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Effects of Different Levels of Garlic Powder Incorporated in the Feed Enriched with *Stylosanthes guianensis* on Reproduction and Pre-Weaning Growth Performances of Cavies (*Cavia porcellus*)

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Abstract

In order to increase the productivity of the local cavies as a meat animal, a study was carried out between November 2021 and March 2022 at the Research and Experimental Farm, Animal Nutrition and Production Research Unit of the Faculty of Agronomy and Agricultural Sciences (FAAS) and the Microbiology and Anti-Microbial Research Unite of the University of Dschang on 72 cavies aged between 4 and 5 months and weighing an average of 450 ± 50 g produced on the farm, including 60 females and 12 males. The females were distributed according to a completely randomized factorial design in twelve (12) rearing boxes numbered G1 to G12, with 15 females per group distributed in 03 boxes and receiving iso-nitrogenated experimental diet (18% protein) R0 enriched with 20% of *Stylosanthes guianensis* (0% garlic powder), R0.25 (0.25% garlic powder), R0.50 (0.50% garlic powder) and R0.75 (0.75% garlic powder). Females were identified by numbered ear tags and mated with a sex ratio of 5 females for 1 male. Drinking water enriched with vitamin C (01 tablet of 240 mg in 1.5 liters of water) was served *ad libitum* and renewed daily. The males were removed after 31 days. A form was established to record the weight of each pregnant female, any abortions during gestation, the date of parturition and the date of birth of each newborn, as well as the number of live-born or stillborn pups. After parturition, the weights of female and newborn cavies were recorded weekly until the 3rd week. The number of cavies that died before weaning and the number of live weaned cavies were also rec-

orded. Reproductive performance significantly increased ($p < 0.05$) fertility rate and net fertility rate, litter size, birth viability rate, and pre-weaning viability rate with rations containing garlic powder, compared to the control ration, especially with the R0.50 ration. In addition, birth mortality and pre-weaning mortality were significantly lower ($p < 0.05$) with rations containing the additive, compared to those of the control ration (R0). However, the R0.50 ration showed the lowest rates, followed by the R0.25 ration, and finally the R0.75 ration. Weight development of young cavies increased with all rations but was more marked with the R0.50 ration. Only total weight gain (TG) and average daily weight gain (ADG) in the pre-weaning phase were significantly increased ($p < 0.05$) with rations R0.25 and R0.50.

Keywords

Cavy, Garlic Powder, Pre-Weaning Growth, Reproduction, *Stylosanthes guianensis*

1. Introduction

The imbalance between demand and supply of animal proteins due to galloping population growth has led to malnutrition, especially among low-income families [1] [2] [3] and [4]. As a way out of the situation of severe food insecurity and poverty facing rural populations in Africa, raising short-cycle animals such as cavy could help reduce hunger and protein malnutrition [5]. Indeed, the quality of their lean, protein-rich meat, their rapid growth and the ease with which they can be raised are major assets for their promotion [6] [7]. To meet their nutritional requirements and improve productivity, Miégoué *et al.* [8] suggested, among other things, that cavies should be fed balanced rations containing around 20% forage legumes. Despite the supplementation of rations with forage legumes, guinea pigs constantly suffer from digestive disorders linked to the frequent instability of the balance of their caecal flora, leading to sometimes fatal enteropathies (diarrhoea, constipation, meteorism) and considerably reducing this animal's production performance [3] [9] [10].

The ongoing quest to improve livestock productivity has prompted producers to incorporate feed additives into their rations [11], in case natural additives are derived from plants, due to their great diversity and varied biological activities [12]. However, phytobiotics can be added in small quantities to feed products to increase their zootechnical efficiency [13], particularly during gestation and lactation, primordial periods in cavy rearing [14]. Indeed, phytobiotics can induce beneficial effects on reproduction via phytoestrogens, which are non-steroidal, plant-derived polyphenolic compounds structurally or functionally similar to estrogens such as coumarins and isoflavones [15]. For example, garlic (*Allium sativum*), cultivated by man for culinary use, has also proved effective in treating a multitude of health problems [16] [17] thanks to the bioactive compounds (allicin, flavonoids, etc.) it contains. Indeed, it is used as an appetite and digestive

secretion stimulant, immune-stimulant, antibacterial, antiviral and antioxidant [18].

Although the benefits of this spice have been tested in a number of animal species, the results are heterogeneous. Indeed, Katschinski [19] and Teff [20] report that the efficacy of phytobiotics is highly variable, depending on the composition of the active ingredient, the dose of administration, the method of presentation or manufacture (powder, extract, etc.), the mode of administration (feed or water), as well as the animal species and age. In addition to these factors, the composition of the basic ration is likely to influence the effect of phytobiotics on animal production. For example, Fogang [21] reported that in guinea pigs, the incorporation of 1% garlic powder into a legume-free ration had no significant effect on reproductive parameters, which remained unchanged, compared to the control ration (without additives). However, the pre-weaning mortality rate was significantly lower with the additive-containing ration (5%) than with the control ration (11%). Weight gains in the pre-weaning phase remained comparable to those recorded with the additive-free ration. As for Islam *et al.* [22], they noted the positive effect of garlic on the microbial flora of rabbits, with a drop in *E. coli* levels and a reduction in mortality at a dose of 0.5 g/kg. The aim of the present study was to evaluate the effect of incorporating different levels of garlic powder in rations enriched with *Stylosanthes guianensis* on the reproduction and pre-weaning growth parameters of cavies.

2. Methodology

2.1. Study Area

The study was conducted between November 2021 and March 2022 at the research and application farm, the de Production and Animals Nutrition Research Unit (URPRONAN) of the Faculty of Agronomy and Agricultural Sciences (FAAS) and the Microbiology and Antimicrobial Substances Research Unit (URMSA) of the Faculty of Science of the University of Dschang. The town of Dschang is located between 5˚26' north latitude, 10˚26' east longitude and at an altitude of between 1400 and 2100 m. The climate of West Cameroon is equatorial in altitude, with annual rainfall varying between 1500 and 2000 mm and average temperatures ranging from a minimum of 10˚C in July and August, to a maximum of 25˚C in February [23]. The average annual insolation is 1873 hours and the average relative humidity is 76.8%. The dry season extends from mid-November to mid-March, and the rainy season the rest of the year.

