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*Research Article*

# *Borassus aethiopum* (Arecaceae, Mart.) ripe fruits' dried peels and pulps as fibre and energy source for locally growing rabbits

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**Abstract**
Industrial feeds for rabbits are expensive in Cote d'Ivoire because the fibre sources are imported. So, in the aim to promote rabbit farming and decrease their feed cost, *Borassus aethiopum* ripe fruits' dried peels and fibrous pulp (*B.a*) were used as fibre sources in the local growing rabbits' diet. The essay assumed that *B.a* could be accepted by growing rabbits, and could positively impact their growth and immune system. Then, obtained from nulliparous does, one hundred and twenty (120) local growing rabbits (*Oryctolagus cuniculus*), weaned at week-5, were selected to form a homogeneous group regarding the weights. Following this, four diets were created, with a control without B.a (0%B.a), and three test diets named 20%*B.a*, 25%*B.a* and 30%*B.a* accordingly. The growing rabbits were randomly allotted in groups of 30 between the 4 diets. The experiment lasted 9 weeks. In week 14, 6 animals with homogeneous weights were slaughtered per diet, comprising 3 females and 3 males. Beginning with an overall mean weight of 775,2 g on the weaning day, at week-9, the overall weight reached 1,828.06 g. In detail, diet 20%*B.a* got the highest weight for 2,090.62 g while diet 0%*B.a* allowed 1,557.12 g ($p<0.0001$). Moreover, the corresponding consumption indexes were 5 and 7.74 for 20%*B.a* and 0%*B.a* diets, respectively. Following the red blood cells' count was improved from $4.05*10^6$/µL with diet 0%*B.a* to $4.8*10^6$/µL ($p=0.011$) with diet 20%*B.a*. So, *B.a* ripe fruits' dried peels and pulps can be used as fibre sources for local growing rabbits' feeding.

**Keywords**: *Borassus aethiopum,* Consumption index, Fibre source, Local growing rabbits, *Stylosanthes guianensis*

## INTRODUCTION

The rabbit is a suitable animal for self-subsistence (Mukaila, 2023). Indeed, it manages to produce high-quality proteins from fodder while remaining within the capacities of poor families (Mukaila, 2023). Compared to many other animals, rabbits' economy in terms of space management and exploitation is less, and their yield is negligible. In fact, the feed represents approximately 70% of the animals' production cost due to the high cost of raw materials. These high costs are notably due to those of proteins and fibres (Mukaila, 2023). Thus, the present test aimed to improve rabbits' feeding by ensuring good productivity, and better economic profitability. Overall, fodder constitutes the main source of fibre in rabbit diets. Indeed, it reduces the feed cost by reducing commercial pellets incorporation rate. But according to Mukaila (2023), the availability and quality of fodder constitute irrefutable constraints for the expansion of rabbit farming.

In this perspective, the dried peels and pulps of Borassus aethiopum's ripe fruits were used as fibre sources in the diets of local rabbits. Despite the nutritional qualities of these large and pulpy fruits when ripe, they are prone to spoiling in the wild due to their short shelf life after dropping and their high fibre content (Yao *et al*., 2023). In addition, they have significant contents of total sugars for 4.47-5.62%, protein for 0.73-0.85%, carotenoids for 26.61-27.42%, calcium for 107.61-108.25 mg/100g FM, and C for 134.82-171.33 mg/100g

FM. When the pulp was dried at 70 °C, fatty acid profile analysis revealed that 76% of the fatty acids were unsaturated. Similarly, Moon *et al*. (2020) reported that 73 -78% of the unsaturated fatty acids are present in *Borassus flabeliffer* pulp. Moreover, this dried pulp is very energetic, as its provides more than 3600 kcal per kg of dry matter (Tiho *et al*., 2018).

In order to take advantage of this potentially valuable and not industrially exploited resource, *B. aethiopum* ripe fruits' dried peels and pulps (*B.a*) were used as fibre and energy source in the diets of growing local rabbits. The hypothesis was that growing local rabbits would consume *B. aethiopum* mature fruits' dried peels and pulps, and the dried materials' incorporation rate would have an effect on animals' growth, and their blood cells' count. Thus, the subsequent objectives were to monitor the growth of local rabbits as a function of weeks and gender, and to determine their blood cell counts after 9 weeks of fattening.

## MATERIALS AND METHODS

In Côte d'Ivoire, located on the coast of western Africa, the term "local rabbit" refers to rabbits raised throughout the country. In reality, no national rabbit research program has been conducted in research institutes. Instead, private companies involved in the rabbit business have imported breeding animals. They crossbred and bred them for their commercial needs. Subsequently, rabbit breeders have lent or purchased breeding animals from each other. Ultimately, no purebred rabbits are available in Côte d'Ivoire. The study involved four diets and 120 growing local rabbits (*Oryctolagus cuniculus*), divided into 30 animals per diet, with 15 females and 15 males in each set. There were 3 replicates of 10 animals per diet. The diet 0%*B.a*, without *Borassus aethiopum* ripe fruits' dried peels and pulps, served as a control, and its pellets were made with *S. guianensis* as fibre and energy sources. In addition, three experimental diets contained 20, 25 and 30% of *B. aethiopum* mature fruits' dried peels and pulps. The experiment was conducted at the Laboratory of Animal Science, National Polytechnic Institute Felix Houphouet Boigny (INP-HB) in Yamoussoukro, Côte d'Ivoire, from June 13th to September 13th, 2024, during a rainy and hot season.

### Experimental diets, housing and animals

Following Yao *et al*. (2023) approach, *B. aethiopum* (*B.a*) mature fruits were collected from the National Polytechnic Institute Felix Houphouet Boigny (INP-HB) compound and in the surrounding villages from December 2023 to May 2024. Moreover, they were sorted and peeled. Following, the hard peels and their fibrous pulps were dried. After drying, the products were crushed and incorporated in the experimental diets. In fact, the diets consisted of a 0% *Ba* control diet without B. a and containing only S. guianensis (Sg) forage as the fibre source. Then, the following test diets were 20%*B.a*, 25%*B.a* and 30%*B.a* without *Sg* and containing 20%, 25% and 30% of *B.a* ripe fruits' dried pulps and peels, respectively (Table 1). During the test, females and males were separated. Additionally, for each diet, there were 5 boxes containing 3 females and 5 other boxes containing 3 males. Taking into account the gender, there were 10 boxes per diet. Overall, 40 test boxes were randomly assigned to the diets' tests. The diets were isoenergetic, and had similar protein content.

