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Gastrointestinal tract morphometry and visceral organ weights of grower rabbit fed dried ginger (*Zingiber officinale*) root meal

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Abstract

Twenty-six grower rabbits of mixed sexes (12 males: 12 females) were used in the study to determine the effect of dietary dried ginger root meal (DGRM) on gastrointestinal tract morphometry and visceral organ weights. The rabbits were assigned by weight (average weight 557.09g) to four dietary treatments in a completely randomized design. Each treatment had six replicates. Four treatment diets; T_1, T_2, T_3 and T_4 were formulated to include 0%, 15%, 25% and 35% of DGRM respectively. Diets were offered ad-libitum to the rabbits. The experiment lasted for 8 weeks. Six rabbits were randomly selected from each treatment and sacrificed and eviscerated. Results showed that mean relative weights of the stomach, oesophagus and pancreas as well as the mean lengths of the oesophagus and intestines did not show any significant ($p>0.05$) variation. But significant ($p<0.05$) differences existed in the mean lengths of the proximal colon and caecum as well as the mean relative weights of the liver, kidneys, heart and lungs in rabbits fed DGRM. It can be concluded from this study that the inclusion of DGRM in the diets of growing rabbits significantly ($p<0.05$) increased the linear measure of the proximal colon and caecum and the mean weights of the visceral organs measured.

Keywords: Rabbit, Ginger, Morphometry, GIT, Visceral

La Morphométrie du tractus gastro-intestinal et poids des organes viscéraux du lapin de croissance nourris avecla farine de racine de gingembre séché (*Zingiber officinale*)

Résumé

Vingt-quatre lapins de croissance de sexes mixtes (12 mâles : 12 femelles) ont été utilisés dans l'étude pour déterminer l'effet de la farine de racine de gingembre séchée (le 'DGRM') sur la morphométrie du tractus gastro-intestinal et le poids des organes viscéraux. Les lapins ont été attribués en poids (poids moyen 557,09 g) à quatre traitements diététiques selon une conception complètement aléatoire. Chaque traitement comportait six répétitions. Quatre régimes de traitement ; T1, T2, T3 et T4 ont été formulés pour inclure respectivement 0%, 15%, 25% et 35% de 'DGRM'. Des régimes ont été offerts à volonté aux lapins. L'expérience a duré 8 semaines. Six lapins ont été choisis au hasard dans chaque traitement et sacrifiés et éviscérés. Les résultats ont montré que les poids relatifs moyens de l'estomac, de l'œsophage et du pancréas ainsi que les longueurs moyennes de l'œsophage et des intestins ne présentaient aucune variation significative ($p> 0,05$). Mais des différences significatives ($p <0,05$) existaient dans les longueurs moyennes du côlon proximal et du caecum ainsi que dans les poids relatifs moyens du foie, des reins, du cœur et des poumons chez les lapins nourris avec du 'DGRM'. On peut conclure de cette étude que l'inclusion de 'DGRM' dans l'alimentation des lapins en croissance de manière significative ($p <0,05$) a augmenté la mesure linéaire du côlon proximal et du caecum et les poids moyens des organes viscéraux mesurés.

