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Effects of Ginger Meal (*Zingiber officinale*) Associated to *Desmodium intortum* and/or *Stylosanthes guianensis* on Growth Performances of Rabbit (*Oryctolagus cuniculus*) in Cameroon

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Abstract

Background: The sustainability of animal production system depends mostly on feed management. Therefore, the combination of local leguminous forage as source of protein and ginger as phytobiotics can be one of the safe ways to attain this goal. The aim of this study was to evaluate the effect of ginger meal associated with ration containing local protein sources *Desmodium intortum* and/or *Stylosanthes guianensis* on growth performance in rabbits. **Method:** A total of 64 young rabbits (32 males and 32 females) with an average weight of 1000 ± 200 g were used. There were randomly assigned to 8 experimental diets in a complete randomized designed with 8 rabbits per treatment and each rabbit serving as an experimental unit. From the control diet R0 (basal diet without legumes and phytobiotic) and 7 other diets (treatment): R1(basal diet without legumes + 1% ginger powder), R2 (basal diet + 20% *S. guianensis* + 1% ginger meal), R3 (basal diet + 20% *D. intortum* + 1% ginger powder), R4 (basal diet + 20% *D. intortum* + 0% ginger powder), R5 (basal diet + 20% *S. guianensis* + 0% ginger powder), R6 (basal diet + 10% *D. intortum* + 10% *S. guianensis* + 0% ginger powder) R7 (basal diet + 10% *D. intortum* + 10% *S. guianensis* + 1% ginger powder). Feed intake, body weight gain, feed conversion ratio, carcass yield and average daily consumption were evaluated using standard procedures. **Results:** Feed intake and feed conversion ratio of animals fed R0 and R7 rations were significantly improved. Animals fed R1 ra-

tion had a significantly lower mean value for feed conversion ratio (1.83 g) and feed intake (1.67 g) respectively. Live weight (2432.54 g), total weight gain (1644.90 g), average daily feed intake (109.06 g) and dressed weight (1404.25 g) were significantly higher for rabbits fed R1 ration. Relative weights of organs of animals fed R4 ration were significantly higher. **Conclusion:** Feeding rabbits with R1 diet significantly improved growth performance.

Keywords

Ginger Meal, *Desmodium intortum*, *Stylosanthes guianensis*, Growth Performance, Rabbits

1. Introduction

Rabbit farming can easily be practiced in all areas, whether rural or peri-urban [1]. It does not require much capital compared to other domestic animal farms. Rabbits have high fertility, short gestation period (28 - 32 days) and great ability to use a variety of forages [2]. They are good converters of feed to meat and use up to 30% of crude fiber compared to 3% - 10% for poultry species [3]. Despite all these advantages, rabbit farming is still underdeveloped in Cameroon because it faces many constraints, including feed. In intensive breeding, the feed cost represents 70% of the production cost [4]. Therefore, any reduction in the cost of feed will significantly reduce production costs [5]. It will therefore be necessary to explore further resources which have the capacity to produce as many conventional feeds and at a lower cost. Among these resources, we have legumes such as *D. intortum* and *S. guianensis* which can be used as protein supplements in the diet of monogastric herbivores [6]. However, the presence of antinutritional factors in these legumes prevents their better use, hence the need to combine them with an additive like ginger which can stimulate bacteria growth of the caecal flora in order to improve their use in animals. The rhizome of *zingiber* and the *zimberacae* family is highly appreciated in cooking due to its taste and smell [7]. Ginger meal contains 40% - 60% starch; 9% - 10% protein; 6% - 10% fat; 5% fiber; 6% inorganic element and 1% - 4% essential oils [8]. Moreover, it is rich in aromatic compounds such as gingerol and gingerdiol with biological activities including antimicrobial, antioxidant, antiviral, anti-inflammatory and analgesic activities; digestive enzyme stimulators [9]. Platel and Srinivasan [10] and Safa [11] revealed that the use of 1% ginger meal in broilers significantly increased weight gain, feed intake and feed conversion ratio. Although several works exist on the use of ginger meals and vegetables (leguminous forage) in animal production, few works have been listed on the synergy between additives and fodder in animal feed [12]. The aim of this study was to evaluate the effect of ginger meal associated with *D. intortum* and/or *S. guianensis* on growth performance in rabbits.

2. Materials and Methods

2.1. Study Site

This study was conducted at the Animal Nutrition and Production Research Unit (URPRONAN) of the University of Dschang. It is located at an altitude of 1420 m above sea level, between latitude 05˚26'N and longitude 10˚26'E. The climate of the region is of the equatorial Cameroonian type with the rainy season that last from mid-March to mid-November and the dry season from mid-November to mid-March. Rainfall varies between 1500 and 2000 mm per year and temperatures range from 14˚C (July-August) to 25˚C (February) with an average temperature of about 21˚C. The average annual insolation is 1873 hours and the average relative humidity is 76.8%.