The weaned local rabbits weighed 775,2g on average at day 35. A homogeneous group was constituted by discarding animals with weights outside the interval of confidence (Eq. 1). Additionally, weaned rabbits were housed in groups of three animals per cage. The cage dimensions were 60 cm x 50 cm x 25 cm, corresponding to the length, width, and height, respectively. To conclude, the animals were fed ad libitum throughout the experiment until 98 days of age, but their feed intake was rationed.

$$\mu - \delta \leq \mu \leq \mu + \delta \quad \text{Eq. 1}$$

Only animals with weights in this range were used.
Where $\mu$ is the population mean, $\delta$ is the standard error.

### Local rabbits' growth and their health state during their fattening period

The animals' growth was monitored individually by a weekly weighing. To avoid wasting pellet feed, according to their live weights, the weaned local growing rabbits received 50, 75, and 100 g of feed per day per animal (El-Sawy *et al*., 2023). Ingestion was assessed daily by group by determining the difference between feed intake and feed refusal. These weightings were used to determine average daily gain (ADG), and feed conversion ratio (FCR). Moreover, the health of all animals was checked twice daily, at 8 AM and 4 PM, to identify any dead or sick animals. Additionally, Excel software was used to calculate the weekly weight gain using its trend curve and the coefficient of determination ($R^2$).

$$Weight(g) = a(Age\_week) + b;\ R^2 \quad \text{Eq. 2}$$

The equation y = ax + b represents an affine function, where ''a'' is the slope and ''b'' is the intercept.

### Blood sampling

Following the approach of Heimann *et al*. (2021), blood was collected from a marginal ear vein for biochemistry analysis and blood cell count. To do so, six animals with similar weights were randomly selected per group, consisting of three females and three males. As recommended, a quantity of 5 mL was collected per animal

**Table 1.** Experimental diets and their analyses

| Ingredients | 0%B.a | 20%B.a | 25%B.a | 30%B.a | Sg hay | B.a |
|---|---|---|---|---|---|---|
| Cottonseed cake | 14 | 13 | 17 | 17 | | |
| Copra cake | 20 | 26 | 21 | 20 | | |
| Rice flour | 18 | 25 | 23 | 16 | | |
| Wheat bran | 19 | 12 | 10 | 13 | | |
| Eggshell | 3 | 3 | 3 | 3 | | |
| Salt | 1 | 1 | 1 | 1 | | |
| Stylosanthes guianensis (Sg) | 25 | - | - | - | | |
| Borassus aethiopum (B.a) | 0 | 20 | 25 | 30 | | |
| Total | 100 | 100 | 100 | 100 | | |
| Bromatology analyses | | | | | | |
| Dry matter (%) | 88.42 | 89.19 | 88.40 | 88.14 | 84.8 | 92.53 |
| Fat matter (%DM) | 3.79 | 2.15 | 2.90 | 2.06 | 2.0 | 4.1 |
| Ash (%DM) | 10.52 | 12.70 | 10.43 | 11.10 | 6.9 | 4.3 |
| Crude protein (%DM) | 18.61 | 18.22 | 18.19 | 18.32 | 10.4 | 8.9 |
| Crude cellulose (%DM) | 33.57 | 34.37 | 31.82 | 33.05 | 35.6 | 17.6 |
| Tot_Carbohydrate | 67.08 | 66.93 | 68.48 | 68.52 | | |
| Gross Energy (kcal/kg) | 4,081.62 | 3,899.62 | 4,030.44 | 3,960.36 | | |

*B.a*: *Borassus aethiopum* ripe fruits' dried peels and pulps; 0%*B.a*: Control diet without *B.a*; 20%*B.a*, 25%*B.a*, 30%*B.a* diets containing *B.a* for 20%, 25% and 30%, respectively; *Sg*: *Stylosanthes guianensis;* Total_Carbohydrate=100-[CP(%)+Fat(%)+Ash(%)] (Weiss, and Tebbe, 2019); Gross Energy (Mcal/kg) = 0.056*CP(%)+0.094*Fat(%)+0.042*Total_Carbohydrate (Weiss, and Tebbe, 2019)

and placed in tubes containing an anticoagulant (EDTA). Less than 30 minutes after blood collection from animals, following centrifugation for plasma separation, the samples were stored at 4 °C in a container and transported to the analysis centre, where they were analysed within the next 30 minutes. Of course, Heimann *et al*. (2021) advised that not more than 20% per kilogram of the live body weight should be collected. Then, haematological parameters, including red and white blood cells, haemoglobin, haematocrit, and mean corpuscular volume (MCV), were measured using a Sysmex KX-21N haematology robot (Zhejiang Xinke Medical Technology Co., Ltd., Zhejiang city, China).

**Animal ethical approval**

The Graduate School of Agriculture at the National Polytechnic Institute Félix Houphouët-Boigny (INP-HB) in Côte d'Ivoire maintains a close research collaboration with the University of Rennes in France. Thus, the rabbits were raised following regulations relating to animal care. Additionally, these provisions outline the conditions of housing, feeding, and care for animals used in research, in accordance with European Directive 86/609. Thus, all precautions regarding live animals used in scientific experiments were respected, in accordance with French national authorisation No. 3502 issued to the University of Rennes by the French Ministry of Agriculture.

**Statistical analysis**

Statistical analyses were performed by using XLSTAT software. Analysis of variance at the 5% threshold was used to compare the values of each parameter. Interactions between diet, gender and period were studied. The means comparison within each group for the different parameters was made using the SNK procedure. Differences were considered statistically significant at 5% level, within a 95% confidence interval.

## RESULTS AND DISCUSSION

The results covered the parameters such as daily weight gain (DWG), feed conversion ratio (FCR), and blood cell counts (BCC).