Mots clés : lapin, gingembre, morphométrie, le 'GIT', Viscéral

Introduction

Physiological response of animals to feedstuff and feed additive greatly affect their productivity. Feed expenses, according to Farooq *et al.* (2001) amounts to about 80% of the total cost of livestock production. Therefore, most efforts in the animal industry are tailored towards minimizing cost of production while meeting the surging animal protein demand. A research strategy for optimum productivity, in some quarters, is the use of antibiotics and synthetic feed additives (Falcão-e-Cunha *et al.,* 2007; Onu and Aja, 2011). But the use of these additives has been banned or restricted in animal feed in parts of the globe due to their residual and detrimental effect on the animals and the consumers (USDA, 2005). To this end, non-conventional alternatives which are apparently safe, cheap and can be easily sourced are being studied as a way of circumventing these challenges for the small-holder livestock producer. Muhammad *et al.* (2009) affirmed that natural additives (phytogenic feed additives) are being used in current researches to maximize the net return for the livestock producer and minimize expenditure on feed. Lewis *et al.* (2003) noted that certain medicinal plants are being investigated and inculcated in livestock feed. Apart from their medicinal values, they are readily available, at low cost implication and having varied functions of performance improvement, enhancing feed intake and conversion ratio. Of such phytogenic feed additive is ginger (*Zingiber officinale*) which possess antimicrobial, anti-inflammatory, antiparasitic and immunomodulatory properties (Muhammad *et al.*, 2009). It also enhances palatability and feed intake (Horton *et al.*, 1991). Onu and Aja (2011) advanced reasons for the usage of ginger in animal diets. These authors noted that ginger can increase feed palatability and thus feed intake and could serve as a growth promoter. In addition, ginger can facilitate feed utilization in monogastric animals such as rabbit. Ginger waste meal was shown to have hypocholesterolemic and hypolipidemic activity (Omage *et al.*, 2007). In addition, these authors reported that this waste meal could effectively replace maize without adverse effect on growth of rabbits. Adanlawo and Dairo (2007) also showed that ethanolic extract of ginger has no health challenging effect on tissue (brain, liver, stomach, small intestine, kidney and serum) of rabbits. The digestive system and visceral organs are the primary point of challenge when a toxicant is consumed by an animal. But the rabbit has a unique digestive physiology which facilitates the use of forages and agro-industrial by-products, thus making it a non-competitive species with man for cereals and legume grains (Pius *et al.*, 2019). The rabbit is also advanced to having the potential to be utilized in closing the gap of animal protein need of man (Gosh *et al.*, 2008). Hence the need for this study, more so that the aforementioned authors worked on extracts and waste and not whole dried roots. On this note, this study was design to investigate the effect of inclusion of dried ginger root meal in the diet of rabbits on gastrointestinal and visceral organs.

Materials and methods

This study was conducted at the Rabbitary unit of the Federal University of Agriculture Livestock Teaching and Research Farm, Makurdi, located on latitude 7˚ 48'33.6″N and longitude 8˚ 37'12.7″E (https://www.google.com/maps). Makurdi is situated in the Benue trough having an average; annual rainfall of about 1244.3mm, humidity value of 60% and temperature of 27.5˚C (NIMET, 2009). Apparently healthy, twenty-eight (28) growing rabbits with an average body weight of 557.09g were used for the study. They were purchased from the University farm and kept in individual cages in hutches made of wood, metal mesh and corrugated roofing sheets. The cages were one meter above the ground and 60 x 60 x 50 cm in dimension according to specifications. (Fielding, 1991). Prophylactic drugs (injectable ivermectin® against ecto- and endo-parasites) were administered in the cause of acclimatization; which lasted for one week. The eight-week experiment was set in a completely randomized design (CRD). The rabbits were randomized by weight into four treatments with six (6) replicates each. Sliced sun dried ginger roots was purchased from a local market and milled using the bore milling machine. The proximate analysis of dried ginger root was according to laid down procedure (USDA, 2005). The values of the composition are presented in Table 1. This was used to compound the diets. Treatment one (T_1 control) diet contained 0% dried ginger root meal (DGRM). The other treatments, T_2, T_3 and T_4, had diets with 15%, 25% and 35% of DGRM inclusion respectively. The diets were iso-caloric and iso-nitrogenous. The dietary composition is presented in Table 2. At the end of the feeding trial, the six (6) rabbits from each treatment were fasted for 12 hours and sacrificed according to the method recommended (Joseph *et al*., 1994). Liver, heart, lungs, kidneys, stomach were carefully harvested after evisceration and weighed using sensitive weighing scale. The weights were expressed as percent body weight. The length of the gastrointestinal tract organs, oesophagus, small intestine, caecum, colon was measured in centimetres (cm) using a flexible measuring tape. Data collected were subjected to analysis of variance (ANOVA), using SPSS® Version 21.0 and the means were separated using Least Significant Difference (LSD).

Table 1: Proximate composition of dried ginger root meal.

Nutrient	Percentage composition (%)
Crude Protein	4.38
Fat	5.33
Ash	11.72
Moisture	13.57
Crude fibre	5.99

Table 2: Ingredient composition and calculated analysis of experimental diets

	Dietary Treatments			
Ingredient (%)	T_1	T_2	T_3	T_4
Maize	39.70	24.86	15.90	7.80
Maize offal	14.40	14.95	13.00	10.00
SBM	19.70	21.30	22.60	24.00
Ginger	0.00	15.00	25.00	35.00
Rice bran	0.80	0.75	1.00	1.40
Rice offal	22.40	20.14	19.5	18.8
Bone ash	2.50	2.50	2.50	2.50
Salt	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis				
CP	15.05	15.01	15.00	15.01
CF	12.03	11.87	11.91	11.87
Fats	3.84	3.99	4.15	4.32
ME (Kcal/kg)	2501.58	2505.00	2500.91	2503.01
Calcium	0.97	1.27	1.48	1.68
Phosphorus	1.23	1.68	1.98	2.28

