Global Scientific JOURNALS

GSJ: Volume 8, Issue 7, July 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

THE EFFECTS OF GARLIC (ALLIUM SATIVUM) POWDER ON GROWTH PERFORMANCE OF RABBITS (ORYCTOLAGUSCUNICULUS)

Ignatius Musenge CHIMBAKA, and Kingsley WALUBITA

Author: Ignatius Musenge CHIMBAKA is currently a graduate of Animal Science Department, School of Agricultural Sciences, University of Zambia, P.O Box 32379, Lusaka, Zambia.
E-mail: ignatiusmusenge43@gmail.com

Co-Author: Kingsley WALUBITA is currently a Senior Lecturer and Researcherof Animal Science Department, School of Agricultural Sciences, University of Zambia, P.O Box 32379, Lusaka, Zambia.
E-mail: kingwalubita@yahoo.co.uk

KeyWords
Feed conversion ratio (FCR), Feed intake, Garlic, Immunomodulation, Rabbits, Weight gain.

ABSTRACT

Garlic (*Allium sativum)* as a natural growth promoter falls under the immunomodulatory category of growth promoters and its main mode of action happens to be the main target for many drugs and other synthetic growth promoters, it is preferred however since it is not associated with the accumulation of undesired drug residues which is the case with synthetic growth promoters. Therefore in place of the synthetic growth promoters garlic can be used as a natural growth promoter in animals, to verify that, garlic powder was added to the diets of rabbits at different inclusion rates; at 0%, 0.3%, 0.6%, and 0.9%. Diets with no garlic inclusion were the controls, meanwhile, each treatment had three replications. Throughout the experiment, rabbits were given as much feed and water as desired, allowing the daily recording of feed intake as well as weekly change in live weight and computations of feed conversion ratio. Weekly average values, live weight gain, feed intake as well as Feed conversion ratio were significantly different ($P<0.05$), confirming that the inclusion of garlic powder to rabbit feed improves the growth performance of rabbits. However, the optimal inclusion rate was not obtained suggesting that the growth performance of rabbits would be enhanced even more at higher inclusion rates, higher inclusion levels of garlic powder in rabbit feed can therefore be used in future to determine the optimal inclusion rate.

