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Effect of In-Feed Guava Leaf Powder (*Psidium Guajava*) on Ingestion, *In Vivo* Digestibility and Biochemical Profile in Rabbits (*Oryctolagus Cuniculus*)

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Abstract

The use of unconventional ingredients in the formulation of monogastric feed is increasingly common and many studies have been conducted on the incorporation of agricultural by-products in rabbit diets. The objective of this study was to evaluate the effect of in-feed guava leaf powder (GLP) on the ingestion, digestibility of feed components and biochemical parameters of rabbits. Thirty (30) rabbits aged 5 months and weighing an average of 2.365 kg were assigned to three (03) groups following a completely randomized design. The first group or control group received the G0 ration made of commercially purchased agro-industrial ingredients. The other two received the G10 and G15 rations which respectively had 10 and 15% GLP in addition to the same ingredients of the G0 ration. The main results showed that crude fiber intake significantly increased and crude protein digestibility significantly decreased with the incorporation of GLP into the diet. Digestibility and nitrogen balance were significantly higher in rabbits from the control group than in the others. For biochemical parameters, only globulin, ASAT and Urea levels were significantly influenced by the presence of GLP in the rabbit diet. The results of the present study provided scientific evidence on the use of GLP (up to 15%) in rabbit diets without any risk of disrupting nutrient intake and digestibility, as well as adverse effects on their physiological functions.

Keywords: Biochemical parameters; feed intake; guava leaves; feed component digestibility; rabbit

Introduction

Rabbit farming is a growing activity in Cameroon, offering opportunities for meat production and income. Although challenges persist, the potential benefits of this activity make it an attractive option for diversifying animal production and strengthening the country's food security [1]. Indeed, rabbit meat is low in fat, low in calories and a good source of good quality protein, and an excellent source of vitamins, minerals and trace elements [2]. However, its production at the national level remains very low (600 tonnes per year or 0.039 kg per inhabitant) due to the low professionalization of the sector [3]. This situation can be addressed through better control of livestock management and feeding. Indeed, feeding remains the major challenge for the success of livestock farming. It represents 60 to 70% of total production costs in intensive livestock farming [4, 5]. Efforts are being made by researchers to minimize problems related to rabbit feeding by exploring new so-called unconventional food sources or by improving conventional sources with less expensive and easily accessible unconventional additives. Indeed, Feed additives are incorporated substances intended to directly or indirectly improve the efficiency of rations, thus optimizing their digestibility while strengthening the animal's digestive health and improving feed conversion [6, 7]. Plant-based additives, including guava leaves, are inexpensive, readily available, and environmentally friendly.

Guava, *Psidium guajava*, from the Myrtaceae family, is a tropical plant cultivated in several African countries. Its leaves are primarily used for their medicinal properties and health benefits. They contain bioactive compounds such as flavonoids, tannins, and essential oils, which confer antibacterial and anti-inflammatory properties [8-10]. Singh *et al.* [11] showed that guava leaves can help prevent bacterial and viral infections in goats. Furthermore, Mahmoud *et al.* [12] and Anju Sati *et al.* [13] found an increase in live weight, a decrease in feed conversion and a significant improvement in health of broiler chickens that received 1% of guava leaf powder in their ration. Nguyen Thi Thuy *et al.* [14] also observed an increase in yellow coloration in local hens. Moreover, Zaminur Rahman *et al.* [15] showed that the addition of 4.5% guava leaf powder in the ration reduced the susceptibility of broiler chickens to microbes and improved production performance. However, there is limited published data on the use of guava leaves powder in rabbit diet, and it is with a view to remedy this situation that the present work was initiated, to evaluate the effect of the level of in-feed guava leaf powder in the ration, on the ingestion, feed components digestibility and biochemical parameters of rabbits.

Materials and Methods

Animal Material, Housing, and Prophylaxis

A total of thirty (30) New Zealand rabbits, approximately 5 months old and weighing an average of 2.365 kg, were used for this study. The animals were housed individually in batteries of galvanized wire cages (50 cm x 45 cm x 26 cm), each equipped with a feeder and a water teats. The digestibility device consisted of a mosquito net lining the cage, used to collect faeces, and plastic paper that drained the rabbits' urine into a bottle. At the beginning of the trial, an anti-stress supplement combined with a vitamin (Introuit A + WS) was administered to the animals. The cages and feeders were cleaned daily, as was the livestock building.

