



Evaluation of Ginger Powder as a Growth Promoter in Rabbit Diets: Effects on Growth Performance, Carcass Traits, and Blood Biochemical Parameters

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Abstract | Antibiotics retraction as feed additives has led to a decline in animal health and reduced economic profitability for farms. This necessitates the identification of effective alternatives that do not compromise human or animal health. This study investigates the impact of dietary ginger powder supplementation as a growth promoter on the productive capabilities of rabbits. A total of 40 rabbits of a local breed, aged 38 days and weighting on average 550±60g, were randomly assigned to five treatment groups, each containing eight animals. The treatments included a control diet without additives (T0-), a diet with 0.1% antibiotic (T0+), and diets with 0.2%, 0.4%, and 0.6% ginger powder (T1, T2, and T3, respectively). Data on growth characteristics, carcass traits, and blood biochemical parameters were collected over a 6-week experimental period. The results showed no significant differences in growth performance and carcass yield among the groups. The T0+ diet, which included antibiotics, was associated with a significant increase in abdominal fat, creatinine, ALAT, and ASAT levels as compared to the other treatments. Conversely, the highest white blood cell and granulocyte values were recorded in the T3 group, which received a diet with 0.6% ginger powder. The study concluded that ginger powder is a promising alternative for improving rabbit health status without compromising growth performance, highlighting its potential as a viable substitute for antibiotics in animal feed. In conclusion, while ginger powder may offer some benefits in terms of growth rates, the lack of statistically significant differences in overall performance suggests that further research is needed to fully understand its potential as a substitute to antibiotics in rabbit diets. Caution is warranted before drawing definitive conclusions about its efficacy as a growth promoter in this context.

Keywords | Ginger powder, Rabbits, Growth performance, Metabolic profile

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Feeding in most developing countries remain a nightmare and particular due to a decline in animal protein production which is favoring malnutrition (Kehinde *et al.*, 2011; AbouKassem *et al.*, 2022). Cameroon as most African countries, protein consumption is about 17g/day/head as compared to 55g/day/head (FAO, 2010), this less protein consumption is due to increase in population which outweighs animal production rate (Henchion *et al.*, 2017). The most appropriate measures to palliate these problems of protein meat shortage lie in the breeding of animals that mature quickly, such as rabbits, pigs, and poultry. Rabbit production is preferable because they are monogastric herbivores, highly prolific (Foku *et al.*, 2019), rapid growth, easy to breed are not in direct competition with humans for cereal and legume grains. (Kana *et al.*, 2022; Guindjombi, 2007; Shiere and coustiaencen, 2008). Although rabbit production is appreciable, breeding animal within short time range requires good mastery of feed formulation among other production parameters. With a view to increasing growth performance, ensuring food self-sufficiency in protein of animal origin in Cameroon, numerous research initiatives and production strategies are being implemented, notably the utilization of antibiotics (Kehinde *et al.*, 2010; Tiseo *et al.*, 2020). Indeed, the fusing antibiotics as a growth factor has improved growth and feed efficiency by 3 to 10% (Thomke and Elwinger, 1998). However, despite their importance for the health and growth of animals, the proliferation of antibiotic-resistant germs and the deposit of chemical residues on livestock products with harmful consequences on the health of consumers have resulted in the complete prohibition on these antibiotics in 2006 in the European Union and in other developed countries (Kana *et al.*, 2012; Giannenas *et al.*, 2019). This suppression caused a deterioration in the animals health condition, a spike in the mortality rate, a drop in live weight, an increase in the consumption indices and consequently a decrease in the economic profitability of the farms (Dibner and Richards, 2005). This is why it is becoming urgent to seek effective alternatives without negative effects on the health of humans and animals (Cardoso *et al.*, 2014). Many alternatives have been proposed. It is in this perspective that our attention has focused on phytobiotics (EL-Deek *et al.*, 2012; Muneendra *et al.*, 2014; Arif *et al.*, 2022). Utilization of natural growth promoter have been used as a strategic way to rapidly increase growth performance in poultry and pigs for decades. In fact, natural feed additives like garlic, pepper oregano and thyme contain large quantities of actives compounds such as flavonoids, terpenes, which possess antiviral, antifungal, antibacterial, antioxidative, appetite stimulant properties (Joke and Susan, 2007; Morvaridzadeh *et al.*, 2020). Similarly, gingerol and shogaol in ginger (*Zingiber officinalis*) are common additive largely used in compounded feeds and beverages owing to its aroma and

the pungent taste (Rafiee *et al.*, 2014; Abd El Tawab *et al.*, 2020). Recent studies have shown that the spices used in the preparation of local dishes were highly effective against certain gastrointestinal diseases in humans (Tchiegang and Mbougueng, 2005). Although these ingredients and their derivatives represent a novel class of growth boosters for farm animals, nothing is currently known about their mechanisms of action or use (Replace, 2004). Similarly, several studies have shown that certain spices, in particular Piper nigrum, have supportive repercussions for domestic animals' growth outcomes (Mbognou *et al.*, 2023). In animal sciences, the addition of ginger powder in animal feed increases palatability, nutrients absorption, appetite triggering, growth performance, gastric juice flow, and piquancy to meals without flavor (Owen and Amakiri, 2012; Siregar *et al.*, 2024). Ginger (*Zingiber officinale*) is renowned for its bioactive compounds, particularly gingerols and shogaols, which exhibit anti-inflammatory, antioxidant, and antimicrobial properties. These compounds modulate inflammatory pathways, enhance gastric motility, and improve gut microbiota composition, contributing to better digestive health and nutrient absorption. In rabbit production, phytobiotics like ginger have been shown to enhance growth performance by stimulating appetite and improving feed efficiency. Research indicates that ginger can reduce the incidence of gastrointestinal diseases in rabbits through its effects on gut health. As a natural alternative to antibiotics, ginger offers a safe option for promoting animal health without contributing to antibiotic resistance. Overall, ginger's mechanisms of action align with the growing interest in phytobiotics as effective growth promoters in sustainable livestock production systems. Further studies are needed to optimize its application in rabbit diets (Siregar *et al.*, 2024).