2.2. Plant Material and Collection Method

The plant material consisted of ginger meal, *S. Guianensis* and *D. intortum*. The leaves of *S guianensis* and *D. intortum* were harvested before flowering in the Faculty of Agronomy and Agricultural Sciences forage farm then dried under shade and crushed. As for the ginger spice, it was bought at the local market in the city of Dschang, sorted, washed, cut and dried, then crushed to obtain powder meal. They were stored separately in sealed polyethylene bags to limit any contact with water or air humidity prior to be incorporated in the different treatments. Bromatological analysis of each sample was carried out in the laboratory of animal production and nutrition laboratory unit of the University of Dschang before the start of the trials.

2.3. Experimental Diet and Management

We used 64 animals (32 males and 32 females) in this trial. The animals were housed in wired cages made of metals measuring 97 × 46 × 26 cm placed in a well-ventilated room. They were randomly assigned to 8 experimental treatments in a complete randomized designed with 8 rabbits per treatment and each rabbit serving as experimental unit. The experimental design was as follows (Table 1):

- R0 (control diet) = Compound feed without leguminous and without ginger meal,
- R1 = basal diet without leguminous + 1% ginger meal.
- R2 = basal diet + 20% *S. guianensis* + 1% ginger meal,
- R3 = basal diet + 20% *D. intortum* + 1% ginger meal,
- R4 = basal diet + 20% *D. intortum* + 0% ginger meal,
- R5 = basal diet + 20% *S. guianensis* + 0% ginger meal,
- R6 = basal diet + 10% *D. intortum* + 10% *S. guianensis* + 0% ginger meal
- R7 = basal diet + 10% *D. intortum* + 10% *S. guianensis* + 1% ginger meal

Feed and water were served *ad libitum* throughout the experimental period. At the beginning and end of the study, the building, cages, feeders and drinkers were thoroughly washed and disinfected. The animals were given anti-coccidian (amprolium), anti-stress before and after each manipulation.

Table 1. Percentage composition of animal feed.

Ingredients (%)	Feeds (Treatment)							
	R0	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Yellow corn	20	20	20	20	20	20	20	20
Palm oil	1	1	1	1	1	1	1	1
Shell	1	1	1	1	1	1	1	1
Cooking salt + detox	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bone meal	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
NMVC 5%	5	5	5	5	5	5	5	5
Fishmeal	2	2	2	2	2	2	2	2
Wheat Bran	22	22	18	18	18	18	18	18
Palm kernel cake	20	20	15	15	15	15	15	15
Soybean meal	8	8	2	2	2	2	2	2
Cotton cake	6	5	2	2	3	3	3	2
Pennisetum purpureum	14	14	12	12	12	12	12	12
Stylosanthes guianensis	0	0	20	0	20	0	10	10
Desmodium intortum	0	0	0	20	0	20	10	10
Ginger meal	0	1	1	1	0	0	0	1
Total	100	100	100	100	100	100	100	100
Calculated chemical composition	**R0**	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**
Phosphorus (%.DM)	0.71	0.7	0.69	0.7	0.74	0.71	0.73	0.71
Calcium (%.DM)	1.22	1.24	1.21	1.21	1.21	1.22	1.2	1.21
Crude fiber (%.DM)	12.25	12.02	12.09	12.21	12.54	12.36	12.11	12.14
Crude Protein (%.DM)	17.01	16.79	16.88	16.71	16.84	16.69	16.94	17.08
Digestible energy (kcal/kg.MS)	2548	2580	2584	2520	2591	2512	2521	2501

NMVC: Nitrogenous Mineral and Vitamin Concentrate. EM: Metabolizable energy.

2.4. Data collection

Growth parameter: the following parameters were evaluated

- **Feed intake**

Feed was weighed at the beginning of the trial and then every 7 days until the end of the trial. Weekly feed consumption was calculated as the difference between the amount of feed distributed during the week and the left over collected at the end of the same week.

$$QC = Qs - RQ$$

where:

QC = quantity consumed (g),

Qs = quantity served (g),

Qr = feed refusal or left over (g).

- **Weight gain**

The weekly weight gain was obtained by computing the difference between two consecutive weekly weights.

$$\mathrm{BWG} = \mathrm{Wn} - (\mathrm{Wn} - 1)$$

where:

BWG = Body Weight Gain (g),

Wn = weight at the week considered (g),

Wn-1 = weight in the previous week (g).