Plant Material

The plant material consisted of guava leaves harvested on plots of the teaching and research farm of the University of Dschang--Cameroon, dried to a constant weight in an oven set at 50°C, and then ground into powder using an electronic grinder. A sample of guava leaf powder was then collected and sent to the laboratory for phytochemical analysis (Table 1) and bromatological analysis [16] (Table 2).

Table 1: Phytochemical analysis of Guava Leaf Powder

Constituents	Guava Leaf Powder
Alkaloids	+
Phenols	+
Flavonoids	+
Sterols	-
Triterpenoids	+
Tannins	+
Saponins	-
Anthocyanins	+
Anthraquinones	+

+ : presence ; - : absence.

Table 2: Bromatological analysis of guava leaf powder

Characteristics	Guava leaves powder
Dry Matter (%)	97.32
Organic Matter (% DM)	93.55
Ash (% DM)	6.30
Crude Protein (% DM)	3.61
Fat (% DM)	1.60
Crude Fiber (% DM)	37.41
Crude Energy (kcal/kg DM)	4328.25
Metabolic Energy (kcal/kg DM)	2488.74

Dietary Rations

The basal or control ration G0 consisted solely of commercially purchased industrial by-products. The other rations G10 and G15 contained, in addition to the basal ration ingredients, 10 and 15% guava leaf powder (GLP), respectively. The rations were formulated as follows:

- G0 = Control ration without guava leaf powder (Group G0);

- G10 = Ration incorporating 10% guava leaf powder (Group G10);

- G15 = Ration incorporating 20% guava leaf powder (Group G15);

The bromatological analysis of the rations is presented in Table 3.

Table 3: Percentage and bromatological analysis of experimental rations

Ingredients	Experimental rations		
	G0	G10	G15
Percentage Composition			
Corn	22	15	15
Wheat Bran	50	49	47
Cotton Meal	5	5	3
Palm Kernel Meal	20	18	17
Shell	0.5	0.5	0.5
Premix 2%	2	2	2
Palm Oil	0.5	0.5	0.5
Guava Leaf Powder	**0**	**10**	**15**
Total	100	100	100
Analyzed Bromatological Composition			
Dry Matter (%)	92.90	92.96	92.21
Crude Protein (% DM)	15.82	15.97	15.30
Crude Fiber (% DM)	11.29	14.04	17.26
Metabolizable Energy (Kcal/Kg DM)	2639.13	2526.55	2688.60

DM : Dry Matter

The formulated rations were pelleted before being fed to the animals.

The experimental design consisted of 30 digestibility cages divided into three groups of 10 each. At the beginning of the trial, the animals were weighed, identified, and divided into three groups of 10 rabbits each, having comparable body weight. Each animal was then randomly placed in a digestibility cage, and each group of 10 replicates was randomly assigned one of the three experimental rations (G0, G10, or G15).

For the duration of the trial (21 days), the animals in the control group received the control ration (G0), while those in groups G10 and G15 were fed rations containing 10% and 15% guava leaf powder, respectively. The animals had *ad libitum* access to feed and drinking water.

Evaluation of the Effect of Guava Leaf Powder on Feed Intake and Digestibility

This evaluation lasted 21 days, divided into two periods: a first period (14 days) during which the animals were adapted to the digestibility cages and experimental rations, and a second period of actual digestibility (7 days) during which feed was weighed and served once a day, in the morning between 8:00 and 9:00 a.m., and refusals were collected 24 hours later and weighed before the next feed was served. The weights thus obtained were used to determine feed intake (FI) using the formula:

FI (g) = quantity of feed served - quantity of feed left

Like the feed refusals, the faeces of each animal were also collected and weighed. A 100 g sample of faeces and a 100 g sample of each ration were taken and dried at 50°C to a constant weight in a ventilated oven. They were then ground to powder. This powder was used to determine their dry matter (DM), ash (A), organic matter (OM), crude fiber (CF), and crude protein (CP) content. Similarly to feed refusals and faeces, the urine produced over 24 hours by each animal was collected in a bottle into which 10% concentrated sulfuric acid (H2SO4) had been previously added, based on the average volume of urine produced by the animal during the adaptation period, in order to stabilize the nitrogen content in the urine. This urine was measured and 10 ml were then collected using a syringe and later use for the determination of urinary nitrogen.