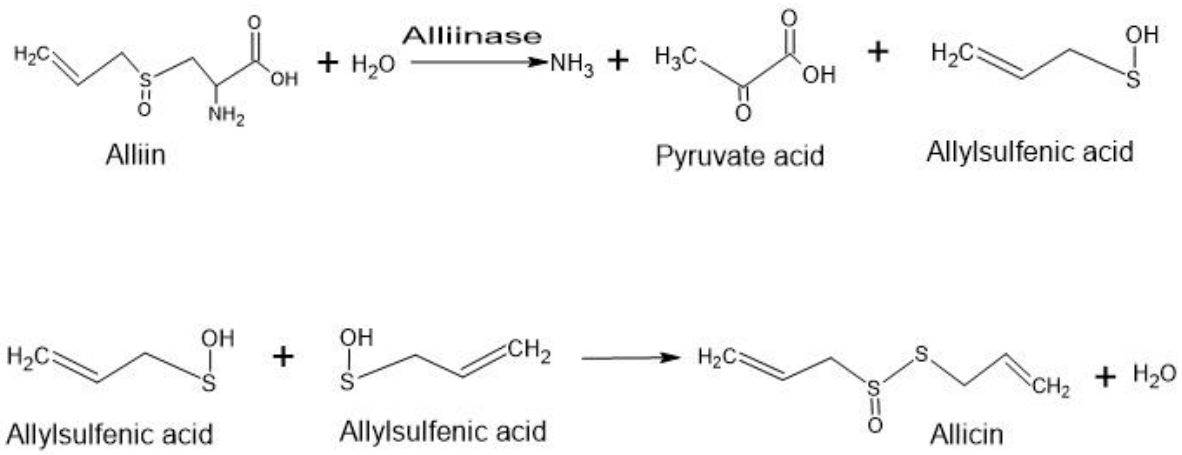
Introduction

Rabbits (*Oryctolaguscuniculus)* are small herbivores belonging to and sharing the family *Leporidae*with its close relatives; hares, also looks similar to Pikas of the *Ochotonidae* family [1], [2]. Appearance-wise; rabbits have big incisors, ears longer than width, small tails, and their front legs are smaller than hind legs creating an orientation suitable for their quick running and jumping abilities as their name "rabbit" implies. Rabbits are kept for an assortment of purposes including; their meat, their nitrogen-rich manure, their wool, fur, and pelts, and as a pet. These animals are very easy to keep and handle as much of their diet is mainly vegetarian which could be widely accessed, this makes them a cheap source of animal protein that the majority of the low-income households can afford to grow. Momoh, Unung, & Attah, 2015 reported that it is their advanced gastrointestinal physiological setup that enables rabbits to digest foodstuff that animals with simple stomachs are unable to, however, it is not just the physical orientation that brings about these capabilities of nutrient retrieval but the presence of a fermentation chamber no other than cecum [3] which houses mainly three types of flora, namely; fungi, bacteria, and protozoa that produce vitamins, amino acids and volatile fatty acids from the ingested feedstuff [4], [5].

For several years, synthetic chemicals have been used as growth promoters, antibiotics, and probiotics in Rabbit production. Of late, the use of these synthetic chemicals in feeding animals has been widely discouraged, and the use of naturally occurring growth promoters is gaining importance. This is because synthetic chemicals remain in the body tissues as drug residues which consequently are conveyed into the consumer's body system after that animal is consumed. Therefore, this process translates to continuous drug administration to consumers as they continue eating such meat and when consumers of such meat fall sick, they experience serious problems with responding to the administered medication due to development of resistance against the same active ingredients that may have been contained in both meat and medication administered resulting in slow or failure to heal which may consequently lead to death [6]–[8].

The majority of the vegetation from the family *Lilliaceae* under the genus Allium are famous for their pharmacological and biological features which are mostly because of the sulfur-containing organic compounds which they produce. Garlic (Allium sativum) popularly known as a herb and a spice for a few millenniums now, is one of the members of this family [9], regardless, its scientific importance has only been developed in the past few decades. [10]–[12] revealed that garlic as a spice contains many things, including but not limited to; amino acids, minerals, Vitamins, several enzymes fiber, and water. [9], [13]–[15] further revealed that as a herb, garlic's main active ingredients are allicin, saponins and organosulfur compounds which are majorly grouped either as water-soluble or oil-soluble organosulfur compounds, under the water-soluble are safer and more stable sulfides with no odor, oil-soluble sulfides on the other hand are less stable and odorous [14], [16], [17]. Among them all, Allicin (allyl 2-propene thiosulfinate) has been named the most effective curative and preventive active ingredients, as demonstrated in figure 1 below, cutting of garlic's clove activates the enzyme alliinase which then converts alliin to allicin, it is therefore only present in crushed garlic and its process of formation can be completed in as little as 0.2 to 0.5 seconds at room temperature [18]–[20].

Figure 1: *showing the generation of allicin from alliin.*



In most synthetic drugs and some foodstuff with pharmacological purposes, immunomodulation has been their design of work, however with recent civilization has come economic and scientific understandings that these substances are generally associated with high cost, toxicity, and long term adverse side effects which in the modern era render them less desirable. Herbaceous vegetation with a similar mode of action on the other hand has had ever-multiplying attention from both consumers and scientific researchers, garlic being one of them has become a very important candidate. The main goal of this research, therefore, is to assess the growth performance of growing rabbits supplemented with varying inclusion levels of garlic powder.

Research Methodology

Experimental Area Description

Research experiments were carried out at the University of Zambia Main Campus, School of Agricultural Sciences in Lusaka, Zambia. It is located at latitude is -15.4° and longitude 28.333°**.**

Experimental Design and Treatments

The study involved four Treatments which are 0.0 % (control), 0.3 %, 0.6 %, and 0.9% garlic inclusion rate, each of which had three replications making a total of 12 experimental areas. These garlic portions where mixed with commercial dairy meal 19 (mash feed) purchased from NamFeed in Lusaka, Zambia.

Rabbit Characterization

Rabbit samples were bought from kanakantapa village of chongwe district, 12 rabbits were randomly selected from 20 bunnies that came from 3 closely related does, the bunnies where born in roughly the same week, therefore, by the time of collection they were of the same age (5 weeks old). The randomly selected rabbits were weighed then only those which weighed about 800 grams (same weight) were bought. In addition to weight and age, sex was considered as well and only males were part of the sample population.

Garlic Characterization

Garlic powder was bought from the Soweto market, Lusaka Zambia, which had already beenprocessed and packaged into 1 kg packages at the cost of k70 per kg. Knowing that the inclusion rates to be used were low, only 1 kg of garlic was bought.

