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Effects of *Ipomoea aquatica* and *Leucaena leucocephala* leaves on the growth performance of rabbits (*Oryctolagus cuniculus*) in southern Benin

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Key words: *Oryctolagus cuniculus*, Diet, *Ipomoea aquatica*, *Leucaena leucocephala*, Growth, Zootechnical parameters

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Abstract

Our study aims to analyze the effect of adding *Ipomoea aquatica* and *Leucaena leucocephala* leaves to the diet of rabbits on their zootechnical parameters. This study was conducted on 16 weaned rabbits aged 8 weeks, divided into four groups and fed different diets, including either commercial feed alone or commercial feed supplemented with *Ipomoea aquatica* or *Leucaena leucocephala* leaves. We measured growth parameters, feed utilization, and carcass characteristics. The results showed that the addition of *Ipomoea aquatica* and *Leucaena leucocephala* leaves significantly improved ($p<0.001$) the rabbits' growth rate. The group fed with commercial feed and *Ipomoea aquatica* leaves exhibited the best feed conversion ratio. Although the diets showed significant differences, there was no significant difference in carcass yield, even though the group receiving commercial feed with *Ipomoea aquatica* leaves had a higher yield. In conclusion, our study demonstrates that adding *Ipomoea aquatica* and *Leucaena leucocephala* leaves to rabbit diets can enhance their zootechnical performance.

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Introduction

Proteins are essential for growth, reproduction, immunity, as well as the maintenance and development of bones in humans. They play a key role in the overall functioning of the body (Elmadfa and Meyer, 2017; Wu, 2016). The rabbit farming industry is an important sector for the economies, both rural and urban, of many countries (Oseni and Lukefahr, 2014). It provides high-quality animal proteins to a growing population and contributes to improving the livelihoods of local producers (Lebas *et al.*, 1997). However, feed costs represent a significant portion of the total production costs for rabbits, posing a major challenge for breeders (Gidenne *et al.*, 2010).

In this context, several studies have explored the incorporation of low-cost, nutrient-rich plant by-products into animal feed. Among them, the leaves of *Ipomoea aquatica* and *Leucaena leucocephala* have been successfully used in the feeding of various animal species, such as poultry, ruminants, and pigs (Pascual *et al.*, 2003; Koné *et al.*, 2020). Research by Defang *et al.* (2014) showed that incorporating 20% *Leucaena leucocephala* into the diet improves feed intake and digestibility in rabbits.

To assess the potential effects of incorporating Ipomoea aquatica and *Leucaena leucocephala* leaves into rabbit feed, a study was conducted under the title: "Effects of *Ipomoea aquatica* and *Leucaena leucocephala* Leaves on the Growth Performance of Rabbits (*Oryctolagus cuniculus*) in Southern Benin." This research aims to evaluate the potential benefits for local producers, including reducing production costs, improving feed quality, and optimizing rabbit growth.

The main objective of this study is to assess the impact of incorporating *Ipomoea aquatica* and *Leucaena leucocephala* leaves on the growth parameters of rabbits. More specifically, it involves analyzing the feed consumption associated with these leaves, as well as their effect on growth rate and meat production in rabbits fed these diets.

Materials and methods

Description of the experimental site and setup of the experimental design

The study was carried out at a rabbit farm (*Oryctolagus cuniculus*) established in 2015 under the Ki.O.P.A (King Of Production Animal, Agriculture, Agro-industry) structure, located in the commune of Ouidah, the arrondissement of Pahou in the Bazounpka neighborhood. The current city of Ouidah has successively been a rural/urban district, a sub-prefecture, an urban district, and eventually became a commune following the decentralization process, which was effectively implemented with the 2002 municipal elections. As a commune, it is located in the Atlantic Department, covering an area of 364 km². It is bordered to the south by the Atlantic Ocean, to the east by the commune of Abomey-Calavi, to the west by the commune of Grand-Popo, and to the north by the communes of Kpomassè and Tori-Bossito. Ouidah has ten (10) arrondissements, subdivided into sixty (60) urban neighborhoods and villages (Fig. 1). It is led by its new mayor, Mr. Christian Houétchénou.