2.2. Animal Material and Housing

For the breeding trials, sixty (60) female cavies were housed in a completely randomized design in twelve (12) rearing boxes numbered G1 to G12 and made of plywood 1 m long, 0.80 m wide and 0.60 m high. The top of the boxes was protected by a wire mesh cover to prevent access by predators, while the floor was covered with a litter of dry, untreated wood shavings, which was renewed every 2 days to prevent the accumulation of faeces and urine. Each lodge was

equipped with lighting, a 400 gram wooden feeder and two (02) 0.5 liter concrete drinkers. These cavies were bred on the farm, and at the end of the breeding trial, the pups were used for pre-weaning growth assessment.

2.3. Plant Material

Plant material consisted of *Trypsacum laxum, Stylosanthes guianensis* and garlic. *T. laxum* and *S. guianensis* were harvested from the forage garden of the University of Dschang farm, then dried and ground, and the powder was kept for ration preparation. Garlic was bought from the market in Dschang, then pulped and chopped. After drying in the sun, it was crushed and the powder was stored in airtight, hermetically sealed containers for incorporation into the corresponding rations.

2.4. Conduct of Trials

2.4.1. Phytochemical Screening of Garlic Powder

One hundred (100) g of garlic powder was sent to the Nutrition, feed Sciences and medicinal plants Biochemistry laboratory (LABPMAN) of the University of Dschang for determination of the classes of compounds present in the sample. Total phenol content was determined using the method described by Ramde-Tiendrebeogo *et al.* [24], total flavonoid content was determined using the aluminum chloride colorimetric method [25], while total tannin content was determined using the Folin-Ciocalteu method as described by Govindappa *et al.* [26].

2.4.2. Manufacture of Experimental Rations

Ration ingredients were purchased from a livestock feed supplier in the town of Dschang, then combined with forages (*T. laxum* and *S. guianensis*). Ration formulation took into account the nutritional requirements of the guinea pigs (**Table 1**).

After formulating the ration, a 100g sample was taken and dried, and the content of dry matter (DM), organic matter (OM), crude protein (CP), fat (FM) and crude cellulose (CC) was assessed using the method described by AOAC [27]. From the R0 ration, 03 other rations were formulated by adding 0.25, 0.50 and 0.75% garlic powder. Thus, the cavies were divided into 4 groups (G0, G1, G2, G3) and the daily rations served to each animal were as follows:

- Group 0: R0 = 40 g of compound feed containing 0% garlic powder/animal/day;
- Group 1: R0.25 = 40 g of compound feed containing 0.25% garlic powder/animal/day;
- Group 2: R0.50 = 40 g of compound feed containing 0.50% garlic powder/animal/day;
- Group 3: R0.75 = 40 g of compound feed containing 0.75% garlic powder/animal/day.

All rations were pelletized using a manual pelletizer before being fed to the animals.

Table 1. Centesimal composition and chemical composition of the basic ration.

Ingredients (%)	**Compound feed (R0)**
Wheat bran	8
Corn	23
Trypsacum laxum	25
Cotton cake	3
Palm kernel cake	7
Soybean meal	4
Fish meal	7
Shell powder	1
Premix 1%	1
Palm oil	1
Stylosanthes guianensis	20
TOTAL	**100**

Premix 5% (VitA: 3,000,000 IU, Vit D: 600,000 IU, VitE: 4,000 mg, VitK: 500 mg, Vit B1: 200 mg, Vit B2: 1,000 mg, Vit B6: 400 mg, Vit B12: 4 mg, Iron: 8,000 mg, Copper: 2,000 mg, Zinc: 10,000 mg, Selenium: 20 mg, Manganese: 14,000 mg, Methionine: 200,000 mg, Lysine: 78,000 mg).

Chemical composition	
Dry matter (%)	95.38
Organic matter (% DM)	88.56
Crude protein (% DM)	18.77
Fat (% DM)	02.84
Crude cellulose (% DM)	15.89
Ca/P (% DM)	02.07
ED (kcal/kg DM)	2865

DM: Dry Matter; ED: Digestible Energy.

2.4.3. Evaluation of Pre-Weaning Growth and Reproductive Performance

Sixty (60) female cavies were placed in a completely randomized design in twelve (12) rearing boxes numbered G1 to G12, with 15 females per batch in 03 boxes as repetitions. They were identified by numbered ear tags and mated with a sex ratio of 5 females for 1 male. Drinking water enriched with vitamin C (01 tablet of 240 mg in 1.5 liters of water) was served *ad libitum* and renewed daily. The males were removed after 31 days. During gestation, pregnant females were weighed weekly. A record was made of each female's weight, any abortions during gestation, the date of parturition and the date of birth of each newborn, as

well as the number of live-born or stillborn pups. The reproductive data collected enabled the following reproductive parameters to be calculated:

$$\text{Fertility or parturition rate}(\%) = \frac{\text{Number of females with calves}}{\text{Number of females bred}} \times 100$$

$$\text{Fecundity rate}(\%) = \frac{\text{Number of stillborns} + \text{Number of live births}}{\text{Number of females bred}} \times 100$$

$$\text{Net fecundity rate}(\%) = \frac{\text{Number of live births}}{\text{Number of females bred}} \times 100$$

$$\text{Litter size} = \frac{\text{Number of births}}{\text{Number of females with mid-calf}}$$

$$\text{Viability at birth}(\%) = \frac{\text{Number of live births}}{\text{Number of births}} \times 100$$

$$\text{Viability at weaning or weaning rate}(\%) = \frac{\text{Number of weanlings}}{\text{Number of live births}} \times 100$$

$$\text{Post-weaning viability}(\%) = \frac{\text{Number of young people alive at 16 week}}{\text{Number of weanlings}} \times 100$$

$$\text{Pre-weaning mortality rate}(\%) = \frac{\text{Number of piglets dead before weaning}}{\text{Number of piglets born alive}} \times 100$$

$$\text{Stillbirth rate}(\%) = \frac{\text{Number of stillborn piglets}}{\text{Number of piglets born or litter size}} \times 100$$

$$\text{Post-weaning mortality rate}(\%) = \frac{\text{Number of piglets dead after weaning}}{\text{Number of piglets weaned}} \times 100$$

As soon as they were born, each newborn was identified at birth by a number written in marker on the coat, and this action was repeated every week. The weights of females and newborn cavies were recorded every week until the 3rd week. The number of cavies that died before weaning and the number of live weaned cavies were also recorded. The growth data collected were used to calculate the following growth parameters:

- Weekly weight trend for the period under consideration (gestation of females, post-partum of lactating females and pre-weaning of pups).