Key: T=Treatment, % = Percentage, CP= Crude protein, CF = Crude fibre,
Premix = 2.5 Kg of Mineral Vitamin Premix contain: Vit A: 10,000,000 i.u; Vit. D_3: 2000,000 i.u; Vit. E: 20,000 mg; Vit. K_3: 2,000 mg; B_1: 3000 mg; B_2: 5000 mg; Niacin: 45,000 mg; Calcium pantothenate, 10,000 mg; Vit. B_6: 4,000 mg; B_{12}: 20 mg; Choline chloride: 300,000 mg; Folic acid: 1,000 mg; Biotin: 50 mg; Manganese: 300,000 mg; Iron: 120,000 mg; Zinc: 80,000 mg; Copper: 8,500 mg; Iodine: 1,500 mg; Cobalt: 300 mg; Selenium: 120 mg; Antioxidants: 120,000 mg.

Result and discussion

The results of relative weight and length of the gastrointestinal tract of rabbits is presented in Table 3. It was observed that oesophagus, stomach and pancreas weights did not vary significantly ($p<0.05$) among treatment means. It could be inferred from this results that the dietary fibre was adequate and could sustain grower rabbits. Anugwa *et al*. (1998) had reported that stomach size is directly proportional the crude fibre content of the diet. It was also observed that oesophagus, small intestine and distal colon did not vary significantly ($p<0.05$) among their treatment means. Further corroborating the inference from the GIT mean weights in this study. However, it was observed that the mean lengths of the proximal colon and caecum varied significantly ($p<0.05$) among the treatment means. The rabbits on 35% dietary DGRM presented higher proximal colon length than the control, but it compared with T_2 and T_3. Similarly, the mean length of caecum of rabbits on 35% dietary DGRM was higher ($p<0.05$) than rabbits on the control diets and 15% dietary DGRM. The mean length of caecum obtained T_4 (35% DGRM) compared with the mean length observed in T_3 (25% DGRM). Increased lengths of the proximal colon and caecum may be attributed to the increased intake of feed causing distension in some segments of the intestine. Yu and Chiou (1997) reported that increase in feed intake will increase hindgut fermentation which may lead to the elongation and/or enlargement of the caecal weights and length. Harcourt-Brown, (2002) explained that hindgut enlargement could be due to ingestion of milled lignified material which may eventually lead to ceacal impaction.

Table 3: Relative weight (percentage of body weight) and length (cm) of gastrointestinal tract of grower rabbits fed dried ginger (*Zingiber officinale*) root meal (DGRM)

	Treatment (Mean ± SEM)			
Parameters	**T_1 (0%)**	**T_2 (15%)**	**T_3 (25%)**	**T_4 (35%)**
GIT Weight				
Oesophagus	0.12 ± 0.02	0.09 ± 0.01	0.09 ± 0.02	0.11 ± 0.01
Stomach	5.23 ± 0.28	5.31 ± 0.45	4.31 ± 0.42	4.92 ± 0.25
Pancreas	0.09 ± 0.04	0.06 ± 0.01	0.04 ± 0.01	0.04 ± 0.01
GIT Length				
Oesophagus	11.88 ± 0.95	11.38 ± 0.50	11.30 ± 0.30	11.36 ± 0.61
Small intestine	280.50 ± 11.59	272.08 ± 10.96	275.50 ± 14.90	279.83 ± 4.94
Proximal colon	29.42 ± 1.97^{b}	31.75 ± 1.28^{ab}	30.60 ± 1.33^{ab}	34.33 ± 0.88^{a}
Distal colon	75.28 ± 8.87	69.67 ± 1.23	73.40 ± 5.90	79.17 ± 3.72
Caecum	44.75 ± 1.29^{b}	45.55 ± 2.10^{b}	48.30 ± 1.22^{ab}	51.17 ± 1.66^{a}

Key: T = Treatment, GIT=Gastrointestinal tract, Means with superscripts (a, b,) are significantly different ($p<0.05$)