**Rabbits' growth**

*Borassus aethiopum* ripe fruits' dried peels and pulps incorporation from 20 to 30% into local growing rabbits' diets adversely affected animals' growth and health. The results showed a significant difference between the control and experimental diets containing *B. aethiopum* dried products (Table 2). In the control diet, there were scabies' cases. For diets containing *B. aethiopum* ripe fruits' dried pulps-peels, rabbits died with swollen bellies. This could be due to the high level of fermentable sugars in the *B. aethiopum* mature fruits' dried pulp. pulp (Van-Der-Sluis *et al*., 2024) . The autopsy showed stomachs filled with air. In fact, Van-Der-Sluis 2024 *et*

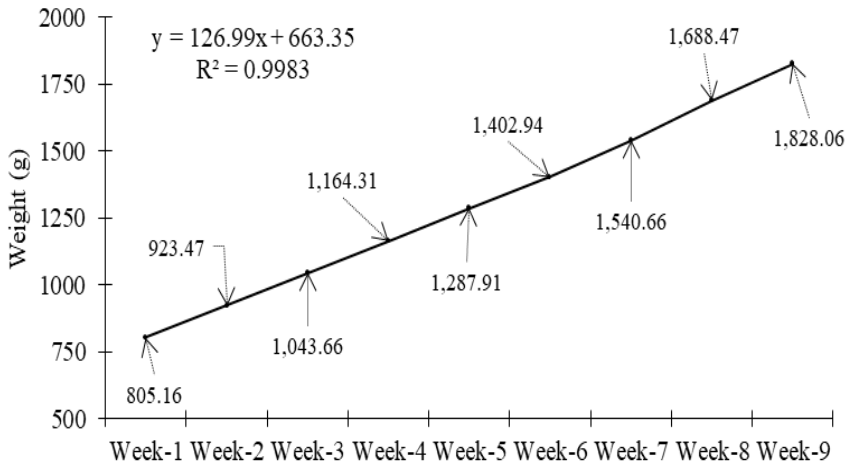


**Fig. 1**. *Rabbits' growth over the weeks*

*al*. (2024) revealed that high input of fermentable substrate in rabbit diets leads to hyper-fermentation and organic acid production. Unfortunately, this important acid production allows an overgrowth of pathogenic microflora. Considering the works of Tiho *et al*. (2018) and Mahilrajan *et al*. (2025), it is established that *B. aethiopum* dried pulps are a very energetic base due to their important sugar contents. Still, Daboussi *et al*. (2025) and Van-Der-Sluis *et al*. (2024) recalled the fibres importance in rabbits' diets, because its insufficient amount can be dramatic (Van-Der-Sluis *et al*., 2024).

**Overall growth and average daily gain**

Beginning with 775,2 g on average at day-35, the weaning day, during the fattening period, the overall animals' growth followed the equation 2 tendency curve (Fig. 1, $R^2$=99.83%). From week-1 to week-9, the animals had a constant growth without any stagnation. So, from 775,2 g, the animals gained 1,052.86 g after 9 weeks of fattening, with diets made without any cereal, and reached 1,828.06 g general average weight. But, all the diets did not exhibit the same average daily gain (ADG).

**Daily weight gain and feed conversion ratio**

Screening only the diets' effect on rabbits' growth (Table 3), first, diet 20%*B.a* produced the higher ADG for 23.13 g (p<0.0001). This output was supported by 5 g/g for the consumption index. Second, it was followed by diet 30%*B.a* with 19.02 g, and this daily weight gain was significantly higher than those of diets 25%*B.a* and 0%*B.a* (p<0.0001). This second performance had a consumption index of 5.97 g/g. Finally, diets 25%*B.a* and 0%*B.a* formed a uniform group with an average daily weight gain of 15.42 g. Kimsé *et al*. (2017) used the local rabbit breed and compared the effect of a pure commercial pelleted diet with the addition of *Pueraria phaseoloides* forage in the test diet. Thus, these tests confirmed the importance of fibres in rabbit diets (Daboussi et al., 2025; Van der Sluis *et al*., 2024).

When they assessed the effect of both diets on the growth of local rabbits, they reported a daily weight gain of 21.2 and 23.2 g for the pure commercial pelleted diet and the one with forage, respectively. Also, they reported an overall 5.8 g/g for the consumption index, from the weaning to day-90. Likewise, they had low consumption indexes in the younger stages, from day 35 to day 63 (week 9). Generally, ongoing results, daily weight gains, and consumption indexes were similar to those announced by Kimsé *et al*. (2017) for the diet supplemented with *Pueraria phaseoloides* forage. Moreover, examining the interaction between diets and gender (diets*gender), when animals were fed the same diet, males and females exhibited different growth patterns. For instance, under diet 30%*B.a*, while males grew at 20.67 g per day, females grew poorly at 17.37 g (p < 0.0001). Additionally, when the diagnostic focused

**Table 2**. Rabbits' mortality rate according to the diets

| Diets | Initial number | Dead number | Final number | Mortality rate (%) |
|---|---|---|---|---|
| 0%B.a | 30 | 4 | 26 | 13.33 |
| 20%B.a | 30 | 5 | 25 | 16.67 |
| 25%B.a | 30 | 6 | 24 | 20.00 |
| 30%B.a | 30 | 6 | 24 | 20.00 |
| Totals | 120 | 21 | 99 | 17.50 |

only on the weeks, weeks 7, 8, and 9 formed one group and performed better than weeks 1, 2, 3, 4, 5, and 6. Altogether, weeks 7, 8, and 9 allowed, on average, 20.56 g, which was significantly higher than the 17.09 g from the remaining diets ($p < 0.0001$).

Recently, the corn was very expensive in Cote d'Ivoire, reaching 300 fr CFA ($US 0.5) per kilogram. So, without any corn and commercial pellets, these ongoing ADG from diets exempt from corn may be considered good or at least acceptable. Elsewhere, Ouedraogo *et al*. (2021) obtained an ADG of 27.04 g, higher than the current results, with fattening rabbits fed on a diet containing commercially concentrated pellets supplemented with *Amaranthus hybridus*, papaya leaves (*Carica papaya*). Also, their control diet contained only concentrated commercial pellets. Likewise, Ognika *et al*. (2021) obtained 28 g for the ADG. This variability in growth between the animals used in the present experiment and those in other authors' studies may be largely explained by the composition of the feeds.