- Total weight gain (TG) (g) = Animal weight at end of period − Animal weight at start of period (pre-weaning of young).

- Average Daily Gain (ADG) (g/day) = TG/duration of period under consideration.

2.5. Statistical Analysis

The statistical analysis software used was SPSS 20.0. Data on pre-weaning weight growth of neonates were subjected to a 2-factor analysis of variance (ration and sex) using the general linear model (GLM). Data on weight growth of pregnant females, post-partum weight development of lactating females and reproductive parameters were subjected to a 1-factor analysis of variance (feed intake) using the general linear model (GLM). When there were significant differences be-

tween treatments, means were separated using the Waller Duncan test at the 5% significance level [28].

3. Results

3.1 Evaluation of Garlic Phytochemical Composition

Table 2 and Table 3 show that garlic powder contains bioactive compounds such as alkaloids, phenols, flavonoids, sterols, Triterpenoids, tannins and anthraquinones. Of the compounds quantified, the phenol content of this garlic powder is the highest.

3.2. Effects of Incorporating Different Levels of Garlic Powder in the Ration on Guinea Pig Reproductive Performance

Table 4 shows the values of the reproductive parameters. It can be seen that rations containing garlic powder significantly increased ($p < 0.05$) fertility rate, fecundity rate and net fecundity rate, litter size, birth viability rate, pre-weaning viability rate and post-weaning viability rate with rations containing garlic powder, compared with the control ration. However, the values of these parameters increased significantly overall ($p < 0.05$) with the ration containing 0.50% garlic powder (R0.50), followed by the R0.25 ration and finally the R0.75 ration.

In addition, birth mortality and pre-weaning mortality were significantly lower ($p < 0.05$) with rations containing garlic powder, compared with those of the control ration (R0). However, the R0.50 ration showed the lowest rates, followed by the R0.25 ration, and finally the R0.75 ration.

3.3. Effects of Incorporating Different Levels of Garlic Powder into Ration on Growth Performance

3.3.1. Effects of Incorporating Different Levels of Garlic Powder in the Ration on the Weight Development of Pregnant Females

The weight gain of pregnant females increased from the beginning to the end of gestation, whatever the ration. However, pregnant females fed rations containing garlic powder showed higher growth rates than those fed control rations.

Table 2. Phytochemical composition of garlic powder.

Extracts	Alcaloides	Phenols	Flavonoides	Sterols	Triterpenoides	Tannins	Saponins	Antho-cyanins	Anthra-quinones
Galic powder	+	+	+	+	+	+	−	−	+

Legend: (+) present; (−) absent.

Table 3. Chemical composition of garlic powder.

	TPT (mg EAG/g de poudre)	TFT (mg EQ/g de poudre)	TTT (mg EAT/g de poudre)
Galic powder	0.166 ± 0.05	0.022 ± 0.002	0.017 ± 0.003

Total phenol content **(TPT),** Total flavonoid content **(TFT),** Total tannin content **(TTT)**.

Table 4. Average reproductive performance in cavies as a function of the level of garlic powder added to the ration.

Parameters	R0	R0.25	R0.50	R0.75	p
Fertility rate (%)	90.00 ± 0.75^{c}	92.33 ± 1.00^{b}	93.84 ± 0.35^{a}	92.73 ± 0.70^{ab}	0.01
Fecundity rate (%)	81.63 ± 0.35^{c}	92.97 ± 0.85^{a}	92.86 ± 0.31^{a}	90.73 ± 0.41^{b}	0.01
Net fecundity rate (%)	81.09 ± 0.77^{c}	91.13 ± 0.98^{a}	92.55 ± 0.73^{a}	89.46 ± 0.73^{b}	0.01
Litter size	1.33 ± 0.06^{c}	1.51 ± 0.05^{b}	1.63 ± 0.05^{a}	1.55 ± 0.03^{ab}	0.01
Viability rate at birth (%)	89.35 ± 0.42^{d}	92.71 ± 0.49^{b}	93.767 ± 0,50^{a}	90.267 ± 0.49^{c}	0.01
Pre-weaning viability rate (%)	90.73 ± 0.20^{d}	94.40 ± 0,45^{b}	95.70 ± 0,10^{a}	93.51 ± 0,57^{c}	0.01
Birth mortality rate (%)	10.65 ± 0.42^{a}	7.29 ± 0.49^{c}	6.23 ± 0.50^{d}	9.73 ± 0.49^{b}	0.01
Pre-weaning mortality rate (%)	9.26 ± 0.20^{a}	5.60 ± 0.45^{c}	4.30 ± 0.10^{d}	6.48 ± 0.57^{b}	0.01

^{a}, ^{b}, ^{c}, and ^{d}: Means bearing the same letters on the same line are not different at the threshold of $p < 0.05$; P: Probability; R0 (Control ration); R0.25 (Ration containing 0.25% garlic powder); R0.50 (Ration containing 0.50% garlic powder; R0.75 (Ration containing 0.75% garlic powder).