The Cages

Rabbits were kept in cages made of chicken mesh wire and wooden frames, each cage had three columns and three rows of separate units. Individual cage units measured about 120*50cm base and 40cm height, each unit had a tray under the base for collection of manure to prevent it from falling on the units below.

Management of Rabbits

A week before the rabbits arrived the house was cleaned and disinfected together with the cages and then 5 weeks old rabbits were put in the cages. The rabbits were subjected to 6 weeks of test ration feeding after a week of acclimatization. During the study period, no clinical signs of illness were observed amongst the rabbits

Experimental Design

With each group of treatments representing a different inclusion rate of garlic i.e. 0%, 0.3%, 0.6%, and 0.9%, 3 replications for each treatment were made accommodating only a rabbit per single replication implying that a total of 12 rabbits were used.

The general linear model used was the fixed effect model (model II Anova) as shown below; $Y_{ij} = u + \alpha_i + e_{ij}$

for which: i = inclusion levels of garlic; 1, 2, 3, 4

j = replicates; 1, 2, 3

$e \sim N(0, \sigma^2)$

Where; Y is the dependent variable being

U is the overall mean.

α_i is the fixed effect of the i^{th} level of garlic powder.

$e_{ij}$is the error associated with the j^{th} replicate of the i^{th} level of garlic.

Data Collection

At the beginning of the experiment initial individually weights of rabbits were obtained and then haphazardly allocated to respective replications within the various treatments, thereafter, the individual weights of the rabbits were taken at weekly intervals while feed intake values were taken every day.

The data obtained on respective dependent variable recordings were subjected to ANOVA using the F-test ($p< 0.05$) to test for any significant deviations of any of the average values from the other. Dependent variables that tested significantly different were further subjected to fisher's least significant difference for further investigations.

Results and Discussion

Feed intake of the rabbits

As demonstrated by Figure 2 below, 0.9% (TR 4) inclusion level of garlic had the highest feed intake from week one to the fifth week of the experiment. The daily feed intake per rabbit per day for the first two weeks ranged from 31g to 111g then it increased significantly with the increase in the inclusion level of garlic and time. Analysis of variance in Table 1 below further confirmed that the observed differences among averages of treatments values were scientifically significant. The increased feed intake may be attributed to the fructans of short-chain length called the fructooligosaccharides present in garlic, which consequently stimulates an increase in feed intake due to their mild sweet taste hence desirable enough to even replace sugars [16], [19], [21], [22]. Additionally, garlic also contains a compound called ally methyl sulfide which gives garlic a distinctive characteristic aroma which happens to be the rabbit's favourite [21] It is therefore evident that as the dietetic inclusion levels of garlic doubled, rabbits found the feed even more palatable thereby increasing the intake as well.

Figure 2:*weekly feed intake with respect to different inclusion levels of garlic.*

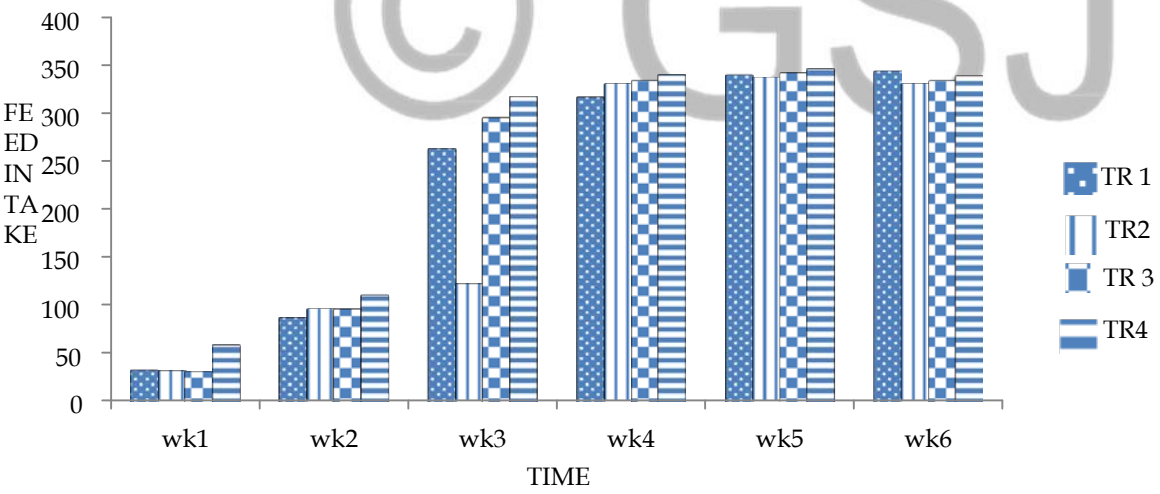


Table 1: *Showing ANOVA of levels of feed intake for the whole six weeks*.