Additionally, Daboussi *et al*. (2025) supplemented the rabbit diets with barley at a concentration of 18 to 21% as an energy source. Equally important, Ibitoye *et al*. (2020) used 52.21% of corn, sorghum, or millet as en-

**Table 3.** Average daily gain (ADG) and feed conversion ratio (FCR) according to diets, gender, weeks, diet*gender

| Parameters | ADG (g), $\mu$ ±SE | FCR, $\mu$ ±SE |
|---|---|---|
| ***Diets*** | | |
| 20%*B.a* | 23.13±0.39$^{a}$ | 5.00±0.15$^{d}$ |
| 30%*B.a* | 19.02±0.39$^{b}$ | 5.97±0.15$^{c}$ |
| 25%*B.a* | 15.90±0.39$^{c}$ | 7.23±0.15$^{b}$ |
| 0%*B.a* | 14.94±0.39$^{c}$ | 7.74±0.15$^{a}$ |
| *p-value* | *<0.0001* | *<0.0001* |
| ***Gender*** | | |
| M | 18.60±0.22 | 6.61±0.12 |
| F | 17.90±0.32 | 6.36±0.08 |
| *p-value* | 0.073 | 0.10 |
| □±SE | *18.25±0.27* | *6.48±0.10* |
| ***Diets-gender*** | | |
| 20%*B.a**M | 23.14±0.45$^{a}$ | 5.01±0.17$^{d}$ |
| 20%*B.a**F | 23.13±0.64$^{a}$ | 4.99±0.24$^{d}$ |
| 30%*B.a**M | 20.67±0.45$^{b}$ | 5.36±0.17$^{d}$ |
| 30%*B.a**F | 17.37±0.64$^{c}$ | 6.58±0.24$^{c}$ |
| 25%*B.a**M | 16.48±0.45$^{cd}$ | 6.96±0.17$^{bc}$ |
| 0%*B.a**F | 15.76±0.64$^{cde}$ | 7.36±0.24$^{b}$ |
| 25%*B.a**F | 15.33±0.64$^{de}$ | 7.49±0.24$^{b}$ |
| 0%*B.a**M | 14.11±0.45$^{e}$ | 8.13±0.17$^{a}$ |
| *p-value* | <0.0001 | <0.0001 |
| ***Weeks*** | | |
| Week-8 | 21.12±0.58$^{a}$ | 7.40±0.21$^{a}$ |
| Week-9 | 20.88±0.58$^{a}$ | 7.42±0.21$^{a}$ |
| Week-7 | 19.67±0.58$^{a}$ | 7.35±0.21$^{a}$ |
| Week-5 | 17.66±0.58$^{b}$ | 5.89±0.21$^{b}$ |
| Week-4 | 17.24±0.58$^{b}$ | 5.80±0.21$^{b}$ |
| Week-2 | 17.17±0.58$^{b}$ | 5.84±0.21$^{b}$ |
| Week-3 | 17.17±0.58$^{b}$ | 5.80±0.21$^{b}$ |
| Week-1 | 16.90±0.58$^{b}$ | 5.80±0.21$^{b}$ |
| Week-6 | 16.43±0.58$^{b}$ | 6.37±0.21$^{b}$ |
| *p-value* | <0.0001 | <0.0001 |

SE: standard error, □: population mean, *B.a*: *Borassus aethiopum* ripe fruits' dried peels and pulps; Under the same parameter, in the same column, means with the different superscripts (a, b, c, d, e, f, g, h) are statistically different, according to SNK procedure multiple means ranking test (α=0.05)

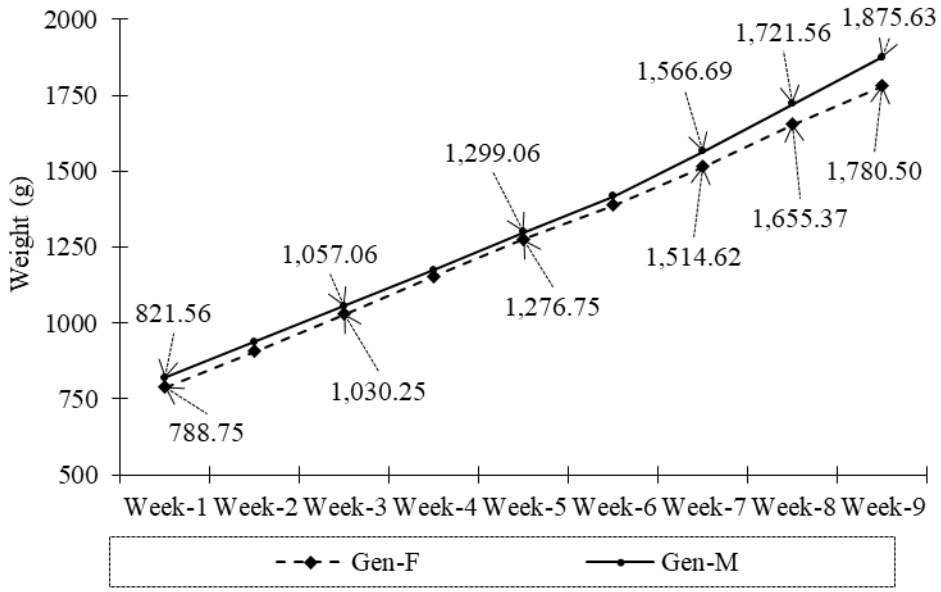


**Fig. 2**. *Rabbits' growth according to weeks and gender*

ergy sources in the rabbit diets. In consequence, in these conditions, the rural areas rabbits' breeders are constrained to be in touch with animals' feedstuff sellers in town. In developing countries, where there is no pure local breed, the rabbits used are the result of poorly controlled crossbreeding under artisanal conditions. Therefore, the lack of a rigorous selection program and control may impact their growth performance (Kimsé, 2017).