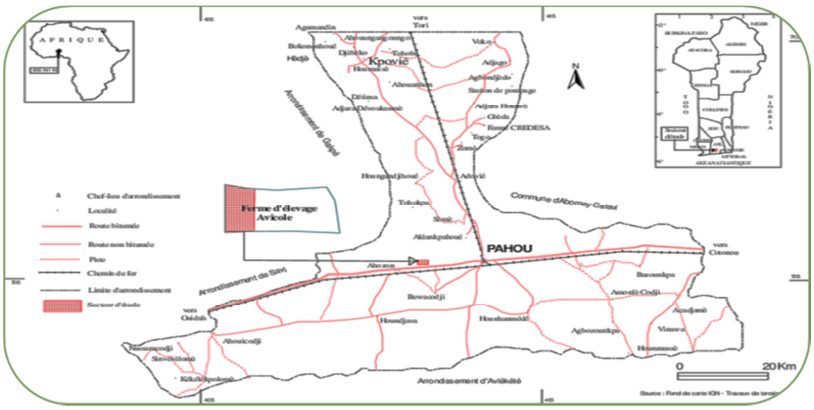

Fig. 1. Geographical location of the experimental site

With its Sudanese-Guinean climate, characterized by two alternating rainy seasons and two dry seasons of unequal durations, it also has soils favorable for growing cassava, beans, cowpeas, sweet potatoes, and vegetable crops such as tomatoes, peppers, okra, onions, leafy vegetables, and fruit vegetables. Coconut plantations also thrive there. Its hydraulic system consists of bodies of water, the main ones being the Djessin, Donmè, and Toho lagoons, fed by the rivers of the southwestern basin, particularly the Kouffo and Mono rivers. There are acacia and eucalyptus trees (Ahouicodji) and large coconut and oil palm plantations (in the village of Gakpé); natural formations including grassy savannas, meadows, and swampy areas with *Raphia gigentea*, some mangroves with *Rhizophora racemosa* and *Avicennia africana* (Akomagni and Guidibi, 2006).

Fig. 2. Experimental cages

A total of 12 eight-week-old rabbits, weighing between 950g and 1000g, were distributed into groups in 4 cages, with 3 rabbits per group. These cages are made of galvanized wire mesh, measuring length × 0.5 m in width × 0.5 m in height. Each cage is equipped with a feeder and a water trough made of fired cement (Fig. 2).

Type of feed

The feed consists of commercial pelletized food from VET service SA, sold on the Beninese market, and freshly picked and washed leaves.

Feeding frequency

The subjects are fed twice a day. The pellets are given in the morning (08:00), and the leaves are given in the evening (17:00).

Fig. 3. Commercial pelletized feed (Album Koukponou, 2023).

Data collection frequency

Data is recorded on a weekly basis (every 7 days). However, the live weights were initially recorded over one week.

Composition of the different treatments

Feeding

The rabbits were divided into four (04) groups, with each group corresponding to a specific diet.

Group 1: Control group, fed only with commercial Veto Service pellets at a quantity of 100g per rabbit.
Group 2: Rabbits fed with commercial pellets (100g) along with *Ipomoea aquatica* leaves (100g).
Group 3: Rabbits fed with commercial pellets (100g) along with *Leucaena leucocephala* leaves (100g).
Group 4: Rabbits fed with commercial pellets (100g) along with both *Ipomoea aquatica* and *Leucaena leucocephala* leaves in equal amounts (100g each).

Medical

Amprolium will be administered at a dose of 2g/l for three days, and SULFA 33 at a dose of 5ml per liter of water for five days for preventive treatment against coccidiosis (Akpo *et al.*, 2016). Oxytetracycline 10% will be given to prevent various infections. Ivermectin will be administered at a dose of 1ml/kg of live weight for preventive treatment against scabies.

Evaluation of zootechnical parameters and digestibility of diets for each group

Growth parameters

Average daily gain

The average daily gain indicates the growth rate of the subjects. It was calculated weekly for each group using the following formula:

GMQ = (Pf – Pi) /dt (Kouhana Soho *et al.*, 2022)

Pi : Initial Weight

Pf: Final weight at the end of the experiment,

dt: duration of the experiment

Specific growth rate

The Specific Growth Rate is important for determining the daily weight gain of the subjects. It was calculated weekly for each group using the following formula:

TCS (%/j) = 100 × (ln Pf – ln Pi) / dt (Kouhana Soho *et al.*, 2022)

Feed utilization parameters

Feed conversion index

The Feed Conversion Index is the amount of feed consumed in kg by an animal to gain 1 kg of live weight. It was calculated every 7 days using the formula :

FCI = Qi / (Pf - Pi)

Where:

Qi = Amount of feed consumed

Pi = Initial weight

Pf = Final weight

Feed conversion efficiency

(%) = 100 × (Pf - Pi) / Qi

Carcass and organ characteristics

The characteristics of the carcass and organs of rabbits fed the different dietary treatments were recorded. These included carcass weight, liver weight and heart weight.