This plant is largely produced in Cameroon particularly in Santchou (West region of the country) and their rhizomes are commonly used as medicinal herbs as well as one of the most commonly used spice in Cameroon dishes. The rationale for selecting ginger for this study lies in its unique mechanisms of action that can address specific challenges in rabbit production. Ginger has been shown to enhance feed efficiency, stimulate appetite, and improve gut health—critical factors for optimizing growth performance in rabbits. Furthermore, its safety profile as a natural alternative to antibiotics makes it particularly relevant in contemporary livestock production practices. This research aims to investigate the effects of ginger supplementation on rabbit growth performance, contributing to improved animal production while addressing protein deficiencies in Cameroon. More specifically, it will be a question of evaluating the effects of supplementing the ration of rabbits with ginger (*Zingiber officinalis*) powder on:

- Growth performance
- metabolic profile

AREA OF STUDY

The present work took place in the Rabbit unit of the University of Dschang (UDs) Teaching and Research Farm (TRF), Animal Production and Nutrition Laboratory (LAPRONA), and in the Physiology and Animal Health Laboratory of the Department of Zootechnic between March and May. The University of Dschang Teaching and Research Farm is situated between Latitude 5°26 N, and Longitude 10°26 E in the West Cameroon with an altitude of 1420m. The climatic situation of this region is the Cameroon-equatorial type modified by the altitude. The temperature oscillates between 10°C (July-August) and 25°C in February with yearly sunshine of 1800 hours and relative humidity greater than 40 - 90%. The annual precipitation varies between 1500 and 2000mm, with rainy season beginning from mid-March to mid-November (corresponding to the period of farming) and dry season from mid-November to mid-March. The vegetation type is the Shrubby savanna with sporadic forest (Pamo *et al.*, 2005).

PREPARATION OF GINGER (*ZINGIBER OFFICINALIS*)

We bought the rhizome ginger at local market in Santchou and washed to remove all ground particles and impurities. Later, it was chopped into smaller fragments and dried at room temperature on the cyline covered with plastic paper until a constant weight obtained with the help of an electronic balance. The ginger was dried and then crushed in a grinding mill to a powder. The powdery ginger was later preserved in a polythene air tight bag until the time for incorporation and sample of this ginger powder was extracted for chemical analysis.

EXPERIMENTAL DIET AND MANAGEMENT

The trial involved the use of 35 male rabbits aged 5- 6weeks weighing about 550±600g on average. We lodged the rabbits in individual galvanized metal cages of dimensions 96 cm long, 40 cm wide and 15 cm high. Five dietary treatments, each with seven rabbits, were assigned to them at random in an entirely randomized method with six replicates per treatment. The diets were designed with five treatments T0+, T0-, T₁, T₂ and T₃ (Table 1). T0+ served as a positive control experiment (will contain 0.1% antibiotic (oxytetracycline)) and T0- as negative control experiment (contain no ginger powder inclusion and antibiotic). T₁, T₂ and T₃, incorporated 0.2, 0.4, and 0.6% levels of ginger (*Zingiber officinalis*) powder inclusion respectively. The dietary ingredient mixtures (concentrate, minerals) were formulated to satisfy the rabbits' complete nutritional requirements for growth. Feed and water were provided ad libitum during the whole trial period. At both the commencement and culmination of the trial, the facility, cages, feeders, and drinkers were meticulously cleaned and disinfected. The

test subjects received treatment for both external and internal pathogens via oral administration of oxytetracycline 400 mg per litre of water for the prevention of respiratory diseases and subcutaneous administration of Ivermectine (0, 2 ml/kg live weight) for other bacterial infections. An anti-coccidian (Amproline) was orally administered at a dose of 1teaspoon (5g) in 10 litters of water for the prevention of coccidiosis. Multi-vitamin (anti-stress) was administered orally to the rabbits monthly at a dose 5g in 10L of water for 3 days.

Table 1: Experimental feed composition.