**Rabbits' growth following the gender and weeks**

Looking at the gender, from the start, males' weights were slightly heavier than females' ones. For example, at the end of week 1 (Fig. 2), males weighed 821.56 g, while females weighed 788.75 g, resulting in a sexual dimorphism favouring males. Although the gap of 32.81 g was insignificant (p = 0.54), it represented a 4% weight loss. Similarly, on week-9, the males weighed 1,875.63 g, while the females weighed 1,780.50 g. Clearly, the gap increased and reached 95.13 g, so 5% weight loss (p=0.077). Similarly, Lamptey *et al*. (2022) found that male rabbits' weight exceeded that of females from week-8 to week-12. As an illustration, at week 12, the females weighed 1,255 g versus 1,261 g for the males (Lamptey *et al*., 2022; p = 0.89). Furthermore, that gap continued to grow and reached 41 g at week 20, when females weighed 2070 g versus 2111 g for the males (Lamptey *et al*., 2022; p = 0.384).

**Rabbits' growth following the diets and weeks**

Following the weeks, the incorporation rates of *B. aethiopum* ripe fruits' dried peels and pulps in the diets were the main effects on rabbits' growth. This was because, in week 9 (Fig. 3), the highest weight was recorded with diet 20%*B.a*, followed by 30%*B.a*, 25%*B.a* and 0%*B.a*, for 2,093.63 g, 1,921.25 g, 1,740.25 g and 1,557.13 g, respectively. The diets 20%*B.a* and 30%*B.A constituted a homogeneous leading group (p* = 0.058). Then, it may be concluded that 20% *B.a and 30% B.a* delivered on average 2,007.44 g, on week-9. However, 172.38 g intra group gap, from 20%*B.a* to 30%*B.a* represented 8.23% weight loss. Finally, diet 20%*B.a* output was highly superior than those of 25%*B.a* and 0%*B.a* (p<0.0001). Comparatively, the performance of diets based on dried products of *B.* aethiopum ripe fruits may be due to their high fibre and sugar content (Mahilrajan *et al*., 2025). Moreover, these dried products exhibit high antioxidant activity due to their high polyphenol content (Yao *et al*., 2023). Importantly, they contained around 76% of unsaturated fatty acids (Tiho *et al*., 2018). Likely, Ouedraogo *et al*. (2021) obtained an average weight of 1,700.67 g in week 8. Additionally, without any cereal in the feed, the ongoing results were similar to those of 1,686.13 g and 1,782.53 g, which were obtained with concentrated feed supplemented with papaya leaves and Amaranthus hybridus leaves, respectively (Ouedraogo *et al*., 2021). So, these findings confirm that adding local ingredients to rabbits' diets may be a good way to reduce feed costs and sustain good growth.

**Diets' effect on rabbits' haematological parameters**

Several hematological parameters were assessed to understand *B. aethiopum* ripe fruits' dried peels and pulps' effect on rabbits' health (Table 4). So, average white blood cells' number (WBC) per micro-liter, red blood cells' number (RBC) per micro-liter, mean corpuscular haemoglobin (MCH), which quantifies the amount of haemoglobin per red blood cell, mean corpuscular haemoglobin content (MCHC), which indicates

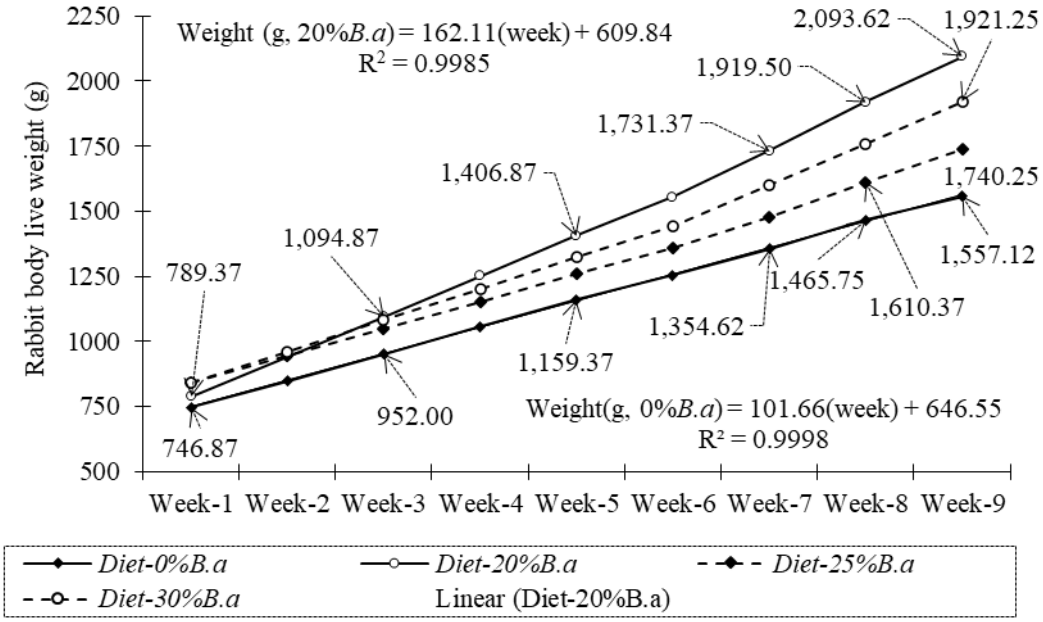


**Fig. 3.** *Rabbits' growth according to the weeks and diets*

the amount of haemoglobin per unit volume, mean corpuscular volume (MCV) in femto-liter, haemoglobin (HGB), and haematocrit (Ht) is a ratio of the packed cells to total volume, were determined. The tests revealed that diets had significant effects on certain haematological parameters.

