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Effects of Incorporating Mango (*Mangifera indica*), Avocado (*Persea americana*) and Guava (*Psidium guajava*) Leaves Powder in the Ration on Growth Characteristics in Rabbits

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Abstract

A study conducted on burgundy rabbits evaluated the effects of rations containing mango (*Mangifera indica*), avocado (*Persea americana*) and guava (*Psidium guajava*) powder. For this purpose, 36 rabbits (20 males and 16 females) aged 60 to 70 days with an average weight of 1012 ± 133 g were divided randomly into 4 equal groups (T0, T1, T2 and T3) of 9 animals each according to body weight (bw). The rabbits were divided throughout the trial, the animals were fed, those of group T0 (control) with a standard feed without any type of leaf powder, while those of groups 1, 2 and 3 received the standard feed supplemented with *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves powder at the rate of 0.5% respectively. After two months of treatment, the animals were fasted for 12 hours (20 h - 8 h) and sacrificed to evaluate carcass and digestive organ weights. The results revealed that the values of feed intake, live weight and weight gain were non-significantly ($p > 0.05$) increased in all animals regardless of the ration in reference to the control. The different leaves powder induced an increase in carcass yield in rabbits but this increase was only significant ($p < 0.05$) with *M. indica* leaf powder (51.03 ± 0.24) as compared to the control (48.63 ± 0.74). Gut length was significantly increased in animals fed rations containing *Psidium guajava* and *Persea americana* leaves powder compared to the control. A significant increase in gut weight was observed in animals fed the *Persea americana* leaf supplemented ration. In general, mango leaf powder performed better than other types of powders.

Keywords

Avocado, Growth Characteristics, Leaves, Guava, Mango, Rabbit

1. Introduction

Various regions of Cameroon are facing an increasingly severe food insecurity crisis, manifested in poverty, hunger and malnutrition (Crush 2016; Doreen 2024) [1] [2]. However, the use of agricultural and livestock products is not yet optimized, despite the fact that livestock is an element of sustainability and economic stability.

In recent years, Cameroon has focused its efforts on the development of large livestock, poultry, pork, sheep and goats. Despite this development, these sectors remain plagued by endemic situations such as "peste des petits ruminants", red swine disease and avian flu, leading to a 4.8% drop in meat production (INS, 2006) [3]. With this in mind, special emphasis has been placed on the production of animals with a short reproductive cycle, such as the rabbit (*Oryctolagus cuniculus*). Indeed, rabbit is a fast growing animal (FAO, 2016) [4]. Due to the simplicity of its breeding, rabbit farming is an activity that requires little space and is likely to contribute significantly to food security and poverty reduction, given the zootechnical potential of the domestic rabbit (Tchoumboué and Téguia, 2004) [5]. Its meat has good nutritional and dietetic values, because being rich in proteins and low in lipids (Larzul *et al.*, 2005) [6], it is likely to bring fatty acids of type omega 3 in consequent quantity, and to cover an important part of the daily needs of the man (Lebas, 2007) [7].

In spite of these assets, the rabbit sector is under the influence of intrinsic and/or exogenous factors that vary the values of the growth characteristics (Akouango *et al.* 2014) [8]. It is therefore advisable to develop strategies to mitigate the effects of the factors influencing animal growth performance in order to increase the availability of meat and reduce the thorny problem of the price per kilogram of meat products on the market. Feeding rabbits with pellets faces many problems. These are the quality of pellets, the availability of pellets and the high cost of pellets on the market. Indeed, the design of pelleted feed has certain requirements related to the nutritional needs of the rabbit. Good control of the quality and rate of incorporation of fiber (digestive or non-digestive), protein, fat, vitamins and minerals is essential when preparing this type of feed (Fortun-Lamothe and Gidenne, 2003) [9]. Also, many plants can be used in food formulation (Benshaul *et al.*, 2000; Briens and Grenet, 2001; Tzung-Hsun *et al.*, 2005) [10]-[12]. Among these plants with proven pharmacological activities, the mango tree (*Mangifera indica*), the avocado tree (*Persea americana*) and the guava tree (*Psidium guajava*) top the list. These plants have modes of action with common points and their activities are very varied: anti-inflammatory, antibacterial, antiparasitic, antifungal, antimutagenic, antioxidant, hepato-protective and stimulating growth and fertility (Chen and Yen, 2007; Chowdhury *et al.*, 2009; Brenes and Raura, 2010) [13]-[15]. In view of the multiple properties of the molecules of these plants, they could be used in animal production to combat stress and boost animal growth. It is with this in mind that the present work was initiated in order to contribute to a better animal productivity.