Furthermore, among the rations supplemented with garlic powder, we noted that before the third week of gestation, the weights of females fed the R0.75 ration were higher than those of females fed the R0.25 ration, whose weights were in turn higher than those of females fed the R0.50 ration. However, the weights of these pregnant females were comparable at the end of gestation. (Figure 1)

3.3.2. Effect of Incorporating Different Levels of Garlic Powder in the Ration on Post-Partum Weight Growth of Lactating Females

Figure 2 shows the post-partum weight growth of parturient females.

This figure shows that lactating female weights decreased progressively from farrowing to weaning, whatever the ration. However, lactating females fed the control ration showed the lowest weight gain compared with those fed rations containing garlic powder. In addition, the weights of lactating females fed rations containing garlic powder, although similar at farrowing, evolved differently afterward to equalize at weaning.

3.4. Effects of Incorporating Different Levels of Garlic Powder in Ration on Pre-Weaning Growth of Newborn Cavies

3.4.1. Pre-Weaning Growth of Young Male Cavies

Pre-weaning weight development of young male cavies is shown in Figure 3. It can be seen that weight development increased with all rations. However, weight growth was more marked with the R0.50 ration than with the other rations containing garlic powder, as well as with the control ration. However, cavies on rations R0.75 and R0 had similar weight trends which were the lowest.

3.4.2. Pre-Weaning Weight Development of Young Female Cavies

Figure 4 illustrates the pre-weaning growth of young female cavies.

The weight trends of female cavies fed R0.25 rations were similar to those of females fed R0.50 rations, which were all higher than those of female cavies fed control rations (R0), which were also higher than those of female cavies fed R0.75 rations.

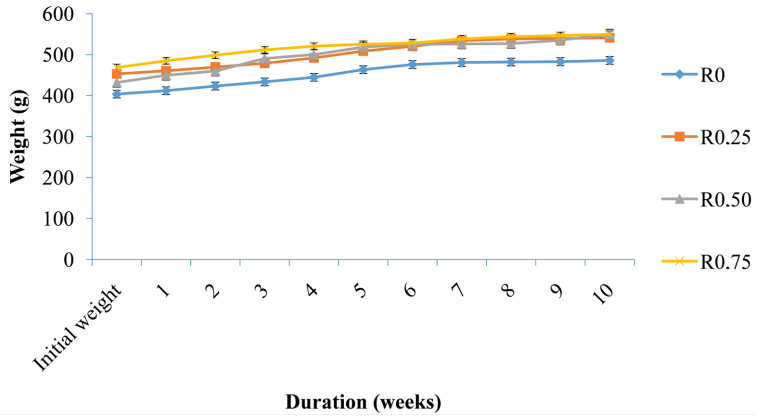

Figure 1. Weight evolution of pregnant females according to the level of garlic powder incorporation in the ration. R0 (Control ration); R0.25 (Ration containing 0.25% garlic powder); R0.50 (Ration containing 0.50% garlic powder; R0.75 (Ration containing 0.75% garlic powder).

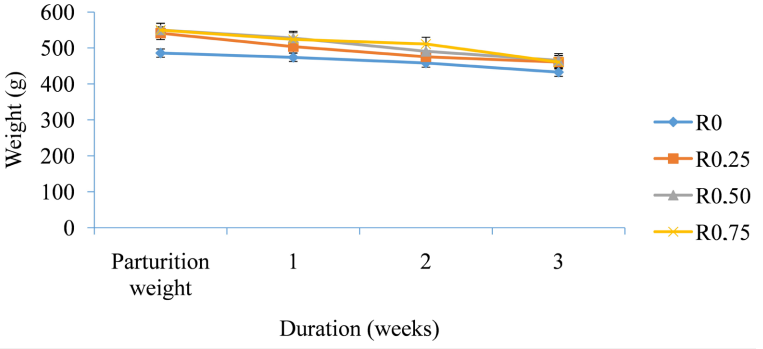

Figure 2. Weight trend of lactating females from farrowing to weaning, according to the level of garlic powder added to the ration. R0 (control portion); R0.25 (portion containing 0.25% garlic powder); R0.50 (portion containing 0.50% garlic powder); R0.75 (portion containing 0.75% garlic powder).

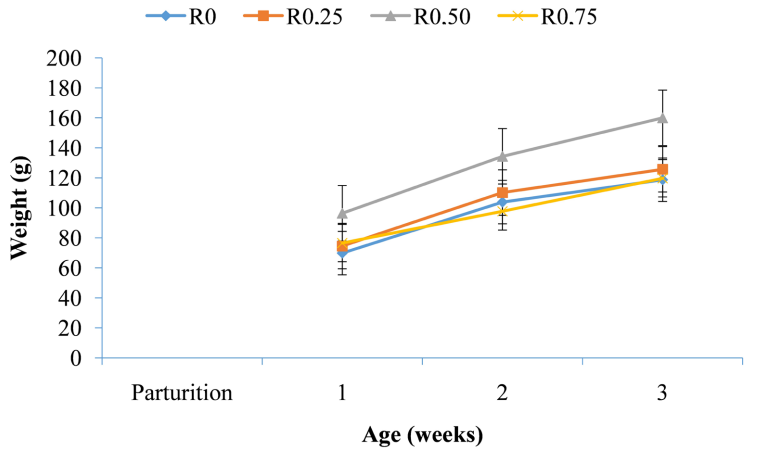

Figure 3. Pre-weaning weight trends in young male cavies as a function of the level of garlic powder added to the ration. R0 (control portion); R0.25 (portion containing 0.25% garlic powder); R0.50 (portion containing 0.50% garlic powder); R0.75 (portion containing 0.75% garlic powder).