**White blood cells' content**

Considered a good indicator of animals' immune status (Ibitoye *et al*., 2020), white blood cells (WBCs) play important roles in the body. For example, WBC defends the body against infectious diseases and foreign materials. Here, the contents of white blood cells did not show significant variations following the diets (Table 4; $p > 0.05$). So, the overall mean was $7.07\times10^3$/µL. It could be concluded that no diet had an adverse effect on growing rabbits' health, through the blood system. The rabbits' mortality with swollen bellies were due to digestive disorders. Notably, the antibacterial, antioxidant, anti-thrombotic, and anti-inflammatory activities of *Borassus spp.* plant parts have been reported (Banu *et al*., 2021). Even so, compared to 0%*B.a*, the highest WBC value was obtained with diet 25%*B.a* for $7.70\times10^3$/µL, and it represented 13.57% increase of $6.78\times10^3$/µL for diet 0%*B.a*. In fact, all these contents were within the 5.8-7.5×10^3/µL range, as announced by Ahmad and Lashari (2022). Focusing on the interaction (gender*diet), apart diet 25%*B.a* whose females' WBC values were higher than those from the males, for 9.40 and $6.00\times10^3$/µL, respectively ($p<0.0001$), all the remaining diets' WBC contents were similar. Referring to Tanczos *et al*. (2021), Californian-New Zealand hybrid rabbits' WBC content depended on the diet. Indeed, from a control to a high-cholesterol diet, WBC content increased from 8.37 to 23.59 × 10^3/µL ($p < 0.0001$). So, they concluded that when important dietary cholesterol is added to the diet, the count of white blood cells tends to increase. In contrast, herein WBC content did not change according to the diets.

The results indicated that the local growing rabbit females were very sensitive to the 25%B.a diet. Indeed, the 25%*B.a* diet induced the production of abundant antibodies and strengthened the immune system. With attention to *Borassus spp*. Pulp has a high content of unsaturated fatty acids at 76% (Tiho *et al*., 2018) and offers interesting health benefits (Banu *et al*., 2021; Mahilrajan *et al*., 2025). Moreover, it is an important dietary cholesterol source. Like the extruded linseed (Daboussi *et al*., 2025), the incorporation of *B. aethiopum* pulp in rabbits' diet admits an optimum incorporation rate. Above this level, the dietary cholesterol source becomes toxic. As observed by Daboussi *et al*. (2025), the incorporation of 2.5% extruded linseed in the rabbit diet yielded better results than 5%. Compared to other diets, diet 25%*B.a* should not be desired because it did not positively impact the rabbits' growth. In contrast, the remaining diets formed a homogeneous group, and the animals' leucocyte average content was 6.73 × 10^3/µL.

**Reb blood cells**

In terms of red blood cells' contents (RBC, Table 4), the differences between diets were significant ($p=0.015$). Because the red blood cells' main role is oxygen transport in the body, the higher their content, better is the diet. Thus, 20%*B.a*, and 30%*B.a* diets with RBC contents of 4.80 and $4.43\times10^6$/µL may be the most suitable. Particularly, diet 20%*B.a* had similar content of WBC than 25%*B.a* for $\underline{7.07}\times10^3$/µL ($0.126\leq p\leq0.574$), meaning an identical immune system level. Better, diet

**Table 4**. Diets, gender, and diet-gender effect on blood cell counts

| | WBC ($10^3$/µL) | RBC ($10^6$/µL) | HGB (g/dL) | Ht(%) | MCV(fL) | MCH(pg) |
|---|---|---|---|---|---|---|
| **Diets** | | | | | | |
| 25%*B.a* | 7.70±0.39 | 4.05±0.16$^{b}$ | 13.35±0.36$^{a}$ | 40.90±1.2$^{a}$ | 49.65±0.71$^{a}$ | 17.70±0.75$^{a}$ |
| 30%*B.a* | 7.38±0.39 | 4.43±0.16$^{ab}$ | 11.57±0.36$^{b}$ | 35.52±1.2$^{b}$ | 42.73±0.71$^{b}$ | 16.10±0.75$^{ab}$ |
| 0%*B.a* | 6.78±0.39 | 4.05±0.16$^{b}$ | 11.61±0.36$^{b}$ | 34.37±1.2$^{b}$ | 42.43±0.71$^{b}$ | 14.25±0.75$^{ab}$ |
| 20%*B.a* | 6.40±0.39 | 4.80±0.16$^{a}$ | 12.28±0.36$^{ab}$ | 37.27±1.2$^{b}$ | 43.05±0.71$^{b}$ | 16.38±0.75$^{b}$ |
| p-value | 0.126≤p≤0.574 | 0.015 | 0.010 | 0.008 | <0.001 | <0.001 |
| $\mu\pm\delta$ | 7.07±0.39 | | | | | |
| **Gender** | | | | | | |
| F | 7.30±0.28 | 4.43±0.11 | 12.24±0.26 | 37.40±0.85 | 45.58±0.51$^{a}$ | 16.58±0.53 |
| M | 6.83±0.28 | 4.23±0.11 | 12.17±0.26 | 36.63±0.85 | 43.35±0.51$^{b}$ | 15.63±0.53 |
| p-value | 0.249 | 0.227 | 0.852 | 0.529 | 0.006 | 0.224 |
| $\mu\pm\delta$ | 7.07±0.28 | 4.33±0.11 | 12.20±0.26 | 37.01±0.85 | | 16.11±0.53 |
| **Diets-gender** | | | | | | |
| 25%*B.a**F | 9.40±0.55$^{a}$ | 4.10±0.23$^{ab}$ | 12.90±0.51$^{ab}$ | 40.30±1.7$^{a}$ | 50.80±1.01$^{a}$ | 18.60±1.06 |
| 30%*B.a**F | 7.13±0.55$^{b}$ | 4.83±0.23$^{ab}$ | 12.43±0.51$^{ab}$ | 37.43±1.7$^{ab}$ | 45.00±1.01$^{b}$ | 17.40±1.06 |
| 20%*B.a**F | 6.10±0.55$^{b}$ | 5.00±0.23$^{a}$ | 12.73±0.51$^{ab}$ | 40.13±1.7$^{a}$ | 44.60±1.01$^{b}$ | 16.33±1.06 |
| 20%*B.a**M | 6.70±0.55$^{b}$ | 4.60±0.23$^{ab}$ | 11.83±0.51$^{ab}$ | 34.40±1.7$^{ab}$ | 41.50±1.01$^{b}$ | 16.43±1.06 |
| 25%*B.a**M | 6.00±0.55$^{b}$ | 4.00±0.23$^{ab}$ | 13.80±0.51$^{a}$ | 41.50±1.7$^{a}$ | 48.50±1.01$^{a}$ | 16.80±1.06 |
| 30%*B.a**M | 7.63±0.55$^{b}$ | 4.03±0.23$^{ab}$ | 10.70±0.51$^{b}$ | 33.60±1.7$^{ab}$ | 40.45±1.01$^{b}$ | 14.80±1.06 |
| 0%*B.a**M | 7.00±0.55$^{b}$ | 4.30±0.23$^{ab}$ | 12.33±0.51$^{ab}$ | 37.00±1.7$^{ab}$ | 42.93±1.01$^{b}$ | 14.50±1.06 |
| 0%*B.a**F | 6.57±0.55$^{b}$ | 3.80±0.23$^{b}$ | 10.88±0.51$^{b}$ | 31.73±1.7$^{b}$ | 41.93±1.01$^{b}$ | 14.00±1.06 |
| p-value | 0.012 | 0.015 | 0.010 | 0.008 | <0.001 | 0.092 |
| $\mu\pm\delta$ | | | | | | 16.11±1.06 |