Ingredients of experimental ration	(%) of Kg
Yellow maize	37
Wheat bran	18
Cotton oil cake	9
Soya beans cake	2
Palm kernel cake	12
Fish meal	1
Marine shell	1
Trypsacum laxum	18
Palm oil	1
Iodised salt	0.5
Premix	0.5
Total	100
Calculated chemical characteristics (%) DM	
CP (%)	16.052
ME (kcal/kg)	2401.23
CF (%)	13.18
Calcium (%)	0.66
Sodium (%)	0.26
Lysine (%)	0.62
Methionine (%)	0.26
Energy/Protein (C/P)	149.59
Calcium/Phosphorus (Ca/P)	1.44
Lysine/Methionine (lys/meth)	2.33

*Chemical composition of premix; **Vit A:** 3.000.000IU; **Vit D:** 50.0000IU; **Vit E:** 6.000mg; **VitB1:** 600mg; **Vit B2:** 8000mg; **Vit B1:** 800mg; **Vit B6:** 400mg; **VitB12:** 6mg; **Acidefolique:** 250mg; **Niancine:** 600mg; **Cl:** 283mg; **Ca:** 215.166mg; **Méthionine:** 130.000mg; **Lysine:** 50.000mg; **EM:** énergie métabolisable; **MS:** matièresache; **Ca:** calcium; **P:** phosphore; **Lys:** lysine; **Meth:** methionine; **T0-**: control; **T0+:** positive control (0;1% oxytetra); **T1:** 0.2% ginger powder; **T2:** 0.4% ginger powder; **T3:** 0.6% ginger powder.

DATA COLLECTION

GROWTH PARAMETER: At the beginning of the experiment, both the feed and the animals were weighed. This process was repeated every seven days until the conclusion of the

trial. The weekly feed intake was determined by subtracting the amount of feed that remained at the end of each week from the total feed provided during that week.

$$FI = Q_s - RQ$$

Where;

FI = Feed Intake (g).

Q_s = quantity served (g).

Q_r = feed refusal (g).

The weekly weight gain is calculated by finding the difference between the weights recorded in two consecutive weeks.

$$BWG = W_n - W_{n-1}$$

Where;

BWG = Body Weight Gain (in grams)

W_n = Weight at the current week (in grams)

W_{n-1} = Weight from the previous week (in grams)

To determine the weekly feed conversion ratio, the weekly feed intake is divided by the weekly weight gain.

$$FCR = \frac{\text{Quantity of feed consumed in a week (g)}}{\text{Weight gain per week (g)}}$$

At the conclusion of the trial, four animals from each treatment group were randomly chosen. After a 12-hour fasting period, they were weighed and subsequently sacrificed for the assessment of carcass characteristics. The animals were fully bled and eviscerated following the guidelines established by Jourdain (1980). The evaluation of carcass yields, relative carcass weight, as well as the weights of various parts (such as heads, legs, and skin) and organs in relation to live weight, was conducted using the formulas outlined below. Commercial carcass output (Cco);

$$Cco \% = \frac{\text{weight of dressed carcass ready for sell (g)}}{\text{live weight during slaughtering (g)}} \times 100$$

Classical carcass output (Clco);

$$Clco \% = \frac{\text{commercial weight of dressed carcass (g) + (legs + liver + head + hide + kidney)}}{\text{Live weight during slaughtering (g)}} \times 100$$

$$\text{Proportion of organ or parts (\%)} = \frac{\text{Weight of intestine (g)}}{\text{Live weight during slaughtering (g)}} \times 100$$

METABOLIC PROFILES

COLLECTION OF BLOOD FOR HEMATOLOGICAL PARAMETERS:

Blood was collected into test tubes containing the anticoagulant EDTA (ethylenediaminetetraacetic acid) to prevent coagulation, allowing for accurate hematological analyses.

COLLECTION OF BLOOD FOR SEROLOGICAL PARAMETERS:

Blood samples from the animals sacrificed for carcass analysis were collected in test tubes containing the anticoagulant EDTA for the assessment of hematological parameters. Additionally, separate test tubes without anticoagulant were used for the evaluation of serological parameters. This method, following the guidelines of the American Society for Veterinary Clinical Pathology (ASVCP), ensures that blood samples are appropriate for the various required analyses, thereby facilitating reliable and accurate results.

STATISTICAL ANALYSIS

The collected data were analyzed using a one-way Analysis of Variance (ANOVA) within a completely randomized design, as outlined by Steel and Torrie (1980). When applicable, means were differentiated using Duncan's Multiple Range Test (1955). The analyses were done using SPSS (statistical package for social sciences) 20.0 for windows XP program.

RESULTS AND DISCUSSIONS

EFFECT OF GINGER POWDER ON GROWTH PERFORMANCE OF RABBIT

Table 2 presents the influence of ginger powder on weekly feed consumption, average weight gain per week, feed conversion efficiency, overall average weight, and final weight. Overall, the analysis revealed no significant differences (p > 0.05) across the different treatment groups.

Table 2: Effect of ginger powder on growth performance of rabbit.

Treatments	Parameters				
	FI(g)	FBW(g)	WWG(g)	TWG(g)	FCR
T0-	555.53±51.56	1660.00±177.81	207.50±22.23	882.50±151.52	2.66±0.48
T0+	476.01±79.63	1653.25±248.12	206.66±31.02	885.75±203.17	2.31±0.28
T1	452.91±75.61	1589.00±213.27	198.62±66	809.00±207.36	2.28±0.20
T2	553.04±58.54	1770.00±124.57	221.25±15.57	988.75±153.32	2.51±0.32
T3	504.34±102.11	1600.00±246.71	200.00±30.84	811.25±209.26	2.52±0.31
p	0.263	0.750	0.750	0.657	0.490

FI: Feed Intake; WWG: Weekly weight Gain; FCR: Feed Conversion Ratio; TWG: Total Weight Gain; FBW: Final Body Weight; P: Probability.