- **Feed conversion ratio**

Feed conversion ratio (FCR) is the amount of feed consumed to produce 1 kg of live weight. It was calculated as follows:

$$\mathrm{FCR} = \text{Total FI}(\mathrm{g}) / \text{Total WG}(\mathrm{g})$$

where:

FI = Feed Intake

WG = Weight gain

- **Carcass characteristics**

At the end of the trial, 32 animals (2 males and 2 females) per treatment were randomly selected, fasted for 12 hours, weight and sacrificed for the evaluation of carcass characteristics. The animals were completely bled and eviscerated as recommended by [13]. The carcass yields, relative weight of carcass, parts (heads, legs, skin) and organs in relation to the live weight were evaluated respectively as follow:

$$\text{Carcass Yield}(\%) = \frac{\text{Weight of carcass}(\mathrm{g})}{\text{Live weight}(\mathrm{g})} \times 100$$

$$\text{Relative Percentage of organs weight}(\%) = \frac{\text{Weight of organs}(\mathrm{g})}{\text{Live weight of animal}(\mathrm{g})} \times 100$$

2.5. Evaluation of the Chemical Composition of Meat

Meat samples (100 g/animal) were taken from the thighs of rabbit and used for the evaluation of the chemical composition of dry matter (DM), organic matter (OM), crude protein (CP) by the Kjeldhal method and as described by AOAC [14].

- **Cost of production**

The cost of production per kilogram of rabbit live weight was evaluated base on the production cost per kilogram of the different experimental feed, feed intake and weekly weight gain of the animals.

The cost per kilogram of feed was estimated from the price of ingredients during the study period on the local market. The cost of feed intake was obtained by multiplying the average feed intake of the animals by the price per kg of feed in the local market. The feed production cost per kilogram of live weight of rabbits was calculated by multiplying the cost per kilogram of feed by the feed

conversion ratio.

2.6. Statistical Analysis

Data collected on growth parameters were subjected to one-way analysis of variance following the general linear model of statistical package for social science software (SPSS.21.1). When significant differences existed between treatments, the mean where separated using the Waller Duncan's test at 5% significance level.

3. Results

3.1. Effects of Ginger Powder Associated with *Desmodium intortum and/or Stylosanthes guianensis* on Growth Performance of Rabbits

The mean values of growth performance of rabbits fed ginger powder associated with *Desmodium intortum and/or Stylosanthes guianensis* on growth performance of rabbit are summarized in Table 2. It shows that no significant difference was

Table 2. Mean value of growth performance of rabbits fed ginger powder associated with *D. intortum and/or S. guianensis.*

Parameters	Rations								*p*
	R0	R1	R2	R3	R4	R5	R6	R7	
IW (g)	1101.25 ± 241.25^{a}	1152.25 ± 341.84^{a}	1120.00 ± 229.52^{a}	1188.38 ± 123.70^{a}	1249.13 ± 241.13^{a}	1201.25 ± 286.37^{a}	1266.63 ± 243.51^{a}	1196.38 ± 194.05^{a}	0.60
FLW (g)	2241.25 ± 237.99^{ab}	2432.54 ± 70.16^{a}	1995.00 ± 327.76^{c}	2326.25 ± 61.17^{a}	2150.25 ± 171.30^{abc}	2048.10 ± 336.52^{abc}	1960.00 ± 360.01^{c}	1947.00 ± 246.724^{c}	0.00
FI (g)	2.40 ± 0.01^{a}	1.67 ± 0.01^{c}	2.12 ± 0.05^{b}	2.08 ± 0.05^{c}	2.12 ± 0.00^{b}	2.34 ± 0.02^{b}	1.84 ± 0.02^{c}	2.55 ± 0.02^{a}	0.00
TWG (g)	1501.01^{a} ± 268.60	1519.21^{a} ± 413.56	1498.75^{a} ± 236.67	1552.58^{a} ± 150.70	1534.00^{a} ± 258.26	1573.04^{a} ± 260.01	1644.49^{a} ± 251.27	1456.250^{a} ± 200.82	0.00
FCR (g)	1.92^{ab} ± 0.71	1.83^{b} ± 0.63	2.03^{ab} ± 0.65	1.96^{ab} ± 0.89	2.23^{ab} ± 1.06	1.88^{b} ± 0.72	2.52^{ab} ± 1.05	3.00^{a} ± 1.59	0.02
ADC (g)	109.41 ± 0.01^{a}	109.06 ± 0.06^{a}	108.36 ± 0.03^{b}	108.98 ± 0.02^{b}	108.22 ± 0.01^{b}	108.16 ± 0.03^{b}	108.77 ± 0.02^{b}	108.22 ± 0.01^{b}	0.00
Cost of KG (US Dollar)	0.41 ± 0.00^{a}	0.40 ± 0.00^{a}	0.42 ± 0.00^{a}	0.42 ± 0.00^{a}	0.40 ± 0.00^{a}	0.40 ± 0.00^{a}	0.40 ± 0.00^{a}	0.42 ± 0.00^{a}	0.80
Cost of feed index (US Dollar)	0.95 ± 0.00^{b}	0.68 ± 0.00^{b}	0.89 ± 0.00^{b}	0.87 ± 0.00^{b}	0.86 ± 0.00^{a}	0.95 ± 0.00^{b}	0.75 ± 0.00^{b}	1.07 ± 0.01^{a}	0.00
Cost of ADC (US Dollar)	43.71 ± 0.01^{a}	44.57 ± 0.06^{a}	45.63 ± 0.03^{b}	45.89 ± 0.02^{b}	44.23 ± 0.01^{b}	44.20 ± 0.03^{b}	44.45 ± 0.03^{b}	45.57 ± 0.03^{b}	0.00