Statistical analysis

After calculating these various parameters, we will perform some statistical analyses to assess the different results. These will mainly include t-tests to compare the diets, and ANOVA tests to compare the different parameters obtained at the end of the experiment.

Results

Growth parameters

The analysis of Table 1 reveals notable differences in the growth of rabbits across the groups. Group 4 shows the best weight gains, ranging from 883g to 925g, suggesting a diet particularly favorable for growth. Group 2 also shows good performance with gains ranging from 778g to 822g, indicating efficient assimilation of the diet. Group 1, on the other hand, records the lowest weight gains (675g to 759g), which may reflect a less suitable diet or other factors influencing growth. Group 3 shows more variability, with a gain ranging from 672g to 864g, and in one case, no final data is available, which could indicate an experimental issue (illness, mortality, or other factors). Overall, Group 4 appears to be the most successful, followed by Group 2, while Groups 1 and 3 show more heterogeneous results.

Table 1. Growth during the experimental period

Group	Subject	Initial weight (g)	Final weigh (g)	Weight gain (g)
Group 1	1-1	1200	1875	675
	1-2	1100	1848	748
	1-3	989	1748	759
Group 2	2-1	1000	1790	790
	2-2	1002	1780	778
	2-3	998	1820	822
Group 3	3-1	912	1776	864
	3-2	1000	1776	822
	3-3	1002	1674	672
Group 4	4-1	1200	2097	897
	4-2	1010	1935	925
	4-3	900	1783	883

Descriptive statistics of the measured parameters

Growth parameters

Table 2 presents the descriptive statistics of the growth parameters. It shows that the Average Daily Gain (ADG) for all subjects across the different groups is on average 25.25 ± 5.32g, with a minimum of 13.57g and a maximum of 34.86g. Additionally, the Specific Growth Rate (SGR) of the groups in this study is on average 1.68 ± 0.39g, with minimum and maximum values of 1.14g and 2.87g, respectively. The average weight obtained is 1524.10 ± 298.99g, with a minimum of 1030g and a maximum of 2106g.

Table 2. Descriptive statistics of growth parameters

Variables	Mean	Standard deviation	Min.	Max.
ADG	25.25	5.32	13.57	34.86
SGR (%)	1.68	0.39	1.14	2.82
Weight	1524.10	298.99	1030	2106

ADG= Average Daily Gain; SGR= Specific Growth Rate; Mean= Average; Min= Minimum; Max= Maximum

Feed utilization parameters

Table 3 presents the descriptive statistics of the feed utilization parameters. It shows that the average Feed Conversion Index (FCI) for the different groups is 7.07 ± 1.65g, with minimum and maximum values of 4.88g and 12.53g, respectively. The average Feed Conversion Efficiency (FCE) obtained in our study is 14.85 ± 3.13g, with a minimum of 7.98g and a maximum of 20.50g.

Table 3. Descriptive statistics of feed utilization parameters

Variables	Mean	Standard deviation	Min.	Max.
FCI (g).	7.07	1.65	4.88	12.53
FCE (%)	14.85	3.13	7.98	20.50

FCI= Food Consumption Index; FCE= Feed Conversion Efficiency; Mean= Average; Min= Minimum; Max= Maximum

Carcass and organ characteristics

Table 4 presents the descriptive statistics of the carcass characteristics. The average live weight of the subjects in our study is 1909.5 ± 234.10g, with a minimum of 1542.00g and a maximum of 2257.00g. The average carcass weight is 1101.75 ± 192.80g, with a yield of 57.36 ± 3.76%, and minimum and maximum values of 801.00g and 1335.00g, respectively.