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	3	1642	547	22.5	<0.0001
Error	9	219	24.4		
Corrected Total	12	1861			
P value < 0.05 means the levels of feed intake of rabbits are different.					

Live Weight gain of the Rabbits

Table 2 below show summarized findings as presented by analysis of variance, exhibiting total live weight gain significant differences among treatment groups ($P<0.05$). Figure 3 below further demonstrated that live weight gain increased with an increase in dietary inclusion level of garlic, results attributed to the effects of immunostimulatory activities of garlic [22]. According to [23]–[26], metabolic syndrome refers to a group or cluster of abnormalities such as glucose intolerance, abnormal obesity, insulin resistance, and hyperlipidemia. At least one or more of these abnormalities are very common in animals and their presence in an animal interferes with an animal's response to the available nutrients in the body thereby ultimately affecting the growth performance. Garlic on a contrary has the potential to cause hypolipidaemia which is the opposite of hyperlipidemia, it has the potential to reduce the lipoprotein content in blood plasma thereby increasing its availability for utilization by various body cells, therefore, dietary garlic prevents the occurrence of hyperlipidemia and increase the availability of nutrients for use in the body. Glucose intolerance additionally is a metabolic condition associated with the presence of higher levels of blood glucose than normal. Higher levels of blood glucose imply that only less is available for utilization by the body cells, this is where garlic comes in and rectifies the condition as reported by [27], dietary garlic intake prevents glucose intolerance thereby improving the nutrient utilization. [21]additionally reported that dietary intake of garlic powder prevents the occurrence of insulin resistance. Under normal conditions, when the levels of glucose in the blood start going up above normal which may be attributed to an increase in the carbohydrates intake or increase in the conversion rate of glycogen back to glucose, insulin hormone is released by the body to stimulate uptake of glucose by cells and its conversion back to glycogen. However, under insulin resistance conditions body cells fail to respond to released insulin, luckily continuous consumption of dietary garlic increases the serum insulin which prevents the occurrence of this condition and consequently improves the utilization of glucose in the body.

In a similar study, [28] stated that garlic improves nutrient digestibility, by various means such as; prevention of peptic and gastric ulcers, promoting the growth of beneficial digestive microorganisms which in ruminants and pseudo ruminants (rabbits) ferment the fibrous feed material thereby increasing the number of nutrients available for assimilation. [29]in a different study stated that Garlic as an immunostimulant maintains a stable equilibrium of the immune system, which ensures that the animal is healthy and a healthy animal maximizes its productions hence higher weight gain in rabbits which increased with the increase in the dietary level of garlic. Garlic has shown to contain antioxidant phytochemicals such as flavonoids that prevent oxidative damage of cell mem-

branes and DNA which may otherwise result in aging disorders such as cardiac vascular, inflammatory diseases, neurodegenerative and cancer [30], [31]. In addition to flavonoids, garlic contains other antioxidant phytochemicals such as diallysulfide (DAS) and S ally mecaptocystein (SAMC), all these anti-oxidative activities translate to a healthy animal and an increase in nutrient utilization as well as animal production (weight gain) [32].

Figure 3: *weekly live weight gain with respect to different inclusion levels of garlic.*