a, b, c, d…: Means with the same letters on the same row are not significantly different at the 5% level; SEM: Standard Error of the Mean; P: Probability; (): effective; IW = initial weight FLW = Final live weight, TWG = Total weight gain, ADG = Average daily gain,, FCR = Feed conversion ratio. WG = weight gain,; R0 = (control) concentrate without leguminous and without GP; R1 = concentrate without leguminous + 1% GP; R2: = concentrate + 20% *S. guianensis* + 1% ginger; R3 = concentrate + 20% *D. intortum* + 1% GP; R4 = concentrate + 20% *D. intortum* + 0% GP; R5 = concentrate + 20% *S. guianensis* + 0% GP; R6 = concentrate + 10% *S. guianensis* + 10% *D. intortum* + 0% GP; R7: concentrate + 10% *S. guianensis* + 10% *D. intortum* + 1% GP = probability.

observed on the initial average weight of the animals at the start of the trial regardless the treatment. Nevertheless, at the end of the trial the mean body weight 2432.54 g and 2326.25 g of animals respectively fed with R1 and R3 rations were significantly ($p < 0.05$) higher compared to those of animals fed with other rations. However, the initial weight, weight gain and the cost per kg of feed were not significantly ($p > 0.05$) affected irrespective of the treatment. Rabbits fed R0 and R7 diets recorded the highest ($p < 0.05$) feed intake compared to those fed R1, R3 and R6 that record the lowest ($p < 0.05$) feed intake. The feed conversion ratio of rabbits fed R1 and R5 rations was significantly ($p < 0.05$) lower compared to those fed R7 ration that was statistically highest.

As for the cost of production, no significant differences were observed among animals fed on different feed type, although animals fed with R1, R4, R5 and R6 rations had the lowest production costs (0.40 US Dollar). While the cost of feed intake and feed production cost per kg of live weight were significantly higher for animals fed with R0 and R5 rations.

3.2. Effects of Ginger Powder Associated with *Desmodium intortum and/or Stylosanthes guianensis* on Carcass Characteristics of Rabbit

Table 3 presents the effect of the experimental feed on carcass characteristics of rabbit. It shows that no significant difference was observed among the different groups. Animals fed R2, R6 and R7 rations showed the lowest ($p < 0.05$) slaughter weights compared to those fed R1 and R3 that had the highest slaughtered weight. The average dressed weight of animals fed R0 and R1 rations were significantly ($p < 0.05$) higher than those of animals fed R2 and R7 rations, but

Table 3. Mean values of carcass characteristics of rabbits fed ginger powder associated with *D. intortum and/or S. guianensis.*

Parameters	Rations								*p*
	R0	R1	R2	R3	R4	R5	R6	R7	
Slaughter weight (g)	2241.25 ± 237.99^{ab}	2432.54 ± 70.16^{a}	1995.00 ± 327.76^{c}	2326.25 ± 61.17^{a}	2150.25 ± 171.30^{abc}	2048.10 ± 336.52^{abc}	1960.00 ± 360.01^{c}	1947.00 ± 246.724^{c}	0.04
Dressed weight (g)	1298.25 ± 129.83^{a}	1404.25 ± 273.71^{a}	1008.75 ± 156.81^{c}	1148.50 ± 57.21^{ab}	1261.75 ± 109.68^{ab}	1173.25 ± 193.23^{ab}	1118.25 ± 188.37^{ab}	1128.75 ± 1.09^{c}	0.01
Carcass yield (%)	57.97 ± 2.18^{a}	57.59 ± 2.35^{a}	56.46 ± 3.83^{a}	56.69 ± 2.50^{a}	58.68 ± 2.09^{a}	57.30 ± 1.40^{a}	57.02 ± 1.92^{a}	56.87 ± 2.51^{a}	0.99
Fur (g)	286.53 ± 33.14^{ab}	301.76 ± 40.84^{a}	237.71 ± 63.87^{b}	261.47 ± 31.86^{ab}	269.46 ± 19.60^{ab}	260.05 ± 19.79^{ab}	243.54^{ab} ± 38.56	252.54 ± 36.75^{ab}	0.02
5th Qter (g)	221.46 ± 26.92^{ab}	268.77 ± 32.95^{a}	197.05 ± 30.43^{b}	194.73 ± 15.53^{b}	219.00 ± 12.65^{ab}	202.96 ± 48.34^{b}	205.68 ± 27.84^{b}	214.34 ± 38.64^{ab}	0.01

a, b, c, d…: Means with the same letters on the same row are not significantly different at 5%; SEM: Standard error of Mean; P: Probability; 5th Qter = Fifth Quarter; R0 = (control) concentrate without leguminous and without GP; R1 = concentrate without leguminous + 1% GP; R2: = concentrate + 20% *S. guianensis* + 1% ginger; R3 = concentrate + 20% *D. intortum* + 1% GP; R4 = concentrate + 20% *D. intortum* + 0% GP; R5 = concentrate + 20% *S. guianensis* + 0% GP; R6 = concentrate + 10% *S. guianensis* + 10% *D. intortum* + 0% GP; R7: concentrate + 10% *S. guianensis* + 10% *D. intortum* + 1% GP.