The determination of DM, Ash, OM and CF contents, and the analysis of excreted nitrogen (N) (fecal and urinary) were carried out according to the methods described by [16]. Crude protein (CP) was determined by the Kjeldhal method. The data thus obtained made it possible to calculate the apparent digestive utilization coefficients (aDUC) of these feed components according to the following formulas [17]:

$$aDUC\ DM\ \ (\%)\ \ = \frac{\text{Ingested DM} - \text{fecal DM}}{\text{Ingested DM}} x\ 100$$

$$aDUC\ OM\ \ (\%)\ \ = \frac{\text{Ingested OM} - \text{fecal OM}}{\text{Ingested OM}} x\ 100$$

$$aDUC\ CF\ \ (\%)\ \ = \frac{\text{Ingested CF} - \text{fecal CF}}{\text{Ingested CF}} x\ 100$$

$$aDUC\ CP\ \ (\%)\ \ = \frac{\text{Ingested CP} - \text{fecal CF}}{\text{Ingested CP}} x\ 100$$

$$aDUC\ N\ \ (\%)\ \ = \frac{\text{Ingested N} - \text{fecal N}}{\text{Ingested N}} x\ 100$$

Evaluation of the effect of guava leaf powder on serum parameters

At the end of the trial, the animals were sacrificed and the blood from each animal was collected using a dry test tube without anticoagulant and centrifugated (3000 rpm) for 15 minutes to obtain serum free of cellular debris. The serum was then collected and stored at -20°C for 12 hours to determine the levels of aspartate aminotransferase (ASAT), alanine aminotransferase (ALAT), total protein, albumin, creatinine, urea, triglycerides, total cholesterol, and High Density Lipoprotein (HDL). The assays were carried out using a spectrophotometer following the protocol described by the commercial RANDOX and SGM® kits. The assay results were then used to calculate:

-Globulin levels were calculated using the following formula:

Globulin levels = Total protein levels – Albumin levels

-Low-density lipoprotein (LDL) cholesterol fraction was calculated using the following formula:

LDL cholesterol (mg/dL) = Total cholesterol – (Triglycerides/5) – HDL cholesterol

Statistical Analyses

Data from the evaluated parameters were submitted to one-way analysis of variance (ANOVA) and Duncan's test at the 5% significance level was used to compare means when significant differences were observed. Data were expressed as mean ± standard deviation. The software used was SPSS 26.0.

The statistical analysis was based on the following illustrated equation:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

Where:

Y_{ij} = Observation (ingestion, digestibility of feed components, biochemical parameters)

μ = Overall mean

T_i = Inclusion level of GLP (0, 10 and 15%)

ε_{ij} = Random error component.

Results

Effect of In-feed Guava Leaf Powder on Feed Components Intake and Digestibility

Feed Intake

Table 4 shows that the incorporation of guava leaf powder (GLP) in the diet of rabbits had no significant (p>0.05) effect on the feed components intake considered except that of crude fiber which significantly (p<0.05) decreased with the incorporation of GLP in the ration. The highest value was obtained from animals in group G0 (28.75±1.07 g/day) and the lowest from those in group G15 (19.70±0.42 g/day). Furthermore, no significant difference was observed on dry matter intake which regularly increased with the incorporation level of GLP in the diet, with the highest value (162.07±3.50 g/day) obtained from animals that received the diet containing 15% guava leaf powder.

Table 4: Effect of in-feed guava leaf powder on feed components intake

Feed components intake (g/day)	Experimental Rations			p
	G0	G10	G15	
Dry matter	153.59±5.72	158.89±10.98	162.07±3.50	0.17
Organic matter	157.94±5.88	153.59±10.62	157.18±3.39	0.56
Crude protein	18.38±0.68	18.85±1.30	17.97±0.38	0.25
Crude fiber	28.75±1.07[a]	23.99±1.65[b]	19.70±0.42[c]	0.00

[a,b,c]: Means assigned the same letter are statistically comparable; G0, G10 and G15: rations containing 0, 10 and 15% of GLP respectively; p: probability.

Feed Components Digestibility

GLP had significant effects on crude protein (CP) digestibility (Table 5), which decreased with its inclusion in the diet. Indeed, rabbits in group G0 had statistically higher aDUC CP values (P<0.05) than those of does in group G10, which were also statistically comparable (P>0.05) to those obtained from does in group G15.