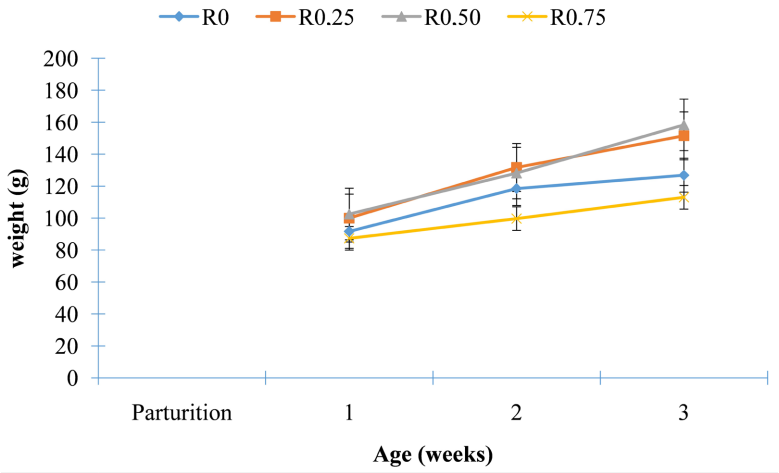

Figure 4. Pre-weaning weight development of young female cavies according to the level of garlic powder added to the ration. R0 (Control ration); R0.25 (Ration containing 0.25% garlic powder); R0.50 (Ration containing 0.50% garlic powder; R0.75 (Ration containing 0.75% garlic powder).

3.4.3. Pre-Weaning Weight Trends in Young Cavies, Irrespective of Sex

Irrespective of sex, the pre-weaning weight gain shown in **Figure 5** was highest with the R0.50 ration, followed by the R0.25 ration, then the R0 ration and finally the R0.75 ration.

3.4.4. Effects of Incorporating Different Levels of Garlic Powder in Ration on Average Birth Weight, Weaning Weight, Total Weight Gain and Average Daily Gain of Young Cavies

The birth weights of male and female cavies, irrespective of sex, fed the control ration (R0) were similar ($p > 0.05$) to those fed the R0.50 ration, which were significantly higher ($p < 0.05$) than those fed the R0.25 and R0.75 rations, which were otherwise comparable (**Table 5**). However, no significant difference ($p > 0.05$) was observed between male and female cavies, whatever the ration.

At three (03) weeks of age, the weights of male cavies fed ration R0.50 were significantly higher ($p < 0.05$) than those obtained with rations R0, R0.25 and R0.75, which were comparable ($p > 0.05$) between them. On the other hand, the weights of females fed the R0.25 and R0.50 rations were comparable ($p > 0.05$) to each other and significantly higher ($p < 0.05$) than the weights of cavies fed the control ration.

However, the weights of guinea pigs fed the control ration (R0) were significantly higher ($p < 0.05$) than those fed the R0.75 ration. Regardless of sex, the weights of cavies fed the R0.50 ration were significantly higher ($p < 0.05$) than those of guinea pigs fed the 0.25 ration. However, the weights of guinea pigs fed the R0.25 ration were significantly higher ($p < 0.05$) than those of guinea pigs fed the R0 and R0.75 rations, which were comparable ($p > 0.05$). On the other hand, the incorporation of different levels of garlic powder in the ration did not significantly influence ($p > 0.05$) the weights of male guinea pigs compared with those of females.

Table 5. Average birth weights, weaning weights, total weight gains and average daily gains of young cavies according to the level of incorporation of garlic powder in the ration.

Characteristics	Sexe	Treatments				p
		R0	R0.25	R0.50	R0.75	
Birth weight (g)	♂ (26)	100.22 ± 0.12^{a} (6)	82.00 ± 0.12^{c} (8)	94.70 ± 0.12^{ab} (8)	87.50 ± 0.12^{bc} (6)	0.00
	♀ (32)	100.12 ± 0.12^{a} (7)	82.90 ± 0.12^{b} (8)	94.50 ± 0.12^{a} (9)	89.97 ± 0.12^{b} (8)	0.01
	♂♀ (58)	100.17 ± 0.12^{a} (13)	82.45 ± 0.12^{b} (16)	94.60 ± 0.12^{a} (17)	88.73 ± 0.12^{b} (14)	0.00
P		0.21	0.31	0.19	0.27	
3-week weight (g)	♂ (24)	118.70 ± 0.22^{b} (5)	125.67 ± 3.40^{b} (7)	160.00 ± 23.93^{a} (7)	119.67 ± 3.09^{b} (5)	0.01
	♀ (26)	126.83 ± 4.77^{b} (5)	151.50 ± 7.08^{a} (8)	158.33 ± 3.40^{a} (9)	113.00 ± 2.16^{c} (7)	0.01
	♂♀ (50)	122.77 ± 2.48^{c} (10)	138.58 ± 3.57^{b} (15)	159.17 ± 13.51^{a} (16)	116.33 ± 0.62^{c} (12)	0.01
P		0.53	0.47	0.32	0.85	
Total gains (g)	♂	48.87 ± 0.82^{a}	51.17 ± 2.95^{a}	63.63 ± 20.42^{a}	43.17 ± 7.10^{aA}	0.10
	♀	35.17 ± 2.72^{b}	51.50 ± 6.72^{a}	55.83 ± 4.37^{a}	25.67 ± 2.49^{cB}	0.01
	♂♀	42.02 ± 1.63^{bc}	51.33 ± 2.86^{ab}	59.73 ± 12.38^{a}	34.42 ± 4.79^{c}	0.01
P		0.40	0.18	0.36	0.01	
Daily average earnings (g/j)	♂	2.33 ± 0.04^{a}	2.44 ± 0.14^{a}	3.03 ± 0.97^{a}	2.06 ± 0.34^{a}	0.10
	♀	1.68 ± 0.13^{b}	2.45 ± 0.32^{a}	2.66 ± 0.21^{a}	1.22 ± 0.12^{c}	0.01
	♂♀	2.00 ± 0.08^{bc}	2.44 ± 0.14^{ab}	2.84 ± 0.59^{a}	1.64 ± 0.23^{c}	0.01
P		0.22	0.10	0.53	0.17	

$^{a, b, c}$ and ^{d}: Values assigned the same letter in the same row do not differ significantly ($p > 0.05$). A and B: Values assigned the same letter in the same column do not differ significantly ($p > 0.05$). P = Probability; R0 (Control ration); R0.25 (Ration containing 0.25% garlic powder); R0.50 (Ration containing 0.50% garlic powder; R0.75 (Ration containing 0.75% garlic powder).