2. Material and Methods

2.1. Animals

For this trial, 36 burgundy fawn rabbits (20 males and 16 females) aged between 60 and 70 days with an average weight of 1012 g ± 133 g reproduced at Teaching and Research Farm of the University of Dschang were used. They were housed in a hutch subdivided into twelve boxes of dimensions 60 by 85 cm each. Recycled cans were used as feeders. The watering system was automatic (pipettes). The barn and all the cages had been disinfected with a solution of bleach and cresyl (0.5 liter of bleach and 0.5 liter of cresyl for 20 liters of water) sprayed in all corners of the barn. The room and the equipment were cleaned daily.

The animals received water and feed *ad libitum*. Table 1 summarizes the components of the ration used in this study.

Table 1. Composition and chemical characteristics of the experimental ration used in rabbits.

Ingredients	Quantities
Corn	10
Soybean	4
Palm kernel cake	38
Wheat bran	40
Cotton cake	4
Bonemeal	1
Iodizedsalt	0.5
Limestone	1
Palm kerneloil	1.5
Total	100
Crudeprotein (%)	17.06
Digestible energy	2343.80
Crude Cellulose	12
Calcium (Ca)	0.80
Phosphorus (P)	0.55
Sodium (Na)	0.24
Magnesium (Mg)	0.1

2.2. Experimental Design

Thirty-six rabbits were divided into 4 groups (T0, T1, T2 and T3) of 9 animals corresponding to 4 treatments in a completely randomized design corresponding to the replicates. Each batch of 09 rabbits was further subdivided into three batches of 3 animals each. The animals were fed for 60 days with one of the following rations:

T0: basic ration without supplement;

T1: basic ration + 0.50% *Mangifera indica* powder;

T2: basic ration +0.50% *Persea americana* powder;

T3: basic ration + 0.50% *Psidium guajava* powder.

From the beginning to the end of the trial, feed intake, live weight change, weight gain and feed conversion ratio were evaluated weekly.

2.3. Feed Consumption

Feed consumption (FC) was obtained by making the difference between the quantity of feed served and the refusals according to the following formula:

$$QC = Qs - Qr$$

QC = quantity consumed (g);

Qs = quantity served (g);

Qr = quantity remaining (g).

2.4. Evolution of live Weight (LW)

The change in weight was obtained by weighing the animals weekly between 6 a.m. and 8 a.m. throughout the experimental period. The weighings were done using an electronic scale with a capacity of 5 kg and a precision of 1 g.

Figure 2 takes live weight of rabbit.

2.5. Weight Gain (WG)

The weight gain of the rabbits was evaluated by making the difference between the weight of the week considered and that of the previous week. The following formula was used:

$$WG = LW_n - LW_{n-1}$$

LW_n = Live weight per week considered (g);

LW_{n-1} = Live weight in the previous week (g).

2.6. Average Daily Gain (ADG)

The average daily gain was obtained by relating the weight gain during a period to the duration of this period.

ADG = weight gain (g)/duration (day)

2.7. The Consumption Index (CI)

The feed consumption index was obtained by relating the quantity of feed consumed during a period to the weight gain of the same period.

CI = feed consumption/weight gain

2.8. Carcass Characteristics

At 12 weeks of age, 4 animals per treatment were subjected to a 12-hour diet (from 8 p.m. to 8 a.m.) then weighed, sacrificed, skinned and eviscerated as recommended by National Academy of Sciences (2011) [16]. The head, legs, kidneys,

heart, liver, pancreas, and fur were removed, stripped off the carcass, and weighed using a 500 g capacity and 10^{-1} g precision scale.

The animals were slaughtered following the steps below:

Fasting animals for 12 hours;

Weighing animals before slaughter using a scale;

Stunning the animal (render unconscious);

Performing bleeding by section near the head of the jugulars;

Skinning by removing skin and extremities (furs, head and legs);

Evisceration, removal of organs by excision.

The relative weight of each organ was calculated using the following formula:

Relative weight (%) = organ weight (g)/live weight × 100.

2.9. Carcass Yield

The following formula was used to calculate the carcass yield (CY):

CY (%) = carcass yield (g)/live weight on fasting (g) × 100.