Table 3: Effect of ginger powder on carcass characteristics and relative weight of organs of rabbits.

Parameters	Treatments					P
	T0-	T0+	T1	T2	T3	
Cco (%)	47.75±2.06 ^a	47.40±0.42 ^a	47.33±0.05 ^a	46.70±1.41 ^a	48.60±1.78 ^a	0.43
Clco (%)	74.70±0.57 ^a	73.18±1.02 ^a	72.75±0.66 ^a	81.33±12.28 ^a	73.93±2.05 ^a	0.21
Head (%)	11.20±0.90 ^a	10.13±0.82 ^{ab}	10.50±0.16 ^{ab}	10.50±0.41 ^{ab}	10.05±0.77 ^b	0.18
Limbs (%)	3.45±0.25 ^a	3.23±0.37 ^a	2.60±0.00 ^b	3.58±0.20 ^a	3.38±0.30 ^a	0.001
Liver (%)	2.70±0.22 ^b	2.50±0.08 ^b	3.10±0.00 ^a	3.58±0.12 ^b	3.58±0.17 ^b	0.00
Heart (%)	0.33±0.05 ^a	0.30±0.08 ^a	0.30±0.00 ^a	0.33±0.05 ^a	0.30±0.08 ^a	0.93
Abdo Fat(g)	0.18±0.24 ^b	0.45±0.25 ^a	0.00±0.00 ^b	0.10±0.08 ^b	0.13±0.10 ^b	0.02
Kidney (%)	0.83±0.05 ^a	0.73±0.13 ^{ab}	0.73±0.05 ^{ab}	0.68±0.05 ^b	0.65±0.60 ^b	0.04
Lungs (%)	0.78±0.21 ^a	0.600±0.00 ^a	0.68±0.13 ^a	0.68±0.17 ^a	0.70±0.24 ^a	0.71

ab Means within a row with different superscript differ significantly ($P < 0.05$); **Cco**: Commercial carcass output /European carcass; **Clco**: Classical carcass output / African and South American carcass; **Abdo Fat**: Abdominal fat.

Table 4: Effect of ginger powder on hematological parameters in rabbit.

Parameters	Treatments					P
	T0-	T0+	T1	T2	T3	
WBCs($10^3/\mu\text{l}$)	3.60±0.29 ^b	4.00±1.26 ^b	5.72±1.33 ^{ab}	5.23±1.26 ^{ab}	6.47±1.62 ^a	0.04
RBCs($10^6/\mu\text{l}$)	5.67±0.50 ^a	6.11±0.65 ^a	5.67±0.29 ^a	5.56±0.42 ^a	5.60±0.26 ^a	0.47
Hgb(g/dl)	11.00±1.10 ^{ab}	12.07±0.69 ^a	10.71±0.84 ^b	11.30±0.79 ^{ab}	11.00±0.22 ^{ab}	0.19
PLT($10^3/\mu\text{l}$)	173.33±63.36 ^a	184.33±25.85 ^a	169.00±84.17 ^a	187.33±107.36 ^a	232.67±33.64 ^a	0.72
Lymph($10^3/\mu\text{l}$)	63.80±6.16 ^{ab}	56.43±3.11 ^{ab}	71.03±9.60 ^a	59.33±15.31 ^{ab}	50.77±6.00 ^b	0.06
MO($10^3/\mu\text{l}$)	11.30±2.02 ^b	9.97±2.49 ^b	11.80±2.86 ^b	16.10±0.500 ^a	9.57±2.35 ^b	0.01
GR($10^6/\mu\text{l}$)	24.90±7.12 ^{ab}	33.6±2.29 ^a	17.17±9.79 ^b	24.57±15.61 ^{ab}	39.67±6.82 ^a	0.03
HCT/PCV (%)	33.40±2.73 ^b	37.50±50 ^a	33.43±1.16 ^b	34.57±2.36 ^{ab}	34.03±0.90 ^{ab}	0.10

ab: Means within a row with different superscript differ significantly ($P < 0.05$) **WBCs**: White blood cells; **RBCs**: Red blood cells; **Hgb**: Hemoglobin; **PLT**: Platelet; **Lymph**: Lymphocytes; **MO**: Monocytes; **GR**: Granulocytes; **HCT/PCV**: Hematocrit or pack cells volume.

EFFECT ON CARCASS CHARACTERISTICS AND RELATIVE WEIGHT OF ORGANS

Table 3 presented below demonstrates the impact of ginger powder on the carcass traits and the relative organ weights of rabbits. The addition of ginger powder to the rabbit diet did not significantly affect any of the carcass parameters ($p > 0.05$), with the exception of the limbs, liver, and kidneys. Additionally, rabbits that were given the positive control diet (T0+) exhibited heavier abdominal fat ($P < 0.05$) as compared to the other groups. Further, rabbits that were fed the T3 diet exhibited the highest commercial carcass yield (Cco) among groups while rabbit fed with T2 diet recorded the heaviest classical carcass output (Clco). Finally, rabbits on the control diet (T0-) showed the highest weights for the lungs, head, and heart.