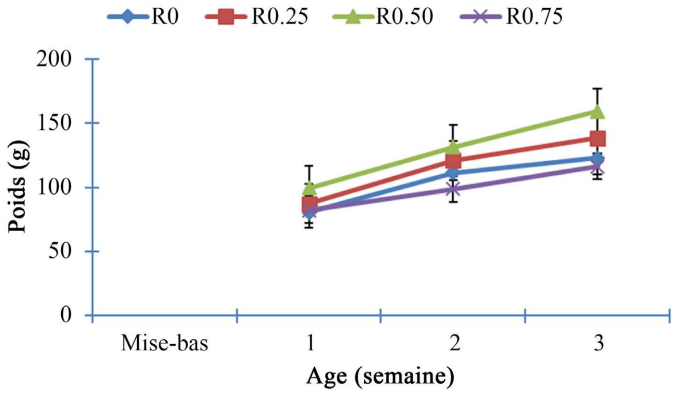

Figure 5. Pre-weaning weight gain of young cavies, regardless of sex, according to the level of garlic powder added to the ration. R0 (control portion); R0.25 (portion containing 0.25% garlic powder); R0.50 (portion containing 0.50% garlic powder); R0.75 (portion containing 0.75% garlic powder).

Total gains and average daily gains of male guinea pigs were not significantly influenced by the level of garlic powder incorporation in the ration. However,

female guinea pigs, or regardless of sex, showed comparable TG and ADG ($p > 0.05$) with rations R0.25 and R0.50, which were significantly higher ($p < 0.05$) than those obtained with rations R0 and R0.75, which were otherwise comparable ($p > 0.05$) with each other.

Except for the fact that total gains and ADG were significantly higher ($p < 0.05$) in male guinea pigs compared to females with the R0.75 ration, sex did not significantly influence ($p > 0.05$) these two indicators for the other rations.

4. Discussion

Rations containing garlic powder significantly increased fertility rate, fecundity rate and net fecundity rate, litter size, birth viability rate, and pre-weaning viability rate with rations containing garlic powder, compared with the control ration. This means that garlic powder provided these rations with sufficient nutrients to improve reproductive parameters in these cavies. Indeed, when phytobiotics are incorporated into animal diets, they improve feed digestibility and nutrient absorption, as well as the elimination of pathogenic microorganisms from the animals' digestive tract, and consequently stimulate reproductive functions [29] [30]. Our results are contrary to those of Djoumessi *et al.* [31], who found that the inclusion of different levels of *Curcuma longa* powder in the ration had no significant effect on these reproductive parameters. Similarly, the work of Fogang [21] reported that incorporating 1% garlic powder into a ration without legumes had no significant effect on reproduction parameters, which remained unchanged compared to the control ration (without additives).

Moreover, the birth and pre-weaning mortality rates were significantly lower with rations containing garlic powder, compared with those of the control ration (R0). Indeed, thanks to their antioxidant properties, phytobiotics reduce the metabolic processes leading to the formation of free radicals, thus improving these animals' resistance to oxidative stress, which has an impact on both their health and the quality of their meat [32] [33]. The results of this work differ from those of Djoumessi *et al.* [31], whose birth and weaning mortality rates remained comparable to those of the control ration.

However, the R0.50 ration in this study showed the lowest rates of birth mortality (6.23%) and pre-weaning mortality (4.30%). These values are lower than those reported by Fogang [21] with 1% garlic powder, *i.e.* 20.8% and 5% respectively, which justifies the fact that it was important to investigate the level of garlic powder needed to reduce cavy rearing mortalities. Furthermore, in the trials performed by Djoumessi *et al.* [31], the lowest birth (0.0%) and pre-weaning (11.1%) mortality rates were obtained in newborn cavies whose mothers were fed with the ration containing 0.25% *C. longa* powder (R0.25), confirming the fact that the use of phytobiotics in cavy feed reduces mortality in cavy farms.

Gestating females fed rations containing garlic powder showed higher growth from the beginning to the end of gestation, compared with females fed control rations. These results corroborate those of Fogang [21] with the inclusion of 1%

garlic powder in a ration not enriched with a legume. Indeed, the bioactive components of phytobiotics eliminate undesirable microbes from the digestive tract, thus promoting the digestive efficiency of the feed and consequently improving the growth performance of the animals [33]. This observation effectively confirms that these females are pregnant.

Parturient weights in this growth trial decrease progressively from farrowing to weaning on all rations, with the lowest change recorded in parturients from the control group. The fact that rations containing garlic powder give the best weight evolution confirms that garlic powder improves the valorization of rations enriched with *Stylosanthes guianensis*. With the incorporation of 1% garlic powder in a non-legume ration, Fogang [21] also obtained a progressive decrease in parturient weight from farrowing to weaning, except that the lowest change was recorded with the ration containing the additive, compared to the control ration. However, these results contrast those of Djoumessi *et al.* [31], who showed that average weekly weights of lactating females fed rations containing *Curcuma longa* powder increased progressively from farrowing to weaning.

Total gains (TG) and average daily gains (ADG) of female cavies or independently of sex were significantly improve by the level of garlic powder incorporation in the ration, confirming the synergistic effect of the legume and garlic on the improvement of these growth parameters. These results corroborate those obtained by Djoumessi *et al.* [31], whose the inclusion of different levels of *C. longa* powder in the ration has significantly improved TG and ADG in cavies. However, the highest values for TG (59.73 g) and ADG (2.84 g) were obtained with the ration containing 0.50% garlic powder, while those for total gain (98.8 g) and ADG (4.70 g) were recorded with the ration containing 0.50% *C. longa* powder were much higher. This discrepancy could be explained by the different composition of the active ingredient. Our results differ from those of Fogang [21], who found that incorporating 1% garlic powder into a legume-free ration did not significantly alter the animals' TG and ADG.