Table 4. Descriptive statistics of carcass characteristics

Variables	Mean	Standard deviation	Min.	Max.
Poids vif	1909.50	234.10	1542.00	2257.00
Masse de Carcasse	1101.75	192.80	801.00	1335.00
Rdt (%)	57.36	3.76	51.95	62.76
Masse Foie	62.25	1.14	60.00	64.00
Masse Cœur	5.75	0.45	5.00	6.00
Masse Cuisse	135.50	23.01	90.00	165.00

Mean= Average; Min= Minimum; Max= Maximum; Yield= Rd.

Study of the measured parameters within each group

Growth parameters

Table 5 presents the growth parameters measured within each group. Since Average Daily Gain (ADG) and weight gain are correlated, it is observed that the highest values occur in the group of subjects fed a diet incorporating *Ipomoea aquatica* leaves, while the lowest values are obtained in the subjects fed exclusively with the commercial pellet-based diet. Additionally, it should be noted that subjects fed a diet incorporating both *Leucaena leucocephala* and *Ipomoea aquatica* leaves show lower ADG and weight gain compared to those fed a diet incorporating the leaves of only one of the two species. The highest Specific Growth Rate (SGR) is observed in the subjects fed a diet incorporating *Leucaena leucocephala* leaves.

Table 5. Growth parameters measured within each group

	Weight gain (g)	ADG (g)	SGR (%)
Group 1	2048	73.14	1.41
Group 2	3180	113.57	2.00
Group 3	3476	124.14	1.90
Group 4	2608	93.14	1.40

ADG= Average Daily Gain; SGR= Specific Growth Rate

Food utilization parameters

Table 6 presents the food utilization parameters measured within each group. Since IC and ECA are inversely correlated, the lowest IC values (and thus the highest ECA values) are observed in subjects fed the diet incorporating *Ipomoea aquatica* leaves. Conversely, the highest IC values (and thus the lowest ECA values) are noted in subjects fed exclusively with the commercial food.

Table 6. Food utilization parameters measured within each group

	IC (g)	ECA (%)
Group 1	9.35	10.75
Group 2	6.02	16.69
Group 3	5.50	18.25
Group 4	7.31	13.69

Food Consumption Index; FCE= Feed Conversion Efficiency

Carcass characteristics

Table 7 presents the carcass characteristics. Analysis reveals that subjects fed exclusively with the commercial food have the lowest yield. The highest yield is obtained in subjects fed a diet of commercial food combined with Ipomoea aquatica leaves. The same observation holds when considering the thigh mass. Furthermore, there is no notable difference in the mass of the viscera (liver and heart) regardless of the treatment.

Table 7. Carcass characteristics measured within each group

	Yield (%)	Thigh mass (g)	Liver mass (g)	Heart mass (g)
Group 1	52.44	100	61	6
Group 2	56.42	142	63	6
Group 3	61.64	155	62	6
Group 4	60.95	145	63	5

Average variability of parameters across the different groups

Growth parameters

Average Daily Gain (GMQ)

Fig. 4 shows the evolution of the GMQ across the different groups over the study weeks. It demonstrates that the GMQ of subjects in groups 1, 3, and 4 increases over the weeks, while for the subjects in group 2, a significant drop in ADG is observed after week 0, followed by a slight increase in the last two weeks.

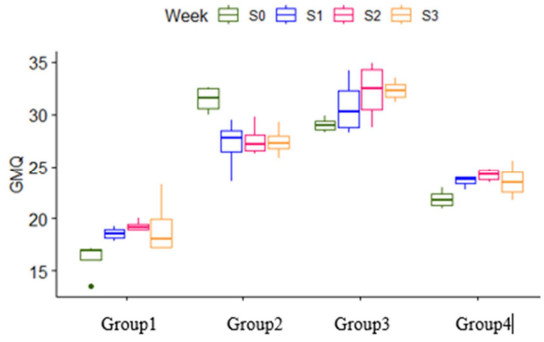

Fig. 4. Variability of average daily gain across the different groups

Specific growth rate (TCS)

Fig. 5 shows the evolution of the specific growth rate of the different groups over the study weeks. A decrease in the TCS of subjects in each group is observed over the weeks.