EFFECT OF GINGER POWDER ON METABOLIC PROFILE

EFFECT ON HEMATOLOGICAL PARAMETERS: Table 4 illustrates the impact of ginger powder on blood traits of rabbits. With the exception of white blood cells (WBCs),

monocytes, and granulocytes, the inclusion of ginger powder in the rabbit diet did not result in significant differences ($p > 0.05$) across the other hematological indices. However, rabbits on the positive control diet (T0+) exhibited the highest counts of red blood cells (RBCs), hematocrit (HCT), and hemoglobin (Hgb) compared to the other groups. Additionally, rabbits fed the T3 diet demonstrated the highest platelet (PLT) count. Lastly, those on the T1 diet showed a greater number of lymphocytes relative to the other dietary groups.

EFFECT ON BIOCHEMICAL PARAMETERS: Table 5 illustrates the effects of ginger powder on the biochemical parameters of rabbits. Significant differences ($P < 0.05$) were observed in the rabbits that were fed a ginger-supplemented diet, with the exception of albumin (Alb) and globulin (Glob) levels. Notably, rabbits in the T3 group, which received the highest level of ginger supplementation, exhibited the highest concentrations of Alb and Glob, comparable to those in the other dietary groups.

Table 5: Effect of ginger powder on biochemical parameters in rabbit.

Parameters	Treatments					P
	T0-	T0+	T1	T2	T3	
TP (mg/dl)	0.69±0.03 ^b	0.72±0.08 ^{ab}	0.70±0.07 ^b	0.74±0.07 ^{ab}	0.76±0.06 ^a	0.02
Alb(mg/dl)	0.69±0.03 ^a	0.72±0.09 ^a	0.70±0.08 ^a	0.74±0.07 ^a	0.76±0.07 ^a	0.46
Glob(mg/dl)	0.24±0.05 ^a	0.22±0.10 ^a	0.29±0.12 ^a	0.23±0.08 ^a	0.31±0.08 ^a	0.39
Chol(mg/dl)	0.24±0.03 ^a	0.19±0.05 ^b	0.16±0.03 ^c	0.25±0.05 ^a	0.19±0.04 ^b	0.00
Urea	0.00±0.00 ^b	0.00±0.00 ^a	0.00±0.00 ^b	0.17±0.39 ^b	0.00±0.00 ^b	0.01
Creat(mg/dl)	0.00±0.00 ^c	1.00±0.00 ^a	0.11±0.32 ^{bc}	0.33±0.49 ^b	0.33±0.49 ^b	0.00
ALAT(IU/L)	1.00±0.00 ^c	2.00±0.00 ^a	1.00±0.00 ^c	1.06±0.24 ^c	1.33±0.49 ^b	0.00
ASAT(IU/L)	1.56±0.51 ^b	2.00±0.00 ^a	1.61±0.50 ^b	1.44±0.51 ^b	1.61±0.50 ^b	0.01

abc: Means within a row with different superscript differ significantly ($P < 0.05$); **TP:** Total Proteins; **Alb:** Albumin; **Glob:** Globulin; **Chol:** Cholesterol; **Creat:** Creatinine; **ALAT:** Alanine aminotransferase; **ASAT:** Aspartate aminotransferase.

THE INFLUENCE OF VARYING LEVELS OF GINGER POWDER ON THE GROWTH PERFORMANCE OF RABBITS

This study revealed that the inclusion of ginger powder in the diets of rabbits did not significantly influence their feed intake. These results are consistent with earlier research conducted by [Doley et al. \(2009\)](#), [Kalyani \(2020\)](#), [Emmanuel et al. \(2020\)](#), all of which reported no notable differences in feed intake among broilers and rabbits consuming diets supplemented with ginger extract. However, these findings contrast with those of [Ademola et al. \(2009\)](#), who reported an increase in feed intake among broilers on a ginger-supplemented diet. This discrepancy can be attributed to the species and the level of ginger incorporation in the aforementioned study. It is well documented that, rabbits possess a complex hindgut fermentation system that allows them to efficiently digest fibrous materials, while broilers have a more straightforward digestive tract optimized for rapid growth on high-energy diets. This anatomical variation can lead to different responses to dietary supplements like ginger powder ([Doley et al., 2009](#); [Kalyani, 2020](#)). Additionally, broilers are selected for rapid growth and higher metabolic rates compared to rabbits, which may result in different feed intake patterns when supplemented with ginger ([Ademola et al., 2009](#)). Moreover, as hindgut fermenters, rabbits have unique digestive systems that may not respond as favorably to high doses of ginger compared to broilers. The fermentation process in rabbits could be less influenced by ginger's active compounds at certain dosages, resulting in no significant change in feed intake.

In the same veins, this study revealed that the inclusion levels of ginger powder did not significantly impact body weight gain. This result was comparable with that of [Kalyani \(2020\)](#), who observed no difference in bodyweight gain of broilers fed with ginger powder. This finding opposes that of [Windisch et al. \(2011\)](#), who reported that dietary herb powder supplementation improved weight gain in animals.

The discrepancies in these results can be attributed to several factors, particularly the specific type of phytobiotic used, the species studied, and crucially, the dosage of ginger incorporated into the diets. Some studies suggest that the appetite-suppressing effect may not be realized in low dose as those use in this work, leading to no significant change in body weight gain ([Zhao et al., 2020](#); [Sayed et al., 2020](#)). In other hand, different herbs contain varying concentrations of active compounds that can interact differently with animal physiology. For example, while ginger has been shown to possess anti-inflammatory and antioxidant properties that can aid in weight management ([Zhao et al., 2020](#)), other herbs might have different mechanisms of action that could lead to improved weight gain.