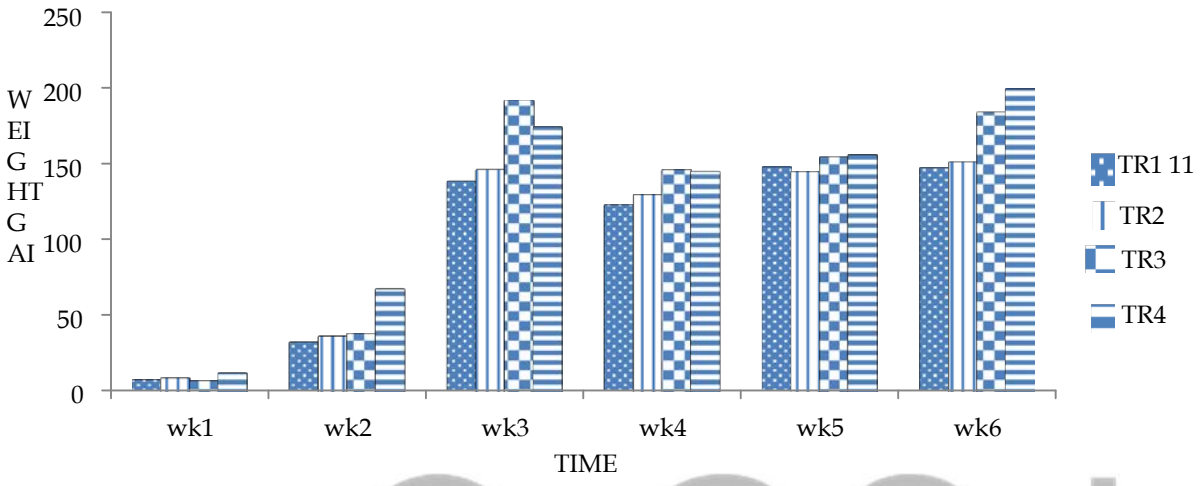


Table 2: *Showing ANOVA of levels of live weight gain for the whole six weeks.*

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	3	59704	19901	10.49	<0.0001
Error	9	17075	1897		
Corrected Total	12	76778			
P value < 0.05 means the levels of weight gain of rabbits are different					

Feed efficiency

The efficiency with which an animal can convert the amount of feed consumed into an output of interest is what is termed as feed conversion ratio (FCR). In this study, the results of this analysis were summarized in Figure 4, comparing FCR of rabbits fed on 0.9% to FCR of rabbits fed on the rest of the treatments in figure 4 showed that 0.9% had considerably least FCR of all the treatment

groups throughout the study period, the differences observed in figure 4 were further confirmed by analysis of variance in Table 3 to be significant. The findings agree with a study conducted by [33] in which 0.25% of Garlic and ginger were added to broiler finisher feed, their analysis too demonstrated a reduction in FCR values alongside an improvement in the growth rate of birds. Another study carried out by [34] totally settles with our findings in this research. Therefore, it is only rational that if garlic can prevent oxidative activities, maintain an animal's immunity at equilibrium, enhance nutrient utilization in the body, and ultimately improving animal production (growth rate) then the feed efficiency of an animal ought to be very effective as demonstrated in this study.

Figure 4: *weekly feed conversion ratio with respect to different inclusion levels of garlic.*

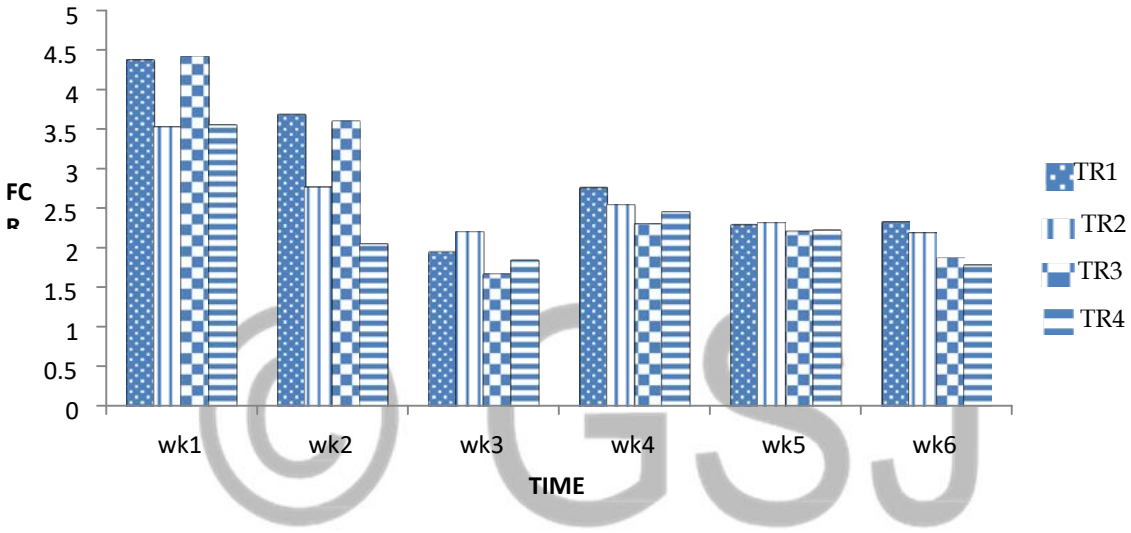


Table 3: *Showing ANOVA of levels of feed conversion ratio for the whole six weeks.*