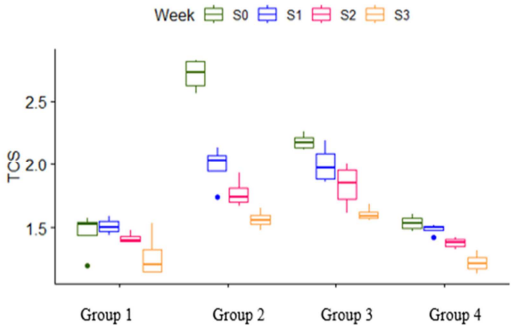

Fig. 5. Variability of specific growth rate across the different groups

Food utilization parameters

Food consumption index (IC)

Fig. 6 shows the evolution of the food consumption index across the different groups during the study weeks. It is observed that the IC of subjects in groups 1, 3, and 4 decreases over the weeks, while in group 2, the IC increases after week 0 before stabilizing and remaining more or less constant during the following weeks. Additionally, there is greater variability, with generally higher IC values in the rabbits of group 1, whereas it fluctuates within a narrower range in the rabbits of the other groups.

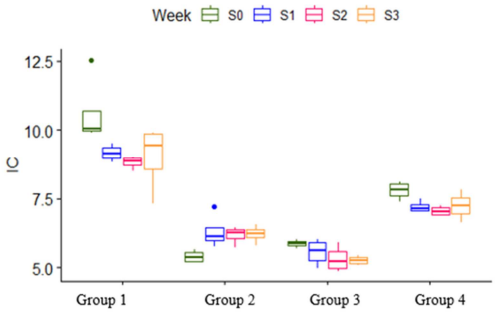

Fig. 6. Variability of the food consumption index across the different groups

Food consumption efficiency (EAC)

Fig. 7 shows the evolution of food consumption efficiency across the different groups during the study weeks. An increase in food consumption Efficiency is observed in the subjects of groups 1, 3, and 4. However, for the subjects in group 2, a decrease in EAC is noted after week 0, followed by stabilization around 16% for the rest of the study. It is also observed that the FCE of subjects in group 1 primarily

fluctuates within a lower range of values, between 8% and 12%.

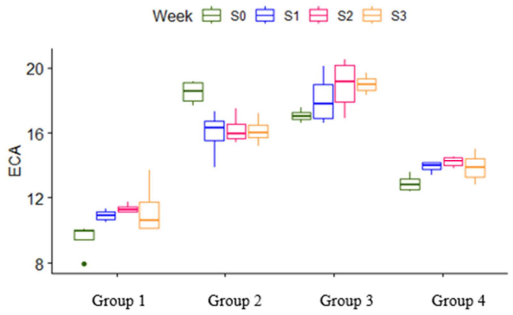

Fig. 7. Variability of food consumption efficiency

Analysis of variance of measured parameters

Growth parameters

Table 8 presents the analysis of variance of the growth parameters evaluated. The results suggest that the observed differences in ADG are not due to variations between the weeks independently of the effects of the different diets. These differences are, on the contrary, significantly associated with the diet to which the subjects of the different groups were subjected. The analysis of variance for SGR, however, shows that the observed differences are due to variations between the weeks on one hand and between the groups on the other. It should also be noted that the interaction between the weeks and the groups is significant for both ADG and SGR

Table 8. Analysis of variance of growth parameters

Variable	Df	SS	MS	F
Week	3	14.2	4.7	1.682^{NS}
Group	3	1531.0	510.3	180.732^{***}
ADG				
Week:Lots	9	100.8	11.2	3.967^{***}
Residuals	48	135.5	2.8	
Week	3	2.617	0.872	68.07^{***}
Group	3	4.827	1.609	125.56^{***}
SGR				
Week: Lots	9	1.430	0.159	12.40^{***}
Residuals	48	0.615	0.013	

ADG= Average Daily Gain; SGR= Specific Growth Rate; Df= Degrees of Freedom; SS= Sum of Squares; MS= Mean Squares; F= F-Statistic; NS= Not Significant.

Significance Threshold: P < 0.001: ***; P < 0.01: **; P < 0.05: *

Food utilization parameters

Table 9 presents the analysis of variance of the food utilization parameters. It results in that the observed differences in IC are linked to variations over the weeks ($p < 0.05$). However, they are much more significantly associated with the diet ($p < 0.001$). It should also be noted that the association of variations between the weeks and diet variations also has a significant interaction on the IC ($p < 0.01$).