were statistically similar ($p > 0.05$) to the other treatment groups. With regard to carcass yield no significant ($p > 0.05$) difference was observed in all the animals of the different groups, however animals fed R4 rations presented the highest average values for carcass yield. Rabbits fed R1 diets recorded the highest quantity of fur compared to those fed R2, but was comparable to the other treatments. With regard to the Fifth quarter, rabbit fed R2, R3, R5 and R6 recorded the smallest ($p < 0.05$) values compared to those of rabbits fed R1 rations.

3.3. Effects of Ginger Powder Associated with *Desmodium intortum and/or Stylosanthes guianensis* on the Relative Weights of Some Organs and Abdominal Fat

The effect of the experimental feed on the relative weights of organs is summarized in Table 4. It appears that the average weight of the animals' heads regardless of treatment showed no significant ($p > 0.05$) difference, however animals fed R1 diet had the highest average weight. Similarly, the average weight of the legs of the animals fed R1 diet presented the highest ($p < 0.05$) average leg weight compared to the control and the other treatment groups. No significant differences were observed on the average relative weight of the heart, liver and kidneys regardless of the treatment group. Rabbits fed R2 and R3 ration had a significantly higher average weight ($p < 0.05$) compared to rabbits fed with the other experimental ration and R1. For the average weight of abdominal fat remained comparable to that of animals fed with the control ration R0 and R7. No significant difference was observed in the relative liver weights of the animals fed different experimental ration. However, in terms of the relative average weight of the head, heart and pancreas, animals fed with R2, R7 and R2 ration respectively presented average values which were significantly ($p < 0.05$) higher.

Table 4. Mean value *on the relative weights of some parts, organs and abdominal fat of rabbit* according to the different feed.

Parameters	Rations								*P*
	R0	R1	R2	R3	R4	R5	R6	R7	
AB f	23.45 ± 7.62^{ab}	37.55 ± 4.08^{a}	7.80 ± 2.29^{b}	10.13 ± 2.66^{bc}	18.36 ± 30.07^{cd}	13.63 ± 2.44^{bcd}	12.20 ± 2.20^{bc}	23.04 ± 4.69^{ab}	0.02
Rw Head	5.59 ± 0.44^{c}	5.25 ± 0.63^{c}	7.16 ± 0.67^{a}	6.01 ± 0.55^{bc}	6.13 ± 0.99^{bc}	5.98 ± 0.26^{bc}	6.57 ± 0.51^{b}	6.12 ± 0.23^{bc}	0.00
Rw Heart	0.41 ± 0.05^{ab}	0.37 ± 0.05^{b}	0.43 ± 0.03^{ab}	0.38 ± 0.04^{ab}	0.40 ± 0.06^{ab}	0.41 ± 0.04^{ab}	0.42 ± 0.01^{ab}	0.47 ± 0.09^{a}	0.02
Rw Liver	2.50 ± 0.41^{a}	2.22 ± 0.44^{a}	2.57 ± 0.27^{a}	2.38 ± 0.24^{a}	2.55 ± 0.26^{a}	2.37 ± 0.10^{a}	2.56 ± 0.48^{a}	2.52 ± 0.32^{a}	0.78
Kidneys	11.91 ± 2.79^{a}	11.42 ± 2.9^{a}	10.77 ± 2.82^{a}	9.86 ± 1.47^{a}	9.99 ± 1.31^{ac}	10.62 ± 2.95^{a}	10.37 ± 1.45^{a}	9.88 ± 1.76^{a}	0.01
Rw Pancrea	0.03 ± 0.01^{bc}	0.03 ± 0.00^{bc}	0.64 ± 0.01^{a}	0.05 ± 0.01^{ab}	0.02 ± 0.00^{c}	0.39 ± 0.10^{bc}	0.05 ± 0.01^{ab}	0.05 ± 0.32^{bc}	0.00

a, b, c, d…: Means with the same letters on the same row are not significantly different at (p > 0.05); SEM: Standard Error of the Mean; P: Probability; (): effective; AB ft = abdominal fat, Rw = relative weight. R0 = (control) concentrate without leguminous and without GP; R1 = concentrate without leguminous + 1% GP; R2: = concentrate + 20% *S. guianensis* + 1% ginger; R3 = concentrate + 20% *D. intortum* + 1% GP; R4 = concentrate + 20% *D. intortum* + 0% GP; R5 = concentrate + 20% *S. guianensis* + 0% GP; R6 = concentrate + 10% c + 10% *D. intortum* + 0% GP; R7: concentrate + 10% *S. guianensis* + 10% *D. intortum* + 1% GP, P = probability.