2.10. Intestinal Measurement

The length of the intestine was determined using a measuring tape and its density calculated using the formula below:

Intestine density (g/cm) = intestinal weight (g)/intestinal length (cm).

2.11. Statistical Analysis

Data (growth characteristics) were subjected to one-factor analysis of variance. When differences were significant, means were separated using Duncan's test at the 5% level. Results were expressed as mean ± standard deviation, and SPSS 23.0 software was used to analyze these data.

3. Results

3.1. Effects of Different Rations on the Growth Performance of Rabbits

Feed consumption of rabbits

Figure 1 shows the weekly evolution of feed consumption in burgundy rabbits fed rations containing *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves. It was found that feed consumption of animals fed rations supplemented with *P. guajava* and *P. americana* leaves was numerically higher than that of the control from weeks 1 to 6. From the 7th week, feed consumption showed a general increasing trend without distinction of feed type until the end of the treatment.

3.2. Effects of Different Rations on Live Weight (LW)

Figure 2 shows that the live weight curves of the animals fed the different rations showed a linear increase in live weight with treatment time until the 5th week. After this, a slight regression in live weight was noted in the animals of the control group and in those fed rations containing *Mangifera indica* and *Psidium guajava*

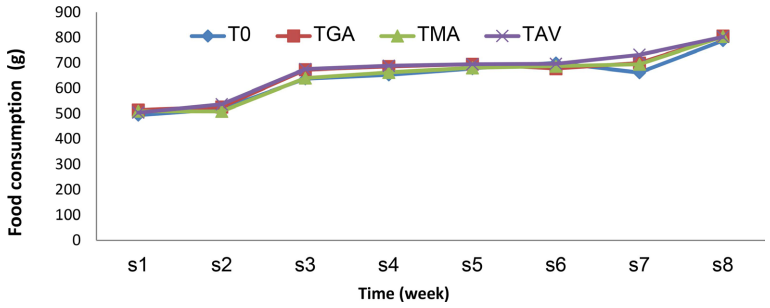

Figure 1. Evolution of feed consumption in rabbits fed *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves. T0: basic feed (without additive); TGA, TMA, TAV, basic ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

leaf powder. However, the evolution curve of the live weight of the animals fed the ration containing *Persea americana* leaf powder remained lower in reference to the others during the whole trial.

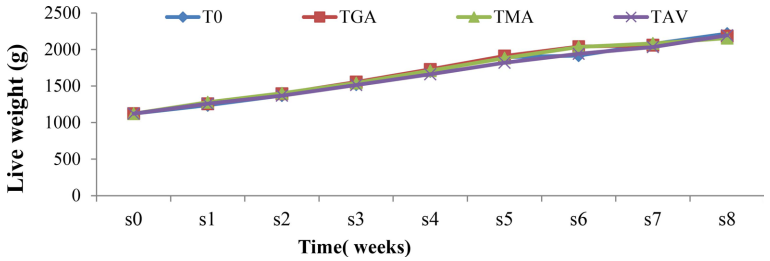

Figure 2. Evolution of live weight in rabbits fed *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves. T0: basic feed (without additive); TGA, TMA, TAV, basic ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

3.3. Effects of Different Rations on Weight Gain

The evolution of weight gain in rabbits exposed to rations containing *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves is illustrated in **Figure 3**. As a result, weight gains in rabbits exposed to the different rations considered changed irregularly. However, no significant differences ($p > 0.05$) were observed regardless of the type of ration administered.

3.4. Effects of Different Rations on Consumption Indices

From **Figure 4**, it can be seen that the consumption indices of rabbits fed rations containing *Mangifera indica*, *Persea americana* and *Psidium guajava* leaves evolved in an irregular way. Nevertheless, the evolution curve of the consumption index noted in the rabbits fed a ration containing *Persea americana* leaf powder remained higher than that of the control throughout the treatment period.