Table 9. Analysis of variance of food utilization parameters

Variable	Df	SS	MS	F
Week	3	3.14	1.05	3.482^{*}
Group	3	145.04	48.35	160.823^{***}
IC				
Week: Lots	9	9.26	1.03	3.423^{**}
Residuals	48	14.43	0.30	
Week	3	4.9	1.64	1.678NS
Group	3	529.9	176.64	180.913^{***}
FCE				
Week: Lots	9	34.9	3.88	3.976^{***}
Residuals	48	46.9	0.98	

IC= Food Consumption Index; FCE= Feed Conversion Efficiency; Df = Degrees of Freedom; SS= Sum of Squares; MS= Mean Squares; F= F-Statistic; Significance Threshold: P < 0.001: ***; P < 0.01: **; P < 0.05: *

Regarding FCE, the analysis of variance reveals that the observed differences are not linked to variations between the weeks, but are significantly related to variations between the groups ($p < 0.001$). Furthermore, these differences are attributable to the association of variations between the weeks as well as those between the groups.

Discussion

The results of this study indicate that the average daily gain of rabbits fed exclusively with commercial food is significantly lower than that of the other groups. This observation suggests that incorporating *Leucaena leucocephala* and *Ipomoea aquatica* leaves into the rabbits' diet could promote their growth. However, Defang *et al.* (2014) reported that incorporating up to 20% of *Leucaena leucocephala* leaf meal did not significantly alter the Average Daily Gain (ADG), which may be explained by differences in

the composition of the diets and environmental conditions specific to each study.

The analysis of variance (ANOVA) reveals that the differences in ADG are primarily attributable to variations between the diets rather than the weekly variations. The simultaneous incorporation of *Leucaena leucocephala* and *Ipomoea aquatica* leaves seems to provide the best results in terms of ADG, suggesting a possible nutritional synergy between these two plants (Konmy *et al.*, 2020). Such synergy may result from the complementary effects of their protein and essential nutrient profiles (Soulemane and Adama, 2018; Xochipelli, 2021). However, some studies suggest that negative interactions between certain phytochemicals in these plants could limit the bioavailability of certain nutrients (Seng and Ven, 2023).

Analysis of food utilization parameters shows that the food consumption index decreases with the increasing proportion of *Leucaena leucocephala* in the diet. These results corroborate those of Defang *et al.* (2014), who observed a significant increase in food consumption with higher levels of *Leucaena leucocephala* leaf meal. This observation could due to enhanced palatability and better digestibility in rabbits receiving a diet enriched with plant-based nutrients (Ognika and Kouadio, 2021).

The ANOVA results suggest that the food consumption index is significantly influenced by the diet and, to a lesser extent, by weekly variations. Furthermore, the significant interaction between these two factors indicates that the effect of the diet on the food consumption index may vary over time. This temporal variability suggests that diet effects might be more pronounced during the initial stages of the experiment and then diminishes over time (Nguemfo and Teguia, 2015). These results highlight the importance of a detailed analysis of temporal variations to better understand the effectiveness of experimental diets.

Regarding food conversion efficiency (FCE), the analysis of variance indicates that the observed differences are primarily related to variations between the diets rather than temporal variations. This suggests that FCE is mainly influenced by the type of diet rather than the duration of the experiment (Kouassi and N'Dri, 2019). However, the significant interaction between the weeks and further supports the hypothesis of a time-dependent dietary effect on FCE.

The results obtained on carcass characteristics confirm that the lowest yield is observed in rabbits fed exclusively with commercial food. This observation is in agreement with the work of Defang *et al.* (2014), who noted an improvement in carcass yield with the integration of Leucaena leucocephala leaves into the rabbits' diet. This result can be attributed to the additional supply of plant-based proteins and other essential nutrients, promoting better muscle growth and, consequently, better meat yield (Tchoumboue and Boukila, 2017; Fomunyam and Kana, 2016).

Conclusion

These observations highlight the importance of a tailored diet formulation to optimize growth and feed efficiency in rabbits. The incorporation of Leucaena leucocephala and Ipomoea aquatica leaves seems to be a promising strategy to improve livestock performance, particularly in terms of ADG, food consumption index, and carcass yield. However, further studies are needed to determine the long-term effects of these diets and evaluate their impact on meat quality. Additionally, analyzing the interactions between the different plant components could further optimize the formulation of rations for rabbit farming.

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