The results of this study indicate that there were no statistically significant differences ($P > 0.05$) in the weekly feed conversion ratio among the various treatments. This finding is consistent with the observations of [Wafaa et al. \(2012\)](#), who reported no difference in feed conversion ratios between birds fed diets containing 0% and 1% ginger root powder. However, these findings are in contrast with those of [Tollba \(2003\)](#), [Onimisi et al. \(2005\)](#), [Herawati \(2006\)](#), [Moorthy et al. \(2009\)](#) and [Herawati \(2010\)](#), who demonstrated that birds fed diets with up to 2% ginger exhibited superior feed conversion ratios compared to those on unsupplemented diets. The absence of notable discrepancies in feed conversion ratios can be attributed to a number of factors, including the distinctive chemical composition of ginger, particularly its active compounds, gingerol and shogaol. These compounds are renowned for their potential health benefits, yet they may not have effectively enhanced the flavour, palatability, or overall taste of the feed in this study. Consequently, they may not have stimulated appetite sufficiently to improve feed consumption among the rabbits. Moreover, the absence of a notable impact on feed conversion ratio and weight gain may suggest that gingerol and shogaol did not effectively promote

the growth of beneficial gut microflora, which is crucial for enhancing digestion and nutrient absorption. A healthy gut microbiome plays a significant role in maintaining optimal digestive function and immune health by protecting against pathogenic microorganisms (Piva and Rossi, 1998; Wenk *et al.*, 2003). However, it is important to note that the assertion regarding gingerol and shogaol's role in the lack of improvement in feed conversion ratios and growth necessitates further supporting evidence, ideally from microbiome studies or histological analyses of gut health which were not performed in this study. Such investigations could provide a clearer understanding of how ginger supplementation influences gut microbiota composition and functionality, ultimately affecting feed efficiency and growth performance.

THE EFFECT GINGER POWDER ON THE CARCASS TRAITS AND ORGANS WEIGHT

In this study, the weights of internal organs, specifically the liver and kidneys, were used as an index to ascertain the extent of toxicity induced by the presence of anti-nutritional factors in the feed. Bone (1979) reported that the presence of toxic elements in the feed would result in observable abnormalities in the weights of the liver and kidneys. The incorporation of ginger powder into the rabbit diet was observed to have no significant effect on the percentage of commercial carcass, classical carcass weight, lungs, heart and head. These findings align with those of El-Deck *et al.* (2002) and Moorthy *et al.* (2009), who observed no significant impact on carcass characteristics of broilers fed with varying levels of ginger powder and ginger extract. The findings of Zomrawi *et al.* (2012) also indicated no statistically significant differences ($p > 0.05$) in dressing percentage among birds fed with different levels of ginger. Conversely, Zeweil *et al.* (2016) demonstrated that the inclusion of ginger powder combined with propolis in the diet of Japanese quail resulted in a notable increase in carcass yield.

The administration of antibiotics (positive control) resulted in the highest abdominal fat percentage, while the incorporation of ginger powder in rabbit diets was found to reduce ($p < 0.05$) reduce the relative weight of the liver and limbs, while also reducing abdominal fat. This finding aligns with the observations made by Safa *et al.* (2014), who reported a significant effect ($P < 0.05$) of ginger powder supplementation in broiler diets on both abdominal fat and liver percentages when compared to control groups. The observed reduction in abdominal fat among diets enriched with ginger powder may be attributed to the lipid-lowering properties of ginger, as noted by Sharma *et al.* (1996). Similarly, numerous studies have shown that incorporating ginger and its essential oils into broiler diets as growth promoters leads to a significant decrease in abdominal fat (Rafiee *et al.*, 2013; Valiollahi *et al.*, 2014). Furthermore,

Ademola *et al.* (2009) suggested that ginger could serve as an antilipidemic agent in broiler diets aimed at reducing abdominal fat. In rabbit, Ibrahim *et al.* (2011) demonstrated that rabbits fed diets supplemented with ginger exhibited lower abdominal fat percentages compared to control groups. Similarly, Mancini *et al.* (2018) found that ginger supplementation improved carcass quality in rabbits, suggesting its potential as a dietary additive for enhancing meat production parameters. The active compounds in ginger, particularly gingerol and shogaol, are known for their antioxidant properties and potential to modulate lipid metabolism, which could explain the observed decrease in fat deposition.

EFFECT OF GINGER POWDER ON METABOLIC PROFILES

HEMATOLOGICAL PARAMETERS: It is evident that the intricate interactions between white blood cells play a pivotal role in the development and stimulation of an effective immune response (Al-Kassie *et al.*, 2009). Incorporating 0.6% ginger into the diet of rabbits has been shown to significantly enhance the production of white blood cells and granulocytes. Furthermore, a notable elevation in monocyte count was observed at the 0.4% inclusion level. The differing effects of ginger powder at various doses (0.4% and 0.6%) on specific immune parameters, such as white blood cells and monocytes, can be attributed to the dose-dependent nature of ginger's bioactive compounds, primarily gingerols and shogaols. At the lower inclusion level of 0.4%, there was a significant increase in monocyte counts, which are crucial for immune response and inflammation regulation. This suggests that this dose may optimally stimulate monocyte production without overwhelming the immune system.