Table 5: Effect of guava leaf powder incorporation on feed components apparent digestive utilization coefficient

aDUC (%)	Experimental rations			p
	G0	G10	G15	
Dry matter	61.57±4.85	53.62±7.72	61.11±4.09	0.06
Organic matter	62.53±4.87	56.45±7.01	63.32±3.73	0.08
Crude protein	62.05±4.14[a]	51.57±6.92[b]	57.24±3.91[ab]	0.01
Crude fiber	64.03±3.61	58.13±8.30	63.11±3.93	0.19

[a,b]: Means assigned the same letter are statistically comparable; G0, G10 and G15: rations containing 0, 10 and 15% of GLP respectively; p: probability; aDUC: apparent digestive utilization coefficient.

Effect of Guava Leaf Powder Incorporation on Nitrogen Balance in Rabbits

Table 6 shows that GLP had significant ($p<0.05$) effects on all nitrogen parameters assessed except ingested nitrogen. The lowest fecal secretion was obtained from animals in group G0 (4.71±5.36 g/day) and the highest from those in group G10 (6.26±12.04 g/day). Regarding urinary secretion, the lowest was obtained from animals in group G15 (0.95±0.29 g/day) and the highest from those in group G0 (1.78±0.72 g/day), although comparable with that of group G10. The amount of total nitrogen excreted was lower in animals from group G15 (6.23±5.15 g/day) compared to that of animals from group G0, and higher in animals from group G10 (7.75±11.91 g/day).

Rabbits fed the control diet had the best nitrogen balance, followed by rabbits from groups G15 and G10, respectively.

Nitrogen digestibility (aDUC N) significantly ($p<0.05$) decreased with the inclusion of GLP in rabbit diet. Indeed, rabbits in group G0 had statistically higher aDUC N values ($P<0.05$) than those in group G10, which were also statistically comparable ($P>0.05$) to those obtained in group G15.

Table 6: Effect of guava leaf powder on nitrogen balance of rabbits fed different diets

Characteristics (g/day)	Experimental rations			p
	G0	G10	G15	
Ingested nitrogen	20.59±0.76	21.11±1.46	20.13±0.43	0.25
Fecal nitrogen	4.71±5.36b	6.26±12.04a	5.28±5.11ab	0.01
Urinary nitrogen	1.78±0.72a	1.49±0.50ab	0.95±0.29b	0.04
Total nitrogen excreted	6.49±5.99ab	7.75±11.91a	6.23±5.15b	0.01
Nitrogen balance	14.1±5.23a	13.36±10.45c	13.9±4.72b	0.04
aDUC of nitrogen (%)	63.42±3.74a	52.71±7.09b	58.04±3.90ab	0.00

[a,b,c]: Means assigned the same letter are statistically comparable; G0, G10 and G15: rations containing 0, 10 and 15% of GLP respectively; p: probability; aDUC: apparent digestive utilization coefficient.

Incorporating GLP into the rabbit diet had significant effects on globulin, ASAT, and urea levels (Table 7). Indeed, globulin levels significantly ($p<0.05$) decreased with increasing GLP incorporation levels; the highest value (2.18±0.37 g/dl) was obtained from rabbits in group G0 and the lowest (1.31±0.65 g/dl) from those in group G15, although both values were comparable with those of animals in group G10. Regarding ASAT, the highest value (123.61±70.13 IU/l) was significantly obtained from rabbits of group G15 and the lowest (64.95±17.82 IU/l), from those of group G0 though comparable to that of rabbits of group G10.

The level of urea decreased with the level of GLP in the ration; the highest level, though comparable, were obtained from animals of groups G0 and G10 respectively, and the lowest significantly (p<0.05) from animals of group G15 (15.15±6.34 mg/dl).

In addition, total protein, total cholesterol, HDL, and LDL levels decreased, and albumin, glucose, creatinine, and ALAT levels increased steadily with the addition of GLP in rabbit diet, although no significant (p>0.05) difference was observed.