3.4. Effect of Experimental Feeds on the Weight of Digestive Organs

Table 5 presents the effect of ginger powder associated with *Desmodium intortum and/or Stylosanthes guianensis* on the weight of digestive organs. It emerges from this table that irrespective of the experimental feed, no significant difference was observed in all the groups. However, R1 ration presented the highest average values of empty intestine weight (76.22 g), ceacum weight (139.43 g) and empty caecum weight, the animals fed with R3 ration presented the highest average value (452.80 g).

3.5. Effect of Experimental Feed on the Chemical Composition of Rabbit Meat

Table 6 illustrates the effect of the experimental rations on the bromatological composition of rabbit meat shows that no significant ($p > 0.05$) difference was observed for dry matter regardless of the feed ration considered, however animals fed R2T3 ration presented the highest mean dry matter values (95.49). Animals fed R4T5, R7T8 and R4T5 recorded respectively significantly ($p < 0.05$) higher values of lipids (5.77), ash (7.15), and proteins (21.77) as compared to the other feed rations

4. Discussion

Animals fed basal diet without leguminous + 1% ginger powder and basal diet +

Table 5. Average weight of digestive organs fed ginger powder mixed with *D. intortum and/or S. guianensis*

Parameters	Rations								*p*
	R0	R1	R2	R3	R4	R5	R6	R7	
W INT	100.61 ± 30.19[a]	110.16 ± 36.73[a]	127.53 ± 26.12[a]	138.40 ± 14.69[a]	130.14 ± 18.11[a]	136.75 ± 37.72[a]	119.34 ± 27.84[a]	123.67 ± 15.59[a]	0.51
W E INT	63.61 ± 12.75[a]	76.22 ± 10.21[a]	70.57 ± 13.19[a]	69.47 ± 12.87[a]	71.15 ± 19.95[a]	62.54 ± 9.95[a]	72.86 ± 11.12[a]	63.21 ± 9.32[a]	0.72
L INT	407.25 ± 45.96[a]	399.45 ± 64.66[a]	394.12 ± 65.81[a]	404.50 ± 40.94[a]	452.30 ± 41.95[a]	413.12 ± 48.38[a]	384.57 ± 28.90[a]	406.50 ± 46.60[a]	0.70
W Cac	134.02 ± 19.07[a]	139.43 ± 10.62[a]	135.20 ± 21.75[a]	135.98 ± 6.79[a]	146.43 ± 29.01[a]	132.86 ± 29.78[a]	125.50 ± 36.92[a]	132.97 ± 20.62[a]	0.96
P E Cac	33.61 ± 3.16[a]	37.96 ± 11.35[a]	32.61 ± 2.28[a]	31.57 ± 6.39[a]	39.63 ± 9.13[a]	30.69 ± 6.88[a]	34.70 ± 6.18[a]	32.19 ± 3.74[a]	0.54
L Cac	49.87 ± 11.21[a]	52.50 ± 5.44[a]	53.12 ± 2.83[a]	56.90 ± 2.28[a]	53.75 ± 2.06[a]	54.75 ± 3.20[a]	51.00 ± 4.89[a]	51.50 ± 2.88[a]	0.63

a, b, c, d…: Means with the same letters on the same row are not significantly different at (p > 0.05); SEM: Standard Error of the Mean; P: Probability;; WINT = Weight of intestine W E INT = Weight of empty intestine: L INT = Length of intestine: P Cac = Weight of cecum: P E Cac = Weight of empty cecum: L Cac = Length of the cecum: R0 = (control) compound feed without leguminous and without GP; R1 = concentrate without leguminous + 1% GP; R2: = concentrate + 20% *S. guianensis* + 1% ginger; R3 = concentrate + 20% *D. intortum* + 1% GP; R4 = concentrate + 20% *D. intortum* + 0% GP; R5 = concentrate + 20% *S. guianensis* + 0% GP; R6 = concentrate + 10% *S. guianensis* + 10% *D. intortum* + 0% GP; R7: concentrate + 10% *S. guianensis* + 10% *D. intortum* + 1% GP, P = probability.

Table 6. Mean value of chemical composition of rabbit meat with respect to different experimental rations.