Conversely, the higher dose of 0.6% resulted in a significant increase in overall white blood cell counts and granulocytes, indicating a broader activation of the immune response. This could be due to the higher concentration of bioactive compounds present at this level, which may enhance the proliferation of various immune cells, including granulocytes that play a vital role in combating infections. Research has shown that ginger can influence the behavior of neutrophils, a type of white blood cell involved in inflammation and immune responses (Ali *et al.*, 2023). Studies indicate that ginger's phytochemicals can modulate immune cell function by targeting multiple signaling pathways, which may explain the varying effects observed at different doses.

These findings are consistent with those reported by Nasiroleslami and Torki (2010), who observed a significant elevation in the total white blood cell count of broiler chickens upon the administration of ginger in their diet.

This suggests an augmented immune response at the cellular level, potentially involving both innate and specific immune system mechanisms. The current study found no significant impact of ginger consumption on white blood cell differential count. This finding contrasts with the results reported by [Ademola *et al.* \(2009\)](#), who found that administering ginger at a concentration of 1.0% to chickens led to a significant reduction in the total white blood cell count. Furthermore, parameters such as hematocrit/packed cell volume (HCT/PCV), red blood cells, platelets, lymphocytes, and hemoglobin levels remained unchanged across different inclusion levels of ginger powder. This difference can be explained by the species and incorporation level of ginger in this different report. The physiological state of the rabbits, including their baseline immune status and health conditions, may also play a role in how they respond to these doses.

The results indicate that ginger supplementation may enhance specific hematological parameters, particularly platelet (PLT) counts and lymphocyte levels. Notably, rabbits on the T3 diet, which contained the highest level of ginger supplementation, recorded the greatest PLT counts, suggesting that ginger may enhance platelet production or function. Additionally, rabbits fed the T1 diet showed an increased number of lymphocytes compared to other groups, indicating a potential immunomodulatory effect of ginger at lower supplementation levels. These findings align with existing literature that highlights ginger's anti-inflammatory and antioxidant properties, which can bolster immune responses and promote better health outcomes in both animals and humans ([Amber *et al.*, 2021](#); [Lufong *et al.*, 2024](#)).

The inclusion of ginger in the rabbits' diet did not result in anemia, as indicated by the absence of significant changes in red blood cell (RBC) counts and hemoglobin concentration. Notably, while hemoglobin levels were higher in the T0+ (positive control) group, they were statistically comparable to those in the T2, T3, and T0 (negative control) groups. The higher RBC, HCT, and Hgb levels observed in the positive control group may reflect improved oxygen-carrying capacity and overall vitality attributed to antibiotic inclusion. However, reliance on antibiotics for growth promotion raises ethical concerns regarding animal welfare and food safety ([Yang *et al.*, 2023](#)). As consumers become more aware of these issues, there is a growing demand for natural alternatives like ginger that can promote health without the associated risks of antibiotic use. This outcome corroborates the findings of [Hanan *et al.* \(2022\)](#), who investigated the impact of ginger powder on various physiological and biochemical parameters in broiler chickens, including productivity, antioxidant capacity, haematological profiles, digestive efficiency, and plasma cholesterol levels. This result is also in contradiction with that of [Ngou-](#)

[la, \(2014\)](#) who reported significant increase in hemoglobin in guinea pigs when using guava leaves extract. The consistent hemoglobin levels observed in all the experimental rabbits likely indicate that the supplementation with ginger rhizome powder has stimulated hemoglobin production. Furthermore, the normal red blood cell counts provide additional evidence of the absence of hemolytic anemia and a lack of suppression in erythropoiesis. Also 0.2 % inclusion level had the highest lymphocytes count, but they generally remain below scores making it significantly inferior. These findings contrast with those reported by [Xianglu *et al.* \(2009\)](#), who observed a decline in white blood cell counts in rats treated with ginger powder. An elevated white blood cell count is typically linked to microbial infections or the presence of foreign bodies or antigens in the body ([Ogbuewu *et al.*, 2010](#)). Additionally, the consistent hematocrit (HCT) and packed cell volume (PCV) levels across all treatment groups do not align with the results of [Rong *et al.* \(2009\)](#), who noted an increase in PCV counts following ginger supplementation in Wistar rats. These results are also inconsistent with the findings of [Ogbuewu *et al.* \(2010\)](#), who reported an increase in packed cell volume (PCV) in rabbits supplemented with ginger compared to the control group. Furthermore, this outcome is inconsistent with the study by [Onu and Aja \(2011\)](#), which observed elevated PCV levels in rabbits receiving garlic, ginger, and a mixture of both. The low monocyte count suggests that ginger does not promote its production. Additionally, the values reported for rabbits in temperate regions may not be applicable for assessing the health and nutritional status of rabbits in tropical environments ([Amata, 2010](#)). The observed variations in hematological parameters underscore the importance of dietary composition in influencing rabbit health. This study emphasizes ginger's positive role as a natural dietary supplement that enhances rabbit health and performance through its immunomodulatory and hepatoprotective effects. In contrast, the use of antibiotics poses significant risks related to resistance and gut health disruption. These findings support the need for further research into natural alternatives like ginger to improve animal production systems sustainably while mitigating the adverse effects associated with antibiotic use.