Table 7: Effect of guava leaf powder on biochemical parameters of rabbits

Biochemical Parameters	**Expérimental rations**			p
	G0	G10	G15	
Total Protein (g/dL)	4.34±0.31	4.12±0.20	3.69±0.87	0.19
Albumin (g/dL)	2.15±0.29	2.38±0.21	2.38±0.43	0.46
Globulins (g/dL)	2.18±0.37[a]	1.73±0.14[ab]	1.31±0.65[b]	0.02
Glucose (mg/dL)	20.97±3.84	21.96±2.48	22.11±5.56	0.89
Creatinin (mg/dL)	1.15±0.21	1.33±0.18	1.33±0.27	0.39
Total Cholesterol (mg/dL)	47.95±13.08	36.02±8.04	42.34±13.68	0.31
HDL (mg/dL)	20.28±8.58	15.84±3.47	17.00±6.87	0.56
LDL (mg/dL)	23.06±16.52	16.49±5.45	19.65±11.21	0.69
Triglycerides (mg/dL)	23.01±6.87	18.37±6.95	28.41±17.51	0.47
ALAT (IU/L)	52.55±15.57	61.11±32.58	69.66±32.60	0.63
ASAT (IU/L)	64.95±17.82[c]	78.74±23.32[bc]	123.61±70.13[a]	0.01
Urea (mg/dL)	34.37±10.08[a]	32.49±26.57[a]	15.15±6.34[b]	0.02

[a,b,c]: Means assigned the same letter are statistically comparable; G0, G10 and G15: rations containing 0, 10 and 15% of GLP respectively; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; ALAT: Alanine Aminotransferase; ASAT: Aspartate Aminotransferase; p: probability.

Discussion

The incorporation of guava leaf powder (GLP) had no significant effect on the intake of dry matter, organic matter, crude protein, and nitrogen in the three diets. These results show that GLP, even at an incorporation rate of 15%, does not affect diet palatability. It could be used as an ingredient in rabbit feed. These results are consistent with those of Noumbissi *et al.* [18] with the incorporation of pineapple press residues in the diet of fattening rabbits. Furthermore, crude fiber intake significantly decreased (p<0.05) with increasing GLP incorporation levels in the diet. This reduction could be explained by an increase in the fiber content in the diets. Rabbits must certainly consume fiber to ensure their digestive health, but at high levels in the diet Fiber causes bloating and gives the animal a feeling of satiety, which reduces the amount of crude fiber consumed [19]. These results are contrary to those of Noumbissi *et al.* [20] who instead observed an increase in crude fiber intake in rabbits fed with rations incorporated with ground coffee pulp.

The digestibility of CP (aDUC CP) decreased with the presence of GLP in the ration. This decrease could be explained by the presence, in guava leaves, of tannins that bind to proteins and reduce their bioavailability. Similar results were reported by El Anany [21] in chickens, where they showed that a 10% inclusion level of guava leaves reduced protein digestibility due to a transient antinutritional effect due to the presence of antinutritional factors such as tannins in guava leaves, which can bind to nutrients and prevent their absorption. Our observations are also similar to those of Usman *et al.* [22] with the incorporation of cooked Bambara nut flour as a replacement to peanut paste in the diet of growing rabbits. However, they are in disagreement with those of Osman *et al.* [23], Czech *et al.* [24]), Noumbissi *et al.* [18] who observed a significant increase in aDUC CP with the incorporation, respectively, of bamboo leaf powders, rapeseeds and pineapple press residues in the diet of fattening rabbits. The aDUC CP values obtained with the test diets in the present study (51.57 - 57.24%) are within the range of those (50.70 - 58.36%) obtained by Noumbissi *et al.* [18], higher than those (31.00 - 48.6%) obtained by Zougou Tovignon *et al.* [25] with the incorporation of *Pueraria phaseoloides* leaf powder in the rabbit ration, and significantly lower than those (80.27 - 85.18%) obtained by Usman *et al.* [22].

GLP had no significant effect on nitrogen intake by rabbits. This observation was the same as that of Basyony *et al.* [26] with the incorporation of *Ziziphus spina-christi* leaf powder in rabbit diet. The values obtained with GLP were higher than those obtained by previous authors. The animals in the control group (G0) recorded the best nitrogen balance in the present study. This observation is in disagreement with those of Basyony *et al.* [26] who obtained their best nitrogen balance with animals receiving incorporated diets. Tripathi *et al.* [27] did not find a significant difference between the different treatments for this parameter, when they incorporated *Brassica juncea* mustard powder into the diet of growing rabbits.