3.5. Effects of Different Rations on Survival Rate

The survival rate noted in animals fed rations supplemented with *Mangifera*

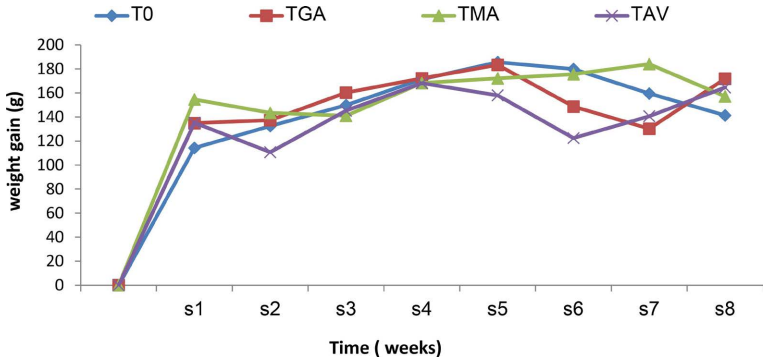

Figure 3. Evolution of consumption index in rabbits fed with *Mangifera indica*, *Persea americana* and *Psidium guajava* leaf powders. T0: basic feed (without additive); TGA, TMA, TAV, basic ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

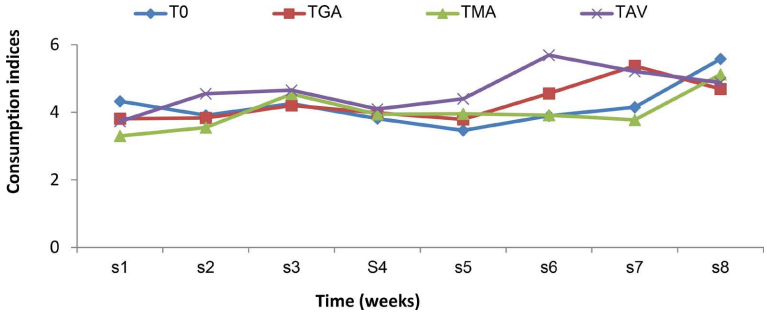

Figure 4. Evolution of weight gain in *rabbits* fed rations containing *Mangifera indica*, *Persea americana* and *Psidium guajava*. T0: basic feed (without additive); TGA, TMA, TAV, basic ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

indica, *Persea americana* and *Psidium guajava* leaves powder is represented by Figure 5. It was found that animals fed the ration containing *M. indica* leaf powder showed a better survival rate (88.89%) with reference to those of the control group and animals fed the rations containing the other types of powder. However, animals exposed to *Persea americana* and *Psidium guajava* leaves powder rations showed a similar survival rate (66.67%).

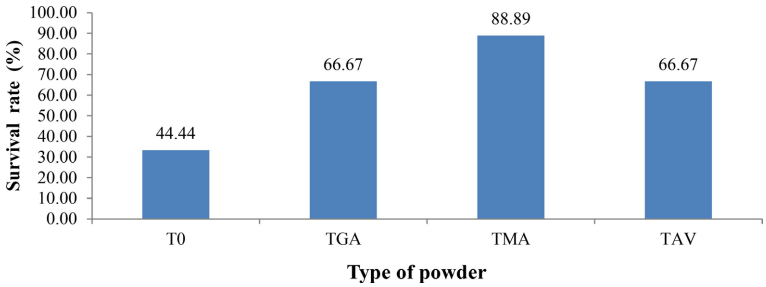

Figure 5. Effects of *Mangifera indica*, *Persea americana* and *Psidium guajava* leaf powders on survival rate. T0: basic feed (*without* additive); TGA, TMA, TAV, basic ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

3.6. Effects of the Different Rations on the Cumulative Growth Characteristics of Rabbits

Table 2 summarizes the cumulative growth performance of rabbits fed rations supplemented with *Mangifera indica*, *Persea americana* and *Psidium guajava* powder. It follows that the addition of the extracts to the feed did not have a significant effect ($p > 0.05$) on the cumulative growth characteristics (feed intake, weight gain, live weight, average daily gain, and feed conversion ratio) of the rabbits compared to the controls.

Table 2. Effects of plant leaf powder type on growth characteristics of rabbits.

Growth characteristics	T0	Type of Powder			p
		T1	T2	T3	
Food consumption (g)	5130.61 ± 21.64	5296.94 ± 153.07	5188.11 ± 204.89	5332.11 ± 53.16	0.28
Live weight (g)	2091.00 ± 48.66	2160.17 ± 127.64	2189.11 ± 51.39	2088.33 ± 71.50	0.19
Weight gain (g)	1071.11 ± 129.09	1088.17 ± 153.23	1123.78 ± 103.27	1068.44 ± 134.34	0.95
Average daily gain (g)	19. 25 ± 2.87	19.54 ± 2.87	20.07 ± 1.84	19.26 ± 2.40	0.97
Consumption index	4.75 ± 0.69	4.97 ± 0.61	4.64 ± 0.49	5.00 ± 0.68	0.88

T1, T2, T3, base ration + 0.50% *Psidium guajava*; *Mangifera indica* and *Persea americana* powder respectively.

