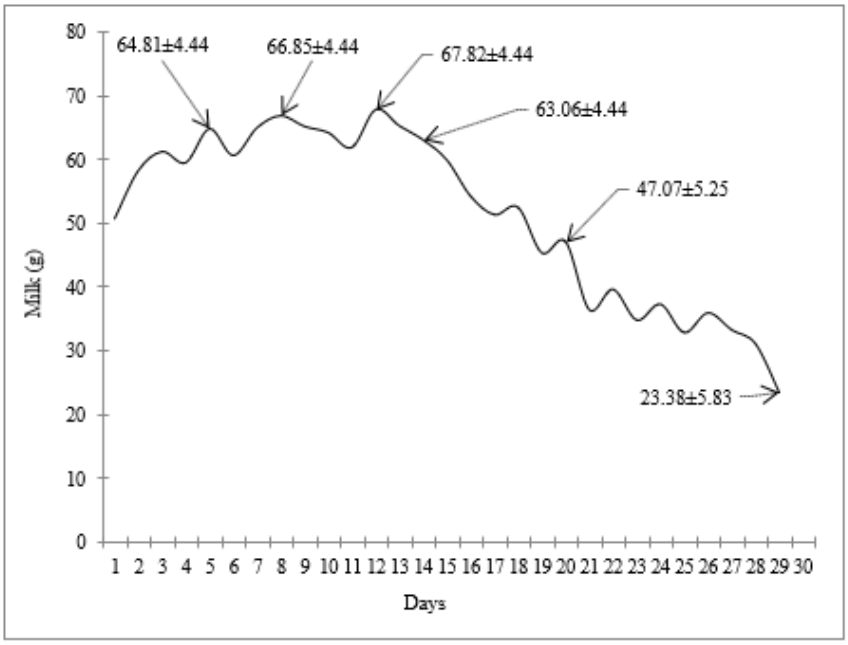
The experiment results showed no significant difference in litter size between the different diets. These results are like Koné *et al.* (2022) ones, who found a litter of 7.7 with a diet of *Desmodium tortuosum* leaves. The litter sizes with *Panicum maximum* diet were comparable to those of Toleba *et al.* (2017) in Benin. Museba *et al.* (2016) observed a litter of 6.25 rabbits with a legume-based diet. The litter size in females fed on *Desmodium tortuosum* diet (*Dt20%*) was like that reported by Hue-Beauvais *et al.* (2015). Also, Ludwiczak *et al.* (2021) noted a larger litter size in female Hycole. Similarly, Mweugang *et al.* (2016) indicated that the litter size range depends on several factors. In the present essay, the rabbit does were nulliparous, which could explain the observed small litter sizes, as nulliparous does generally have smaller litter size than multiparous does (Miégoué, 2018). Several studies showed that litter size increases with the litter number or rang (Zougou *et al.*, 2017; Zerrouki *et al.*, 2014). Consequently, these present findings confirm Zerrouki *et al.* (2012), Ngoula *et al.* (2009), and Sulistiawati *et al.* (2017) results. In fact, these authors obtained average litter sizes of 5.6, 6.4, and 5, respectively, with primiparous rabbit does.

During the lactation period, weight loss was observed regardless of diet with the rabbit does. This weight loss could be due to the amount of energy consumed by the rabbit does to produce milk, which is essential for the development for the rabbit kits (Michel and Bonnet, 2012; El-Azayem *et al.*, 2023). Also, the lactation affects the milk composition, particularly its fat content. For example, the linseed oil addition in rabbit does' diet improved milk production while altering the fatty acid profile. The optimal production observed in certain diets could be linked to their lactogenic properties of the components, which would stimulate the prolactin secretion, a hormone that promotes milk synthesis (Akouedegni *et al.*, 2013). Indeed, plant-derived polymers, such as galacturonic acid and β-glucan, are considered plant hormones. This suggests that animal cells could also respond to these hormonal messengers (Sawadogo *et al.*, 1989). Certain plants in the legume and Moraceae families are used to stimulate milk production in animals due to their lactogenic properties (Akouedegni *et al.*, 2013).