Nitrogen digestibility significantly decreased with the presence of GLP in the ration. Our observations are in line with those of Walaa Salama *et al.* [28] who also noted a significant decrease in this parameter with the incorporation of treated *Jatropha curcas* seed powder in the feed of growing rabbits. Furthermore, our observations are contrary to those of Oyelami *et al.* [29], Basyony *et al.* [26], Asar *et al.* [30] who rather noted an increase with the incorporation, in the ration of growing rabbits, respectively, of Nutrizyme, *Ziziphus spina-christi* leaf powder and corn cob flour mixed with faba bean straw.

The results obtained in the present study show that GLP had no significant effect on the total protein level. These results are in agreement with those of Abou-Shehema *et al.* [31], Akpet and Gboshe [32], Amao *et al.* [33], Morsy *et al.* [10] who found no difference regarding this parameter between the control group and the groups supplemented, respectively, with pumpkin seed powder, cassava peel powder, African apple *Chrysophyllum albidum* seed powder and guava leaf extract. On the other hand, they disagree with those of Mubé *et al.* [34] who found significant differences in this parameter with the incorporation of ginger powder in the rabbit diet. Furthermore, the total protein level decreased with the level of GLP incorporation in the diet. Indeed, given that total protein is an important blood constituent used, among other things, to assess the nutritional status and functional status of certain detoxifying organs of the organism (liver and kidneys) of animals [35], the low levels observed with the rations incorporated with GLP compared to the control ration, show that this additive is safe on the hepatorenal functions of rabbits. Our observations are consistent with the remarks of Esiegwu *et al.* [36], who reported that supplementation with *Garcinia kola* induced a reduction in the total protein level in rabbits. On the other hand, Ilo *et al.* [35] observed rather a significant increase in this parameter with the level of incorporation of *Garcinia kola* seed powder in the ration of fattening rabbits.

The increase in albumin in rabbits receiving GLP in their diet could indicate an improvement in hepatic protein synthesis, favoured by the richness of guava leaves in antioxidants (flavonoids and vitamin C). These observations are consistent with the results of Sun and Zhang [37] and those of Mube *et al.* [34] in rabbits fed, respectively, with alfalfa meal as a substitute to *Moringa oleifera* and with ginger powder.

Total cholesterol decreased insignificantly with the presence of GLP in the diet of the rabbits. The values obtained in the presence of GLP (36.02 and 42.34 mg/dl), although lower than that of the control, are nevertheless within the normal range (10 to 80 mg/dl) [38]. All these observations imply that GLP has no adverse effect on the biochemical response of the rabbit. HDL and LDL cholesterols followed the same trend as total cholesterol. Azdinia *et al.* [39] also found no significant difference in these parameters with the incorporation of jujube pulp powder in the diet of rabbits. Furthermore, Morsy *et al.* [10] and Crespo and Esteve-Garcia [40] found a significant decrease in total cholesterol and LDL levels but rather a significant increase in HDL levels, with the incorporation of guava leaf extract, respectively, in the diet of rabbits and broiler chickens. In the same vein, Mahmoud *et al.* [12] also observed a decrease in the lipid profile in broiler chickens that received 1% of dried guava leaves in their diet.

GLP induced a non-significant increase in glucose levels in rabbits. Since guava leaves do not contain particularly sugar, the observed increase in glucose levels could be explained, among other things, by stress, the method of blood collection or the housing conditions of the rabbits [41]. This increase was also observed by Azdinia *et al.* [39] by incorporating jujube powder into the diet of rabbits during all physiological stages, by Ogunsipe and Agbede [42] in rabbits fed with millet tops. The values observed with guava leaf powder (21.96 - 22.11 mg/dl) remain lower than those (92.6 - 94.8 mg/dl) obtained by Igwebuike *et al.* [43] in their studies on the incorporation of dried *Acacia albida* pods in the rabbit diet, to those (76.3 - 94.3 mg/dl) obtained by Adamu *et al.* [44] when they incorporated the pulp of *Prosopis africana* in the rabbit diet.

The globulin level significantly decreased with increasing GLP incorporation level in the diet. These results are in agreement with those of Ogunsipe *et al.* [45] with the incorporation of sorghum tops in the rabbit diet, but are contrary to those obtained by Njidda and Isidahomen [46] who rather observed an increase in this parameter in rabbits fed with the diet incorporated with increasing levels of sesame seed flour. The values observed in the present study (1.31 - 1.73 g/d1), although lower than the values (1.70 - 1.87 g/dl) obtained by Ogunsipe *et al.* [45], to the values (2.02 - 2.40 g/dl) obtained by Olatunji *et al.* [47] with the incorporation of *Moringa oleifera* Leaf flour in the rabbit ration, are not far from the normal margin (1.5 - 3.3 g/dl) recommended by Benkhelfa [48] in domestic rabbits.