Parameters	Rations								p
	R0	R1	R2	R3	R4	R5	R6	R7	
DM	95.38 ± 0.56^{a}	95.06± 0.12^{a}	95.49 ± 0.39^{a}	95.38± 0.16^{a}	94.72± 0,11^{a}	94.64± 0.17^{a}	94.53± 0.26^{a}	92.84 ± 1.83^{b}	0.00
Lip	5.28 ± 1.24^{abc}	4.35± 0.02^{c}	5.22± 0.27^{abc}	4.40 ± 0.03^{c}	5.77 ± 0.20^{a}	5.40 ± 0.87^{ab}	4.53± 0.17^{bc}	4.47 ± 0.54^{bc}	0.01
Ash	4.61 ± 0.56^{b}	4.93 ± 0.01^{bc}	4.50 ± 0.03^{b}	4.61± 0.16^{b}	5.27 ± 0.11^{b}	5.35± 0.17^{b}	5.46± 0.26^{b}	7.15± 1.83^{a}	0.00
CP	20.57± 0.7^{c}	20.4 ± 0.14^{bc}	21.36 ± 0.14^{ab}	21.39± 0.52^{ab}	21.77 ± 0.24^{a}	19.63 ± 0.50^{d}	19.28 ± 0.37^{d}	20.31 ± 0.20^{c}	0.00

a, b, c, d: Means with the same letters on the same row are not significantly different at ($p > 0.05$); SEM: Standard Error of the Mean; P: Probability;; DM = Dry matter: Lip = Lipid::, CP: Crude protein. R0 = (control) concentrate without leguminous and without GP; R1 = concentrate without leguminous + 1% GP; R2: = concentrate + 20% *S. guianensis* + 1% ginger; R3 = concentrate + 20% *D. intortum* + 1% GP; R4 = concentrate + 20% *D. intortum* + 0% GP; R5 = concentrate + 20% *S. guianensis* + 0% GP; R6 = concentrate + 10% *S. guianensis* + 10% *D. intortum* + 0% GP; R7: concentrate + 10% *S. guianensis* + 10% *D. intortum* + 1% GP, *P* = probability.

20% *D. intortum* + 1% ginger powder presented the highest final live weights and those fed with basal diet + 10% *S. guianensis* + 10% *D. intortum* + 1% ginger meal showed the lowest average weight. These results are similar to those obtained by Matho *et al.* [15]. This could be due to the feed quality, the nutritional and chemical composition which is closely similar to the one use in their trials. This could also be explained by the feeding behavior of the monogastric herbivore, indeed rodent prefers green or preserved vegetables (grasses and leguminous forage) but also cereals, vegetables, fruits and germinated seeds [16]. These results are also similar to those obtained by Matho *et al.* [15] this could be explained by the protein nutritional value of leguminous contained in the feed and the bioactive effect of different compounds of ginger which help to the transformation of leguminous of diet by acting to increase beneficial bacteria [17] [18]. Hence, the antibacterial properties of ginger which promotes the development of beneficial bacteria which help to transformed the feed and provide the animal with all the nutrients it needs to ensure its growth and the proper development of its organs [19]. Animals fed basal diet + 10% *S. guianensis* + 10% *D. intortum* + 0% ginger meal) showed the highest weight gain (1644.49 g). These results are higher (1282.93 g) than those obtained by Matho *et al.* [15] who evaluated the incorporation of boiled rubber seed meal in the diet of rabbits. Their differences may be due to the leguminous forage which according to Tedonkeng *et al.* [20]. Feed containing leguminous forage has the advantage of boosting growth performance on herbivores. However, it was similar to those obtained by Tchibozo *et al.* [21] who worked on the evaluation of feed resources in the diet of fattening rabbits in Africa. This similarity could be due to the synergistic action of the feed additive (enrichment of the microbial flora of animals) in association with leguminous forage (local source of proteins) which improves the growth of animals with an herbivorous tendency [6].

The economic evaluation of the cost of production revealed that the animals fed with the R0 control feed were significantly lower 0.40 Dollar US (242.67

FCFA) than that of the other group. These results are similar (223.25 Fcfa) to those obtained by Harinder *et al.* [22] and contrast to those of Matho *et al.* [15] who obtained the costs per kg varying between 858.3Fcfa and 601.41 Fcfa. Who used experimental feeds with higher production costs than those we used in this study. This could be due to the fact that this study was conducted in 2021 increase the cost of production of feed ingredients, more specifically those rich in forage. The Dressed weights (1298.25 g) of the animals fed basal diet without leguminous forage and without ginger powder followed by those fed with the basal diet without legume + 1% ginger powder were significantly higher in this study. This could be due to a better valorization of the nutrients in the feed by the beneficial microorganisms of the intestinal flora. According to Kamel [23], this feed additive may inhibit the growth of harmful bacteria such as *E.coli* in the intestinal tract thanks to its antimicrobial activity, this is what would allow pseudo-ruminants to better utilize nutrients. Animals fed basal diet + 20% *Desmodium intortum* + 0% ginger powder showed the highest carcass yield (58.68%). These results are contradictory to those obtained by Tougan *et al.* [24] who obtained values between 55.7% and 64.4% for carcass yield. These results are comparable to those obtained by foku *et al.* [5] who evaluated the effect of graded levels of boiled wild sunflower (*Tithonia diversifolia Hemsi A. Gray*) leaf meal on growth performance and carcass characteristics of rabbits. They obtained carcass weights varying between 1257 g and 1374 g and the carcass yield varying between 49.66% and 54.48%. This similarity could be due to the age at which the rabbits were slaughtered, which was substantially the same in the two trials. Moreover, for identical animal species, the values of the characteristics are closely similar under the same breeding conditions [25]. These results corroborate those obtained by Olabandji *et al.* [26] who evaluated Growth Performance, Organ Characteristics and Carcass Quality of Weaner Rabbits fed Different Levels of Wild Sunflower (*Tithonia diversifolia* Hemsl A. Gray) Leaf-Blood Meal Mixture. The presence of feed additive enriches the microbial flora of the organism and facilitates the process of digestion and therefore reduces the physical work of the organs of digestion [27].