$\mu\pm\delta$ : mean ± standard error; WBC: White blood cell, RBC: Red blood cell; HGB: Haemoglobin; Ht: Haematocrit; MCV: Mean corpuscular volume; MCH: Mean corpuscular haemoglobin; Values in columns followed by letter a, b, are significantly different.

20%*B.a* allowed higher RBC content than diet 25%*B.a* for 4.80×$10^6$/µL and 4.05×$10^6$/µL, respectively (p<0.0001). Herein, RBC contents were within the range of Ibitoye *et al*. (2020) results, as they reported an interval of 3.52 to 4.61 × 10^$^6$/µL. Numerically, when it came to the interaction between gender and diets (Diet-gender), the highest RBC content was obtained with diet 20%.*a* for 5×$10^6$/µL with females. Whereas the lowest RBC content was observed with 0% B.a at 3.8 × 10^6/µL, this was also true for females (p < 0.0001). Truly, apart from diet 0%*B.a*, all the diets containing *B.a* exhibited consistent RBC contents and formed a homogeneous group with 4.43×$10^6$/µL. But this average was slightly lower than Ahmad and Lashari's (2022) results. Their RBC contents were between 4.8 × 10^6 and 5.5 × 10^$^6$/µL following the hot and cold periods, respectively.

**Haemoglobin content (HGB, g/dL)**

It is widely reported that haemoglobin is a protein containing iron in the blood of many mammals, inside the red blood cells. It binds and transports oxygen molecules from the lungs to the tissues, and brings back carbon dioxide from the tissues to the lungs for excretion in the air. To begin, diet 25%*B.a* delivered 13.35 g/dL, while diet 20%*B.A allowed 12.28 g/dL, and both constituted the leading group, with an average of 12.82 g/dL* (Table 4). Following this, the second group was formed by diets 0% B.a and 30% *B.a, which* got an average HGB content of 11.59 g/dL. The gap between the second group and diet 25%*B.a* was important (p<0.0001). Regarding Ahmad and Lashari's (2022) results on rabbits' haemoglobin content, which ranged between 10 and 9.9 g/dL during the hot and cold periods, respectively, the current diets did not have an adverse effect on the animals. Again, Tanczos *et al*. (2021) reported an interval from 8.39 to 15.25 g/dL, with high dietary cholesterol and a control diet, respectively.

On the interaction between gender and diets, all rabbits had good haemoglobin contents, from 10.88 g/dL with females fed on diet 0%*B.a* to 13.80 g/dL with males fed on diet 25%*B.a*. This result interval was larger than that reported by Ibitoye *et al*. (2020) for 9.72 to 10.34 g/dL. In short, all diets' haemoglobin contents fell within acceptable intervals.

**Mean corpuscular volume (MCV, fL)**

The mean corpuscular volume (MCV) is the average red blood cell volume in femtolitre (fL). Two extremes were observed between the leading diet 25%*B.a* and a following homogenous group composed by diets 0% *B.a*, 20%*B.a*, and 30%*B.a*, with 49.65 fL, and an average of 42.74±0.71 fL, respectively (p<0.0001). Looking

at 57.3 fL announced by Ahmad and Lashari (2022) during the summer season, and 59.7 fL during the winter season, the present results were lower. In particular, Ahmad and Lashari (2022) reported that weather conditions have an impact on the haematochemical composition of rabbits. As an illustration, they reported 59.7 and 57.3 fL, during winter and summer, respectively. So, in hot conditions, rabbits' mean corpuscular volumes tend to be small. Coming back to rabbits' growth, diet 25%*B.*A surely induced anemia leads to big red blood cells. Specifically, females had higher red blood cell counts compared to males by a gap of 2.23 fL ($p = 0.006$). However, both genders behaved similarly under diet 25%B.a, resulting in 50.80 fL and 48.50 fL for the females and males, respectively ($p = 0.127$).

## Conclusion

The test assessed the effect of *B. aethiopum* ripe fruits' dried peels and pulps in rabbit feed on their growth performance, daily weight gain, and haematological parameters. The results showed that to achieve the best growth and health parameters with the dried products, the dried product could be incorporated at a 20% level into pelleted rabbit feed. Even without any corn grain, bran, or other protein source, the growth was acceptable. A diet with 20% B.a had a positive impact on growth performance and animal health. The outputs showed that *B. aethiopum* ripe fruits' dried peels and pulp uses in growing rabbits' feedstuffs may be very interesting. Thus, this product may be used as a source of energy and fibre in rabbit diets. So, in case of a shortage of parts for *S. guianensis* plants or any other fibre source for rabbits, *B. aethiopum* ripe fruits' dried peels and pulp may be very good alternatives. However, observing mortality with swollen bellies, future experiments could reduce the incorporation rates of B. aethiopum ripe fruits' dried peels and pulps to 5%, 10%, 15%, and 20%.