BIOCHEMICAL PARAMETERS: The finding of the current study had shown that 0.6 % ginger powder inclusion has a significant effect on total protein. There was no significant effect on albumin and globulin in all the treatments. The inclusion level at 0.4% had a significant effect on cholesterol and urea while the positive control experiment (T0+, at 0.1% antibiotics) significantly affected the amount of creatinine, ALAT and ASAT. However, creatinine, ALAT and ASAT was not significantly affected by ginger powder inclusion but showed increasing trend with increased level of ginger inclusion. This result is in agreement with ([Onu and Aja, 2011](#)) who found that

garlic, ginger supplementation slightly increase total protein concentration and urea in rabbit but observed no significant differences in fowl. This finding is inconsistent with the study by Barazesh *et al.* (2013), who reported no significant differences in blood LDL and total cholesterol levels in chickens fed a ginger powder diet. Furthermore, in contrast to the previous findings by Saeid *et al.* (2010) that ginger reduced blood cholesterol and LDL levels in broilers, Ogbuewu *et al.* (2020) found a linear increase in serum cholesterol levels in rabbits fed ginger powder. The observed discrepancies may be partly due to differences in species, supplementation level and feeding duration (Ogbuewu *et al.*, 2020). Increased level of ASAT, ALAT and creatinine with antibiotics (T0+ positive control) in the blood serum is an indication of toxicity at the level of the liver, while the inclusion of ginger powder showed no significant effect, hence less toxic to the level. This suggests that ginger may have beneficial effects on liver function and metabolic profiles, potentially aiding in detoxification processes and improving nutrient absorption. Ginger's bioactive compounds, such as gingerol, are known to support liver health by reducing oxidative stress and inflammation (Ali *et al.*, 2024). Beyond these specific findings, ginger has been widely recognized for its numerous health benefits, including its ability to reduce nausea, alleviate pain, and improve digestive health. Its antimicrobial properties can also help combat infections, making it a valuable addition to animal diets for promoting overall well-being (Foshati *et al.*, 2023). This finding aligns with the research conducted by Dias *et al.* (2006), which indicated that serum creatinine levels remained unchanged following ginger treatment, suggesting that the inclusion of ginger does not adversely affect renal function. Conversely, our results contrast with those of Mallikarjuna *et al.* (2008), who reported that administering an ethanolic extract of ginger at a dosage of 200 mg/kg from day 15 to day 21, in conjunction with country-made liquor (CML), significantly reduced levels of aspartate aminotransferase (ASAT) and alanine aminotransferase (ALAT). While our study observed a decrease in proteinuria, it is noteworthy that an increase in proteinuria was documented by Al-Attar *et al.* (2022) potentially due to the different forms of ginger used; this study employed ginger oil, whereas others utilized powdered or extracted forms of ginger. Furthermore, ginger has been shown to mitigate glomerular and tubular degeneration, reduce thickening of the glomerular basement membrane, and restore the integrity of kidney tissue membranes (Fathi *et al.*, 2021; Veisi *et al.*, 2022).

CONCLUSIONS AND RECOMMENDATIONS

At the conclusion of this study, which aimed to explore the effects of different concentrations of ginger powder. The findings indicated that ginger powder did not significantly

affect overall growth performance and most carcass parameters, except for limb, liver, and kidney weights. Additionally, ginger inclusion did not markedly influence metabolic profiles, with notable exceptions in albumin (Alb), globulin (Glob), white blood cells (WBCs), monocytes, and granulocytes. While ginger powder shows promise for enhancing rabbit health without compromising growth performance, the study's limitations, such as a short experimental duration, may restrict the generalizability of the results. The lack of microbiological analysis also limits our understanding of ginger's impact on gut health. Future research should focus on larger-scale studies with extended durations and microbiological assessments to better understand ginger's effects on rabbit health and productivity. In conclusion, while ginger appears to be a beneficial dietary supplement in rabbit production systems, further investigation is needed to optimize its use and clarify its effects.

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NOVELTY STATEMENTS

The withdrawal of antibiotics as feed additives has highlighted the necessity for the development of alternative growth promoters that ensure the health and economic viability of animals in farming. This study investigates the potential of ginger powder as a dietary supplement for rabbits, demonstrating favourable outcomes in terms of health enhancement without any adverse effects on growth performance. Despite the absence of notable differences in overall growth metrics in comparison to traditional antibiotics, ginger powder exhibited beneficial effects on immune parameters, indicating its potential as a viable substitute in animal nutrition. However, it is essential to exercise caution as further research is necessary to fully ascertain its efficacy and to establish comprehensive guidelines for its application in livestock diets.

AUTHOR'S CONTRIBUTIONS

Mube Kuintche Hervé, Kana Sagne Derrick, and Saknteh W. B. were instrumental in the initial drafting, validation, formal analysis, data curation, and conceptualisation of the original document. Azoutane Julien, Vemo Bertin, Djoumessi Gina, and Tatsinkou Alain Serge were instrumental in the review and editing processes, as well as the conceptualisation of the study. Francois Djitie contributed to the writing of the review and editing, methodology, formal

analysis, and data curation. Defang F. Henry provided supervision, data curation, and a writing review.

CONFLICT OF INTEREST

The authors confirm that they have no known financial conflicts of interest or personal relationships that could be perceived as influencing the work presented in this paper.

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