The results of relative visceral organ weights of the rabbits are presented in Table 4. All parameters measured varied significantly ($p<0.05$) among treatment means. Wang *et al*. (2009) had noted that increase in feed intake to meet the energy requirement of the animal could result in visceral organ mass. Emmanuel and Ochefu (2020) had reported a surge in feed intake of the rabbits on DGRM diets, especially in the seventh and eight week of the study. This could imply that as the rabbits grew older, organ weight increased, which would increase the amount of energy necessary for maintenance; this further increase intake and further enlargement of organs. Wang *et al*. (2009) had documented that the visceral organs' energy expenditure is a function of the metabolic rate and size of the organs. It was observed that mean liver weights of rabbits ranged from 2.42±0.03 – 2.77±0.11, which is lower than reported by Omage *et al*. (2007) and Olabanji *et al*. (2007). Variation of the finding of this study from the previous results may be due to differences in initial weights of the experimental animals. Rabbits on 25% and 35% DGRM presented similar mean liver weights which were significantly ($p<0.05$) heavier than those on 0% and 15%. The later were also similar ($p<0.05$). The increase in liver weights suggests hepatocytosis due to liver overload (Olabanji *et al*., 2007) from certain phytochemicals in the DGRM. Pius *et al*. (2019) stated that liver in the animal body functions as a detoxifier, protein synthesizer and the production of certain biochemical that enhances digestion. Increased hepatocytes activity could lead to cell division to facilitate liver function or cellular inflammation which might be deleterious. The mean weights of the left and right kidneys were observed to be significantly ($p<0.05$) influenced by dietary DGRM. Apart from the suggestion that increase metabolism could result in increased organ weight (Wang *et al*., 2009), ginger contain certain anti-nutrients such as Tannin, Phytin and oxalate which when toxic threshold is attained could exact an injurious overload on the kidney (Adanlawo and Dairo, 2007). The kidney is responsible for the excretion of dissolved toxic waste or elements from the body fluid (Scanlon and Sanders, 2007).

Table 4: Relative weights of some visceral organs of grower rabbits fed dried ginger (*Zingiber officinale*) root meal (DGRM)

	Treatment (Mean ± SEM)			
Parameters	**T_1 (0%)**	**T_2 (15%)**	**T_3 (25%)**	**T_4 (35%)**
Liver	2.42 ± 0.03^{b}	2.48 ± 0.06^{b}	2.77 ± 0.11^{a}	2.77 ± 0.12^{a}
Left kidney	0.27 ± 0.02^{b}	0.33 ± 0.01^{a}	0.33 ± 0.02^{a}	0.32 ± 0.01^{a}
Right kidney	0.26 ± 0.11^{b}	0.33 ± 0.02^{a}	0.32 ± 0.03^{a}	0.32 ± 0.02^{a}
Heart	0.18 ± 0.02^{b}	0.20 ± 0.01^{ab}	0.23 ± 0.02^{a}	0.25 ± 0.01^{a}
Lungs	0.39 ± 0.02^{b}	0.56 ± 0.07^{a}	0.53 ± 0.04^{ab}	0.46 ± 0.05^{ab}

Key: T = Treatment, GIT=Gastrointestinal tract, Means with superscripts (a, b,) are significantly different ($p<0.05$)

Mean heart weights in this study showed that rabbits on control diet presented lower weight which compared ($p<0.05$) with the observation in rabbits on 15% DGRM diet Wang *et al*. (2009) reported increased visceral organ weight with increased dry matter intake in rabbits. The finding of this study compared with the weights 0.20 – 0.24% reported (Pius *et al*., 2019). Omage *et al*. (2007) reported mean heart weight of rabbit between 0.05 – 1.01g, which varied significantly for different inclusion levels of ginger. The linear increment of heart weight in this study could be attributed to dry matter intake. Wang *et al*. (2009) reported that heart weight of lambs increased linearly with dry matter intake. In addition, heart growth is stimulated by dietary volume which had increased visceral blood flow. It is also noted that organ size is proportional to its work load. Mean lung weight of rabbits on 15% dietary DGRM inclusion was higher ($p<0.05$) than the control (0% DGRM). Both compared with the mean lung weight of rabbits on 25% and 35% DGRM dietary inclusion. Adeyemo *et al*. (2014) and Pius *et al*. (2019) also reported significant variation in lung weights of rabbits on concentrate and forage diet at different ratios. An explanation of the variation of lung weights in this study could be that there was an increase in oxygen extraction which resulted from the supply of nutrients from increased dry matter consumed. Fitzsimons *et al*. (2014) reported that increase in metabolism results to increase in organ weight. Han *et al*. (2002) also documented that portal –drained viscera blood is stimulated by bulk diet intake but nutrient supplied by this dietary bulk stimulate oxygen extraction by the portal-drained viscera. Increase in weights of visceral organs could have a debilitating effect on their functions (Greener, 2015).

Conclusion

It can be concluded from this study that dietary inclusion of ginger root meal in rabbit should be lower than 15% of the diet. A prolong usage of DGRM in rabbit diet as a substitute for conventional feed stuff is not encouraged.

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