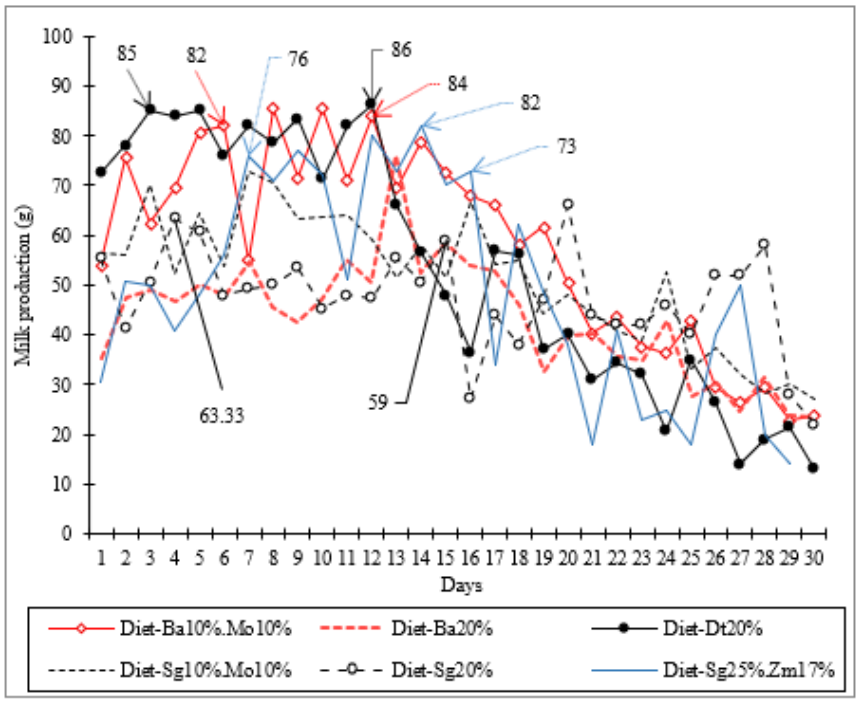
The milk quantities produced by rabbit does fed on *Dt20%* and *Ba10%Mo10%* diets could be linked to the intrinsic biological activities of these plants. Indeed, they promote efficient milk production through prolactin secretion. In fact, according to Sulistiawati *et al.* (2017) and Akouedegni *et al.* (2013), the presence of phytosterols and phenols in *M. oleifera* leaves exerts a significant influence on prolactin levels. Furthermore, *D. tortuosum* is a forage plant that remains relatively unknown and given the milk yield of rabbits fed on *D. tortuosum,* it is undeniably an excellent green forage. According to Morris *et al.* (2014), their analysis of flavonoid concentrations revealed an isorhamnetin production of 718 µg/g. They also examined its oil content and fatty acid composition, concluding that *Desmodium species* could serve as alternative feeds for livestock. Given the negative impact of hot climate on rabbit lactation (Hue-Beauvais *et al.*, 2015; Zerrouki *et al.*, 2014), current milk production could

have been improved. Zerrouki *et al.* (2014) and Hue-Beauvais *et al.* (2015) demonstrated that rabbits experience adaptation problems at temperatures of 30°C or higher, which significantly reduces their milk production potential. Furthermore, the lactogenic effect attributed to certain plants is thought to result from a combination of their nutritional content and substances that promote prolactin production in the pituitary gland (Sepehri *et al.*, 2000).

The rabbit does fed on diet *Sg25%Zm17%* showed better growth performance for their rabbit kits. These results are similar to those presented by Siviholya (2023), who showed that corn-based diets are better than grass-based (*Galinsoga ciliata*) diets. The