## Conflict of interest

The authors declare that they have no conflict of interest.

## REFERENCES


1. Ahmad, I., & Lashari, M.H. (2022). Effect of season and housing system on hematochemical attributes in rabbits of Southern Punjab, Pakistan, *Arquivo Brasileiro de Medicina Veterinária e Zootecnia*, 74(4), 603-610, http://dx.doi.org/10.1590/1678-4162-12654
2. Banu, S.M., Vigasini, N., & Surenderan, S. (2021). Phytochemical screening, in vitro antioxidant and anti-inflammatory activity of freeze-dried *Borassus flabellifer* L. seed powder, *Asian Journal of Biological and Life Sciences*, 10(1), 202-209, DOI:10.5530/ajbls.2021.10.29
3. Daboussi, I., Fehri, Contò, N.E, Castrica, M.M., Bejaoui, S., Quattrone, A., Ferchichi, M.A., Amraoui, M., Tibaoui, S., Curone, G., Vigo, D., Menchetti, L., Dal-Bosco, A., Andoni, E., Brecchia, G., Failla, S., & Jemmali, B. (2025). Growth Performance, Carcass Traits and Meat Quality in Rabbits Fed with Two Different Percentages of Extruded Linseed. Foods 14, 1778, https://doi.org/10.3390/foods14101778
4. El-Sawy;M.A., Emam, A.M., & Tamma, A.M. (2023). Productive and economic efficiency of growing rabbits fed two levels of protein, *Egyptian Journal of Rabbit Science*, 33 (2): 105-114
5. Heimann, M., Bachmann,S., Chabaud,F., Camenisch,G., & Schäfer D. (2021). Guideline on blood collection techniques in rodents and rabbits, Swiss Animal Welfare Officer Network
6. Ibitoye, E.B., Jimoh, A.A., Hussaini, A., & Sanni, B.S. (2020). Comparative evaluation of three different energy sources on performance, carcass characteristics, hematology and serum biochemistry of rabbits, *Nigerian Journal of Animal Sciences*, 22(3), 139-146,
7. Kimsé, M., Yapi, Y.M., Karamoko, M., Gidenne, T., Zongo, M., Gnanda, B.I., Akoutey, A., Bodji, N.C., Fantodji, A., & Otchoumou, A. (2017). Effect of tropical green forage (*Pueraria phaseoloides)* addition to a pelleted complete feed on rabbit growth performance and digestion, *World Rabbit Science*, 25, 225-231, https://doi.org/10.4995/wrs.2017.5126
8. Lamptey, V.K. , Hagan, J.K, Hagan, B.A., Kruenti, F., & Osei, D.Y. (2022) The influence of sex and age on growth rate of domestic rabbits (*Orycotolagus cuniculus*), *Journal of Innovative Agriculture*, 9(2), 21-27, DOI:10.37446/jinagri/rsa/9.2.2022.21-27
9. Mahilrajan, S., Thuraisingam, S., & Prabagar J. (2025). Exploring the nutritional, health and economic potential of palmyrah fruit pulp, *Food Chemistry Advances*, 6, 100880, https://doi.org/10.1016/j.focha.2024.100880
10. Moon, S.N,. Naime, J., Ara, M.H., Nazmul-Islam, A.B.M., Kundu, R., & Karim, K.Md.R. (2020). Fatty acids profile and phytochemical activity of Borassus flabellifer and Nypa fruticans mesocarp oil in Bangladesh, *Bioresource Technology Reports*, https://doi.org/10.1016/j.biteb.2020.100592
11. Mukaila, R. (2023). Measuring the economic performance of small-scale rabbit production agribusiness enterprises, *World Rabbit Science, 31: 35-46. https://doi.org/10.4995/wrs.2023.18660*
12. Ognika, A.J., Dimi, N. S., Ekou, D.C., Bahouna, M., & Akouango, P. (2021). Effet du *Moringa oleifera* sur les performances de croissance du lapin (*Oryctolagus cuniculus*), *Journal of Applied Biosciences, 168, 17468-17476*
13. Ouedraogo B., Zoundi, J.S, Nikiema, Z.S., & Sawadogo, L. (2021). Performances de croissance comparées des lapereaux nourris avec du concentré granulé complémenté par des feuilles d'Amarante hybride (*Amaranthus hybridus*) et par des feuilles de papayer (*Carica papaya*). Science de la vie, de la terre et agronomie, *RAMRES*, 9 (1), 63-68
14. Tanczos, B., Somogyi, V., Bombicz, M., Juhasz, B., Nemeth, N., & Deak, A. (2021). Changes of hematological and hemorheological parameters in rabbits with hypercholesterolemia, Metabolites, 11, 249, https://doi.org/10.3390/metabo11040249

15. Tiho, T., Adima, A.A., Brou, Y.C., Traoré, N., Kouassi, G.F., Kouamé, T.R., & Kouba, M. (2018). *Borassus aethiopum* Mart ripe fruits' parts, and drying temperature effect on its pulp protein, fat, sugars, metabolisable energy and fatty acids profile", *American Journal of Food and Nutrition*, 6(3), 67-75, *http://pubs.sciepub.com/ajfn/6/3/2*
16. Van-Der-Sluis, M., Van-Zeeland Y.R.A.V., & De-Greef K.H. (2024). Digestive problems in rabbit production: moving in the wrong direction? *Frontiers in Veterinary Science*, 11, 1354651, doi:10.3389/fvets.2024.1354651
17. Weiss, W.P., & Tebbe, A.W. (2019). Estimating digestible energy values of feeds and diets and integrating those values into net energy systems, *Translational Animal Science*, 3, 953-961, https://doi.org/10.1093/tas/txy119
18. Yao, K.A., Tiho, T., Silué, N., Assidjo, N.E., & Koné, K.Y. (2023). Total polyphenols, total flavonoids, condensed tannins, and antioxidant activity of *Borassus aethiopum* (Arecaceae) ripe fruits' peels, and peel-pulps, dried at different temperatures, *Asian Journal of Chemical Sciences*, 13(2), 20-33, *no. AJOCS 98940*, https://doi.org/10.9734/ajocs/2023/v13i2236