The control ration (basal diet without legumes and without ginger powder) induced a high significantly abdominal fat value (23.45 g) while those who were fed basal diet + 20% *Stylosanthes guianensis* + 1% ginger presented the lowest abdominal fat values (7.85 g), These results are greater to those obtained by foku *et al.* [5] who would have obtained values between 0.87 g and 3.65 g. This could be explained by the absence of leguminous forage and/or food additives in the R0 control feed. Indeed, the high presence of cellulose in the feed accelerates intestinal transit and leads to a low deposition of abdominal fat [28]. Animals fed basal diet + 20% *Stylosanthes guianensis* + 1% ginger presented a high significant relative weight for the head (7.16) and the pancreas (0.64). A similar tendency was observed for the relative weight of the heart (0.47) for rabbits fed basal diet + 10% *Stylosanthes guianensis* + 10%

Desmodium intortum + 1% ginger. These values are comparable to those obtained by Maidala *et al.* [29] who evaluated growth performance and carcass characteristics of rabbits fed with differently processed Soybean. This could be explained by the fact that the animal species is identical and the bromatological variation of the feed is very low, moreover in the two studies the variation factor is a source of protein for both studies. Rabbits fed concentrate without legumes + 1% ginger powder presented the highest mean values for the empty intestine weight (76.22 g), caecum weight (139.43 g) and empty cecum weight. These results are comparable to those obtained by Harinder *et al.* [22] who worked on performance of growing rabbit offered rubber leaf protein replacement for soybean meal. Indeed, for both studies they are the same animal species, in addition, Ayssiwede *et al.* [30] showed that the development of organs is often proportional to the live weight or the age of the subjects. The significant increase in caecal weight with the inclusion rate of ginger powder in feed (basal diet without legumes + 1% ginger powder observed in this study is in agreement with the observations of Niba *et al.* [31]. Indeed, the caecum in pseudo ruminants like the guinea pig are the privileged site for the digestion of fibers not degraded by digestive enzyme and pancreatic juice, since it harbors the microbial flora capable of digesting cellulose [32] [33]. Ginger may have reduced the population of pathogenic microbes and, multiply beneficial microbes and lactobacilli. This increase in the population of beneficial microbes could explain the increase in the weight of the caecum.

The meat of rabbits fed basal diet + 20% *Sthylosanthes guianensis* + 1% ginger presented the highest average dry matter values (95.60). This could be explained on one hand by the presence of anti-serotoninergic gingerol whose quantity at this rate in feed boost the dry matter of meat better still in synergistic action with *Sthylosanthes guianensis* [12]. Leguminous are high sources of protein which are more valorised when associated to feed additives [34]. Animals fed rations respectively containing basal diet + 20% *Desmodium intortum* + 0% ginger powder for lipids, basal diet + 10% *Sthylosanthes guianensis* + 10% *Desmodium intortum* + 0% powder ginger for ash and protein showed significantly higher mean values. These results are contradictory to those obtained by Matho *et al.* [15] in addition to the feed additives which were different in the two trials, the method of preparation of the additives was also different, in the case of Matho *et al.* [15] who incorporating the powder, the boiled seeds into the feed of rabbits, while in this trial ginger powder, and/or the legumes was incorporated in the feed rabbits. According to Tchoumboué *et al.,* [35] the values of the final characteristics of a product vary according to endogenous and exogenous factors.

5. Conclusion

Rabbits fed with the basal diet without leguminous + 1% ginger had a significant improvement in growth performance and the cost of production per Kg of feed. Nevertheless, toxicity studies are required to validate their safety.

Authors' Contributions

Noumedem Fouegap Jodel Ghandi conducted trial, collected data and drafted the manuscript; Miegoue Emile designed the experimental set-up and monitored the work. Ebile Dayan Agwah, Tchoffo Herve, Yamssi Cedric, Mouchili Mama, and Vemo Bertin Narcisse participated in the revision of the manuscript and provided scientific assistance in the realisation of this work. Fonteh Florence Anyangwe Angaba participated in the critical reading of the manuscript, coordinated and guided the realization of the work.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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