5. Conclusions

This study on the effects of incorporating different levels of garlic powder into rations enriched with *Stylosanthes guianensis* on reproductive and pre-weaning growth performance in cavies shows that:

Incorporating different levels of garlic powder into the ration enriched with *Stylosanthes guianensis* improved several reproductive parameters, such as birth mortality and pre-weaning mortality, which were low compared to those recorded with the control ration (R0), with a more marked effect with the R0.50 ration.

-Incorporating different levels of garlic powder into the ration enriched with *Stylosanthes guianensis* improved pre-weaning weight evolution, particularly with the R0.50 ration. This additive produced the best weight gains in the pre-weaning phase with the R0.25 ration.

Thus, Garlic powder has improved the valorization of *Stylosanthes guianensis* in the rations and then the reproduction and animals' growth performance. Garlic powder can then be used as feed additives to improve the utilization of ration enriched with legumes and then the production performances.

Conflicts of Interest

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

References

[1] Noumbissi, M.N.B., Tendonkeng, F., Zougou, T.G. and Pamo, T.E. (2014) Effet de différents niveaux de supplémentation de feuilles de *Tithonia diversifolia* Hemsl. Sur l'ingestion et digestiblité *in vivo* de *Penissetum purpureum* K. Schum. Chez le cobaye (*Cavia porcellus L*). *Tropicultura*, **3**, 138-146.

[2] Miegoue, E., Tendonkeng, F., Mweugang, N.N., Lemoufouet, J., Tatang, M.V., Ntsafack, P., Mouchili, M. and Tedonkeng, P.E. (2018) Effect of Inclusion Levels of *Arachis glabrata* in the Diets on the Ingestion and *in Vivo* Digestibility of *Panicum maximum* in Guinea Pigs (*Cavia porcellus*). *International Journal of Veterinary Science & Technology*, *SCIRES Literature*, **3**, 27-32. https://www.scireslit.com

[3] Miégoué, E., Tendonkeng, F., Mweugang, N.N., Tatang, M.V., Ntsafack, P., Lemoufouet, J., Mouchili, M. and Tedonkeng, P.E. (2019) Ingestion and *in Vivo* Digestibility of *Pennisetum purpureum* Supplemented with Graded Level of *Arachis glabrata* in Guinea Pigs (*Cavia Porcellus*). *Austin Journal of Veterinary Science and Animal Husbandry*, **6**, Article No. 1050. https://doi.org/10.26420/austinjvetscianimhusb.2019.1050

[4] Miégoué, E., Tendonkeng, F., Mweugang, N.N., Fossi, J., Ntsafack, P., Ebile, A.D, Fogang, M.D., Mouchili, M. and Pamo, E.T. (2019) Post-Weaning Growth Performance of Guinea Pigs (*Cavia porcellus* L.) Fed on *Panicum maximum* Supplemented with Graded Levels of *Arachis glabrata* in the Diet. *Journal of Veterinary Science & Animal Husbandry*, **7**, 102.

[5] Metre, T.K. (2012) Possibilités d'amélioration de l'élevage de cobaye (*Cavia porcellus* L.) au Sud Kivu, à l'est de la République Démocratique du Congo. Mémoire présente en u diplôme de Master complémentaire en gestion des ressources animales et végétales en milieux tropicaux. Université de Liège, Académie Universitaire Wollonie-Europe. 52 p.

[6] Kouakou, N'G.D.V., Kouba, M. and Thys, E. (2016) Etude comparative de la digestibilité *in Vivo* de l'herbe de guinée (*Panicum maximum* Jacq.) associée aux feuilles et tiges de patate douce (*Ipomea batatas* (L.) Lam) ou l'herbe de lait (*Euphobia heterophylla* L.) chez le lapin (*Oryctolagus cuniculus* L.) et le cobaye (*Cavia porcellus* L.). *Tropicultura*, **34**, 158-165.

[7] Faihun, A.M.L., Zoffoun, A.G., Hounzangbe-Adote, M.S., Samati, G., Akouedegni, C.G., Akakpo, G.A., Wabi, F., Kulo, A. and Houndonougbo, F. (2020) Effet des feuilles de *Moringa oleifera* et de *Commelina benghalensis* sur les performances de croissance et les caractéristiques de carcasse des cobayes (*Cavia porcellus*) au Sud-Bénin. *Journal of Applied Biosciences*, **134**, 13657-13672. https://doi.org/10.4314/jab.v134i1.4

[8] Miégoué, E., Tendonkeng, F., Lemoufouet, J., Mweugang, N.N., Noumbissi, M., Fongang, M.D., Zougou, T.G., Matumuini, N.E.F., Mboko, A.V., Boukila, B. and Pamo, T.E. (2016) Ingestion et digestibilité de *Pennisetum purpureum* associé à une

légumineuse (*Arachis glabrata*, *Calliandra calothyrsus* ou *Desmodium intortum*) comme source de protéines chez le cobaye. *Livestock Research for Rural Development*, **28**, Article No. 12.

[9] Bindelle, J. and Picron, P. (2013) Le cobaye, Un petit herbivore facile à nourrir dans des petites parcelles. Troupeaux et Cultures des Tropiques: Spécial Elevage de Rongeurs, Kinshasa, RDC. CAVTK, 1-10.

[10] Losson, B. (2013) Le cobaye et ses principales maladies. Troupeaux et Cultures des Tropiques: Spécial Elevage de Rongeurs, Kinshasa, RDC. Laboratoire de Parasitologie, Faculté de Médecine vétérinaire, Université de Liège, Liège.

[11] Bastianelli, D. and Lebas, C. (2006) Evaluation du rôle de l'alimentation animale dans la sécurité des aliments: Perspectives d'actions. Programme de production animale, Département d'élevage et de médicine vétérinaire, Centre de coopération internationale en recherche agronomique pour le développement (CIRAD-EMVT), Montpellier.

[12] Aouadi, D. and Ben Salem, H. (2012) Effets de l'administration des huiles essentielles de Rosmarinus officinalis et d'*Artemisia herba* alba sur l'ingestion et la digestion chez des béliers de race 2 et 3 décembre 2020 25e édition Congrès international francophone—Centre des Congrès Paris La Villette.