The urea level decreased significantly with the increasing level of GLP in the rabbits' diet. Since an increase in blood urea level can be associated with renal dysfunction [49], the results of the present study may mean that GLP does not impair renal function. Indeed, guava leaves are rich in flavonoids and these have protective effects on the kidney thanks to their antioxidant properties. Since urea is a waste product of protein degradation and must be eliminated by the kidneys [50], the decrease in its level in the blood can also mean either a hepatic failure to degrade the proteins producing it, or the efficiency of the kidneys to eliminate it from the blood. Let us also not lose sight of the fact that apart from the diet in rabbits, unlike other animals, the level of urea can be easily influenced by other physiological or environmental factors (stress, time of blood sample collection, etc.). Our results are contrary to those of Ogunsipe *et al.* [45] who observed a significant increase in urea levels with increasing levels of sorghum haulm in the rabbit diet. Furthermore, the urea levels obtained with GLP (15.15 - 32.49 mg/dl) were not far from the normal range (13-30 mg/dl) recommended by MediRabbit [38].

Creatinine levels increased insignificantly with the presence of GLP. Since creatinine (like urea) is a waste product that must be eliminated by the kidneys through urine, an increase in its level could indicate poor kidney function, not sufficiently cleaning the blood of this waste. Ogunsipe *et al.* [45] also observed a trend towards increased creatinine levels in rabbits fed sorghum haulm. On the other hand, Khayyal *et al.* [51] observed a rather regular decrease in creatinine levels with increasing levels of dried green beans in the rabbit diet. In addition, the levels obtained with GLP (1.33 - 1.35 mg/dl) remain lower to those (2.32 – 2.51 mg/dl) obtained by Ogunsipe *et al.* [45], but higher than those (1.03 - 1.10 mg/dl) of Khayyal *et al.* [51], to those (0.73-0.80 mg/dl) obtained by Ahemen *et al.* [52] in rabbits supplemented with *Ipomoea aquatica* leaf flour. Nevertheless, our values remain within the standard of 0.5 to 2.6 mg/dl recommended by Benkhelfa [48] in domestic rabbits.

ALAT and ASAT levels increased with the increasing level of GLP in the ration. This could mean on the one hand that GLP induced a better metabolism of amino acids (alanine and aspartate respectively) and on the other hand, it could induce a depression of liver or kidney activity, given that aminotransferases are indicators of hepatic, renal and cardiac health. Khayyal *et al.* [51] also observed an increase, compared to the control, in transaminase levels in rabbits consuming the diet enriched with dried green beans. Amao *et al*. [33] observed an increase in ASAT levels with 5 and 10% of African apple seed flour *Chrysophyllum albidum*, but rather a decrease of the ALAT level with the increasing level of the same flour. The ALAT levels (61.11-69.66 IU/L) obtained with GLP are within the physiological range proposed by MediRabbit [38] (55-260 IU/L) and the ASAT levels obtained (78.74-123.61 IU/L) are rather higher than the norm (17.49-29.18 IU/L) [38].

Conclusion

From this study, guava leaf powder had no significant effect on feed components ingestion or intake and digestibility except for crude fiber and crude protein respectively. Furthermore, it had significant effects on all nitrogen characteristics except for ingested nitrogen, the best nitrogen balance having been obtained with 0% guava leaf powder. Regarding biochemical parameters, globulin and urea levels significantly decreased and ASAT levels significantly increased with the presence of guava leaf powder in the ration, while other parameters remained comparable regardless of the ration. In summary, guava leaf powder could be incorporated into the ration at a level of 15% without deteriorating effects on the ingestion and digestibility of feed components and on the health of rabbits. However, production studies are necessary to optimize its use and better clarify its effects.

Further Research

Further studies can be conducted to evaluate :

- The effect of GLP on growth characteristics, carcass characteristics and quail meat quality ;
- The reproductive performance of female quails fed with GLP-incorporated feed ;
- The effect of GLP on production cost of rabbits.

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