3.7. Effects of Different Rations on Carcass Characteristics and Relative Organ Weights of Rabbits

Table 3 shows the variation in carcass characteristics and relative organ weights in rabbits according to the type of powder incorporated in the ration: it was found that the different leaves powder induced an increase in carcass yield in rabbits, but this increase was only significant with the *M. indica* leaf powder compared to the control. Conversely, kidney weights were significantly reduced in these same animals compared to the control group.

The values of the characteristics (legs, fur, head, heart, liver, pancreas) were not significantly affected ($p > 0.05$) by the addition of the leaf powder for any of them.

Table 3. Variation in carcass characteristics and relative organ weights in rabbits according to plant leaves powder.

Characteristics (% of live weight)	T0	Type of Powder			p
		T1	T2	T3	
Carcass yield	48.63 ± 0.74^{b}	49.70 ± 0.58^{b}	51.03 ± 0.24^{a}	49.70 ± 0.61^{b}	**0.01**
Legs	2.61 ± 0.18	2.72 ± 0.26	2.72 ± 0.38	2.68 ± 0.66	0.93

Continued

Furs	9.80 ± 0.20	11.09 ± 1.16	10.57 ± 0.90	10.15 ± 0.38	0.27
Head	5.87 ± 0.32	5.83 ± 0.34	5.96 ± 0.26	5.71 ± 0.18	0.76
Loins	0.76 ± 0.02^{ab}	0.86 ± 0.03^{a}	0.62 ± 0.08^{c}	0.70 ± 0.06^{bc}	**0.00**
Heart	0.24 ± 0.06	0.30 ± 0.02	0.28 ± 005	0.29 ± 0.04	0.24
Liver	2.56 ± 0.17	2.57 ± 0.15	2.61 ± 0.08	2.65 ± 0.07	0.82
Pancreas	0.54 ± 0.07	0.52 ± 0.02	0.55 ± 0.12	0.50 ± 0.01	0.84

a, b and c: Means with different letters on the same line are significantly different ($p < 0.05$). p = probability. T1, T2, T3, base ration + 0.50% *Psidium guajava*; *Mangifera indica* and *Persea americana* powder respectively.

3.8. Effects of Leaf Powder Type on the Development of Digestive Organs and Stomach Contents in Rabbits

The organs of digestion and stomach contents in rabbits fed rations containing *Mangifera indica*, *Persea americana*, and *Psidium guajava* leaves are summarized in Table 4. It was found that the gut lengths recorded in rabbits fed rations consisting of *P. guajava*, and *P. americana* leaves were comparable and, significantly ($p < 0.05$) higher than those recorded in rabbits fed control rations and supplemented with *M. indica* leaves. Similarly, an increase in gut weight was recorded although it was only significant with the inclusion of *M. indica* and *P. guajava* leaf powder in the feed compared to the control. The gut and empty stomach density values were not significantly ($p > 0.05$) affected by the addition of the leaf powder regardless of the type considered.

Stomach fullness decreased with the inclusion of the different powders in the feed, but this decrease was only significant ($p < 0.05$) with the *M. indica* and *P. guajava* leaf powders compared to the control.

Table 4. Effects of leaf type on digestive organs and stomach contents in the fawn rabbit.

Digestive organs	T0	Type of Powder			p
		T1	T2	T3	
Intestine length (cm)	10.64 ± 0.93^{b}	11.82 ± 0.50^{a}	11.02 ± 0.49^{b}	12.16 ± 0.35^{a}	**0.00**
Intestine weight (g)	11.48 ± 0.50^{c}	11.95 ± 0.75^{bc}	12.65 ± 0.52^{b}	13.77 ± 0.36^{a}	**0.00**
Density of intestine	1.08 ± 0.06	1.013 ± 0.14	1.16 ± 0.22	1.13 ± 0.15	0.57
Stomach full (g)	6.22 ± 0.42^{a}	4.39 ± 0.36^{c}	5.54 ± 0.41^{ab}	5.09 ± 0.23^{b}	**0.00**
Empty stomach (g)	1.35 ± 0.07	1.16 ± 0.06	1.16 ± 0.06	1.25 ± 0.03	0.17

a, b, c: Means with different letters on the same line are significantly different ($p < 0.05$). p = probability. TGA, TMA, TAV, basal ration + 0.50% *Psidium guajava* powder; *Mangifera indica* and *Persea americana* respectively.