[13] Blain, J. (2002) Introduction à la nutrition des animaux domestiques. Technique et Document, Médicales Internationals, France, 167-170.

[14] Kouakou, N'G.D.V., Angbo-Kouakou, Assidjo, E.N. and Grongnet, J.F. (2015) Stratégies incitatives à la pratique de l'élévage des cobayes (*Cavia porcellus* L) en Côte d'Ivoire. *International Journal of Biological and Chemical Sciences*, **9**, 664-678. https://doi.org/10.4314/ijbcs.v9i2.8

[15] Kahouli, A., Kaboul, N., Yousfi, M. and Rekike, F. (2020) Les phytobiotiques, une alternative potentielle aux antibiotiques promoteurs de croissance chez les ruminants. *Revue Agrobiologia*, **10**, 1950-1966.

[16] Iserin, P. (2001) Encyclopedia of Médicinal Plants. Département de phytothérapie à la faculté de médecine de Bobigny, Larousse, 59.

[17] Dufresne, C. and Ouellet, C. (2010) Filière des plantes médicinales biologiques du Québec. L'ail, Guide de production sous régie biologique. FPMQ, Québec, 29 p.

[18] Aarti, C. and Khusro, A. (2020) Rôle of Garlic (*Allium sativum*) as Feed Supplements in Poultry Industries: An Overview. *World News of Natural Sciences. An International Scientific Journal*, **29**, 151-161.

[19] Katschinski, M. (2000) Nutritional Implications of Cephalic Phase Gastrointestinal Responses. *Appetite*, **34**, 189-196. https://doi.org/10.1006/appe.1999.0280

[20] Teff, K. (2000) Nutritional Implications of the Cephalic-Phase Reflexes: Endocrine Responses. *Appetite*, **34**, 206-213. https://doi.org/10.1006/appe.1999.0282

[21] Fogang, M. (2023) Effet de l'inclusion de la poudre de thym et d'ail comme additifs alimentaires sur les performances de production et quelques paramètres hémato-sérologiques chez le cobaye (*Cavia porcellus*). Thèse de Doctorat/PhD, Faculté d'Agronomie et des Sciences Agricoles, Université de Dschang, Dschang, 115 p.

[22] Islam, M.F., Haque, M.N., Parvin, A., Islam, M.N., Alam, M.N. and Sikder, M.D. (2017) Effect of Dietary Supplementation of Garlic on Feed Conversion Ratio, Carcass Physionomies and Bromatological Parameters in Broilers. *Bangladesh Journal of Veterinary Medicine*, **1**, 60-74. https://doi.org/10.3329/bjvm.v15i1.34047

[23] Pamo, T.E., Niba, A.T., Fonteh, F.A., Tendonkeng, F., Kana, J.R., Boukila, B. and Tsachoung (2005) Effet de la supplémentation au *Moringa oleifera* ou aux blocs

multinutritionnels sur l'évolution du poids post-partum et la croissance pré-sevrage des cobayes (*Cavia porcellus* L.). *Livestock Research for Rural Development*, **17**, Article No. 46. http://www.lrrd.org/lrrd17/4/tedo17046.htm

[24] Ramde-Tiendrebeogo, A., Tibiri, A., Hilou, A., Lompo, M., Millogo-Kone, H., Nacoulma, O.G. and Guissou, I.P. (2012) Antioxidative and Antibacterial Activities of Phenolic Compounds from Ficus Sue Forssk. *International Journal of Biological and Chemical Sciences*, **6**, 328-336.

[25] Chang, C., Yang, W.H. and Chern, J. (2002) Estimation of Total Flovonoid Content in Propolis by Two Complementary Calorimetric Methods. *Journal of Food and Drug Analysis*, **10**, 178-182. https://doi.org/10.38212/2224-6614.2748

[26] Govindappa, M., Naga Sravya, S., Poojashri, M.N., Sadananda, T.S. and Chandrappa, C.P. (2011) Antimicrobial, Antioxidant and *in Vitro* Anti-Inflammatory Activity of Ethanol Extract and Active Phytochemical Screening of *Wedelia trilobota* (L) Hitch. *Journal of Pharmacognosy and Phytochemestry*, **3**, 43-51. https://doi.org/10.5530/pj.2011.25.15

[27] AOAC (Association of Official Analytical Chemists) (2016) The Official Method of Analysis. 20th Edition, AOAC International, Rockville.

[28] Steele, R.G. and Torrie, J.H. (1980) Principles and Procedures of Statistics. McGraw Hill Book, New York, 633 p.

[29] Balunas, M.J. and Kinghorn, A.D. (2005) Drug Discovery from Medicinal Plants. *Life Science*, **78**, 431-441. https://doi.org/10.1016/j.lfs.2005.09.012

[30] Athanasiadou, S., Githiori, J. and Kyriazakis, I. (2007) Medicinal Plants for Helminth Parasite Control: Facts and Fiction. *The Animal Consortium*, **1**, 1392-1400. https://doi.org/10.1017/S1751731107000730

[31] Djoumessi, T.F.G., Tendonkeng, F., Miégoué, E., Camara, S., Fokom Wauffo, D., Emale, C. and Pamo Tedonkeng, E. (2020) Effet de différents niveaux de *Curcuma longa* dans la ration sur les performances de reproduction et de croissance pre-sevrage des cocons d'Inde. *Livestock Research for Rural Development*, **32**, Article No. 88.

[32] Brenes, A. and Roura, E. (2010) Essential Oils in Poultry Nutrition: Main Effects and Modes of Action. *Animal Feed Science and Technology*, **158**, 1-14. https://doi.org/10.1016/j.anifeedsci.2010.03.007

[33] Mohamed, N.A. (2011) Les phytobiotiques comme alternative aux antibiotiques promoteurs de croissance dans l'aliment des volailles. Institut Agronomique Méditerranéen de Zaragoza (Espagne). *Livestock Research for Rural Development*, **23**, Article No. 133.