**a: All rabbit does' milk production ($n$=60).**




**b: Rabbit does' milk production according to the diets**

**Figure 2:** Rabbit does' milk production.

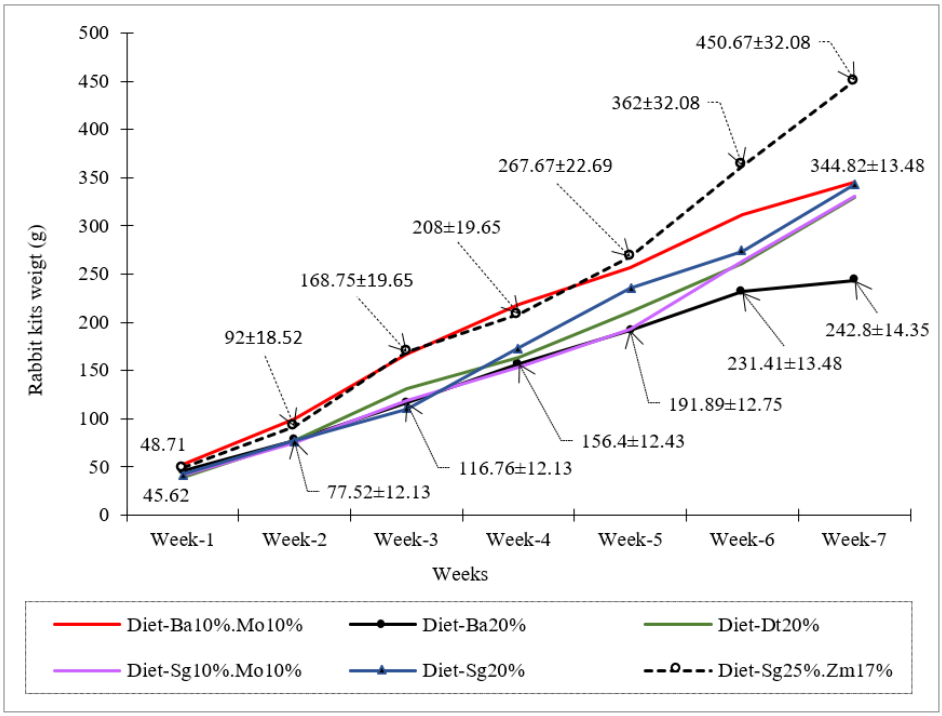



**Figure 3:** Rabbit kits' weights according to the diets and weeks.

soybeans' addition to these diets further increases growth. This could be related to the quality of the protein provided by the rabbit does, as kits, being herbivores, utilize plant protein more efficiently (Nkana *et al.*, 2020). These results confirm Miégoué *et al.* (2018) findings, who found that piglets fed on legumes weighed more than those in the control group. All piglets' groups saw an increase in weight, especially those fed on *Curcuma longa* powder. Chibah-Ait *et al.* (2015) noted that rabbits of the same strain had a higher average weaning weight at 35 days than that recorded in our study for 667 g versus 490 g. The additives' absence that could improve the feed palatability (Dosoky and Setzer, 2018; Sherif, 2018) may have limited feed intake in the young kits. From birth until day-21, rabbit kits feed entirely on their mother's milk, although they may begin to consume some hard maternal, deposited in the nest by the mother during the first week of lactation (Gidenne *et al.*, 2015).

## CONCLUSION

The experiment investigated the possibility of replacing the core *Stylosanthes guianensis* fibrous and the maize-based energy source in *Sg25%Zm17%* diet for rabbits' nutrition. To this end, 60 nulliparous does were divided into 6 groups of 10 each. Then, 5 experiment diets were formulated, *Dt20%, Sg20%, Ba20%, Ba10%Mo10%*, and *Sg10%Mo10%*. A group of rabbit does was randomly assigned to each diet. The experiment showed that the dried pulp and peels of ripe *B. aethiopum* ripe fruits, *D. tortuosum*, and *M. oleifera* forages were effective. Incorporating it into the rabbits' pelleted feed had no negative effect on the rabbit does' performance. Even better, rabbit does fed on *B. aethiopum* -based feed performed better. Associated with *M. oleifera* (*Ba10%Mo10%*) and *D. tortuosum* (*Dt20%*) had very good galactogenic effects. Rabbit does fed on *Ba10%Mo10%* and *Dt20%* diets produced on average 85.60 and 86 g of milk per day at the lactation peak, respectively. Thus, *B. aethiopum* combined with *M. oleifera* (*Ba10%Mo10%*), and *D. tortuosum* (*Dt20%*) could provide main nutrients for rabbits and replace the fibrous core of *Stylosanthes guianensis* and the corn in rabbit pelleted feeds. For a more qualitative approach, the fatty acid profiles of rabbit milk and meat could be analysed.

## ACKNOWLEDGEMENT

None.

## ABBREVIATIONS

**AW:** Rabbit does' Weight After Suckling; **BA:** *Borassus aethiopum*; **BW:** Rabbit does' weight before suckling; **DM:** Dry matter; **Dt:** *Desmodium tortuosum*; **ME:** Metabolizable energy; **Mo:** *Moringa oleifera*; **MQ:** Milk quantity; **Sg:** *Stylosanthes guianensis*; **Zm:** *Zea mays*.

## CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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## AUTHOR CONTRIBUTIONS

All authors contributed to the study conception and design. The material preparation and data collection were performed by Kan Adonise Yao and Kouassi Hervé Tani. They served the feeds to the animals, weighed the rabbits, and cleaned the cages. Tagouèlbè Tiho performed the statistical analyses. The first draft of the manuscript was written by Kan Adonise Yao and Kouassi Hervé Tani in French. This document has been translated in English by Tagouèlbè Tiho. Finaly, all authors commented on the translated versions. All authors read and approved the final manuscript.

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