4. Discussion

Food security is one of the important conditions that must be met for the individual to be nutritionally secure and to maintain good health at the household level (Chakraborty & Newton, 2011; Hellen & Abdoulaye 2024) [17] [18]. In the present study, feed intake in rabbits was not affected by leaf powder of any type in reference to the control. This result is similar to that reported by Kambou *et al.* (2015) [19] in Brahma hens fed a diet containing mango leaves. Furthermore, it is contradictory to the results of the work of Bello (2010) [20], who found that the incorporation of *M. oleifera* leaf powder at the rates of 16% and 24% in the feed of local hens induced a significant decrease in feed consumption compared to control birds. The discrepancy between these two studies could result from the incorporation rate of the different powders and animal material. Indeed, the rabbit being a strict monogastric herbivorous animal would not have had difficulties to ingest a compound feed containing the powder of plant leaves.

The values of live weight and weight gain noted in rabbits fed rations consisting of the three types of leaves considered were not significantly ($p > 0.05$) affected compared to the control. This result might be just a consequence of the effect of these leaves on feed intake. According to Van *et al.* (2006) [21], there is a positive correlation between feed consumption and weight gain. This author mentions that the growth of an animal is primarily determined by the quantity and quality of the feed it consumes. Furthermore, weight gain, which is the difference between live weights of two consecutive weeks, changed at the same rate as live weight. The results of the present study are contradictory to those of Konmy *et al.* (2021) [22] who observed a significant ($p < 0.05$) increase in live weight from the 5th week onwards in rabbits fed the ration supplemented with M. oleifera leaf powder at the rates of 5%, 10% and 15% compared to the control. This discrepancy between these results and those obtained by Konmy *et al.* (2021) [22] would be related to the incorporation rates (0.5%) and especially to the nature of the ration (mealy or granular form) in which they were incorporated.

The different leaf powders induced an increase in carcass yield in rabbits, but this increase was only significant ($p < 0.05$) with the *M. indica* leaf powder compared to the control. The increase in carcass yield observed in animals fed a ration supplemented with *M. indica* leaf powder may be the consequence of a tendency to increase live weight and weight gain noted in this batch. According to Ouhayoun (1989) [23], rabbit slaughter yield is positively correlated with live weight. In the same vein, Dahouda *et al.* (2013) [24] showed that low carcass yield in rabbits is due to a recognized low weight performance in these animals.

In the present study, liver weight was not influenced by rations consisting of the different plant leaf powders. However, kidney weights were reduced in animals fed rations rich in powdered *M. indica* and P. *americana* leaves. These results suggest the non-toxic effect of these leaves in the diet and therefore could justify the high survival rate recorded in the animals compared to the control. Furthermore, Rouas (2010) [25] showed that the variation in the weight of these organs

would indicate their broad involvement or not in the elimination of undesirable substances from the body. Regarding the organs of digestion, the weights of filled stomachs decreased in animals fed rations supplemented with different leaf powders, however, this difference was only significant in those exposed to the ration containing *Psidium guajava* leaves in reference to the control group. This result can be explained by the fact that the different leaf powders have a high fiber content that may facilitate digestive transit. According to Gidenne (2015) [26], a high fiber content shortens the transit time and could reduce the digestibility of nitrogenous materials. Similarly, intestinal lengths and weights were increased in animals fed rations containing the different leaf powders. However, this increase was only significant in animals exposed to rations containing *Psidium guajava* and *Persea americana* leaves compared to the control. This result would again be related to the fiber richness of the leaves incorporated in the ration, showing a close correlation between the increase of the gut length and its weight.

5. Conclusion

The incorporation of mango, avocado and guava leaf powders in the ration leads to an improvement of the growth characteristics (carcass yield, development of digestive organs) in rabbits. However, this effect is more marked with mango leaf powder. Rabbits fed rations containing this plant extract showed a high survival rate (88.89%), reduced kidney weights, filled stomach and increased gut weight and length.

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Conflicts of Interest

The authors of this article certify that there is no conflict of interest.

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