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	3	32.3	10.8	8.01	<0.0001
Error	9	12.1	1.35		
Corrected Total	12	44.4			
P value < 0.05 means the levels of weight gain of rabbits are different					

Fisher's least significant difference analysis

Since ANOVA results for each of the dependent variables gave a significant result, it implies that under each dependent variable there is at least one group of treatments that significantly differs from the other, to find out more about which treatment group significantly differs from the other under each dependent variable, Fisher's least significant difference was employed. As shown in table 4, significant differences in feed intake averages were observed between 0% and 0.3%, 0.3% and the two 0.6% and 0.9% with

the highest values observed in 0.6% and 0.9%, meanwhile, between the two (0.6% and 0.9%) the difference isn't significant. According to the weight gain findings (Table 4), there were no significant differences between 0% and 0.3% just like between 0.6% and 0.9%, but, 0% and 0.3% were significantly different from 0.6% and 0.9%. The highest weight gain was observed in week 6 of the study, in rabbits that were fed on 0.9% garlic. Rabbits that were fed on 0.6% showed the second-highest weight gain in all the weeks following after those that were fed on 0.9%. Feed efficiency, on the other hand, was lowest and significantly different in rabbits fed on 0.9% inclusion level of garlic, and as shown in Table 4, there was a steady decrease in feed conversion ratio values from 0% inclusion to 0.9% inclusion levels. The continuous trend in an increment of feed efficiency observed, together with an observation of the highest feed intake and total weight gain in rabbits fed on 0.9% inclusion levels incites anticipations of even better growth performance if levels of garlic inclusions were to be more than 0.9%.

Table 4: *Average measurements of dependent variables on Rabbits fed diets with different with different inclusion rates of garlic (0%, 0.3%, 0.6% and 0.9%).*

Dependent variables	Experimental diets			
	0%	0.3%	0.6%	0.9%
Feed Intake	191±42.6 [b]	146±40.7 [c]	236±32.5 [a]	248±31.5 [a]
Weight gain	80.2±29.1 [b]	70.9±26.4 [b]	121±17.3 [a]	126±17.3 [a]
Feed conversion ratio	3.22±0.46 [a]	2.81±0.42 [ab]	2.68±0.27 [ab]	2.32±0.27 [b]
Levels not connected by the same letters (a, b and c) within the same row are significantly different				

Conclusion

Garlic as a spice adds a very attractive aroma and a mild sweet taste to the feed which encourages very high feed intake by the animals, additionally, as a herb, it's numerous phytochemicals carry out a number of physiological functions in the body of an animals, such as prevention of abnormalities under metabolic syndrome, inhibition of oxidation, cancer and inflammation, cardio protective and microbial protection which ultimately render animals healthy and consequently enhance their feed efficiency translating into boosted production. From the results obtained, it is therefore concluded that dietary inclusion of garlic powder improves the growth performance of rabbits. Growth performance improved linearly with the level of garlic powder inclusion. Regardless, the optimum growth performance was not obtained which therefore provokes a recommended that further research should be done in the same line like this one but by increasing the inclusion rate to more than 0.9% to determine the optimum inclusion rate that gives the highest possible weight gain and lowest possible feed conversion ratio. We further recommend that in further studies pelleted feed should be used as there was a challenge in this study with the feed form, Feed mash was found to be too dusty and often times used to choke the rabbits, hence less pleasant, therefore since garlic is needed in powder form but feed as a final product should be in pellets, feed mash can be made or bought having correct nutrient requirement then mix with garlic powder and later form pellets out of the mixture.

Acknowledgment

I firstly express my appreciation to Mr and MrsChimbaka (my parents) and my siblings for the encouragement and financial support rendered to me during the research, secondly, I acknowledge Animal Science Department for allowing me to carry out my research at UNZA field station, and lastly, John Manda, and Natasha Sakala are highly acknowledged for the physical help rendered during the research.

References

[1] O. M. Momoh, H. U. Unung, and S. Attah, “Growth Performance of Two Crossbred Rabbit Genotypes Fed Two Levels of Dietary Protein,” *East African Agric. For. J.*, 2015, doi: 10.1080/00128325.2015.1041256.

[2] M. Kamalakannan, K. Chandra, J. K. De, and C. Venkatraman, “The identification of pika and hare through tricho-taxonomy (Mammalia: Lagomorpha),” *J. Threat. Taxa*, 2019, doi: 10.11609/jot.4598.11.10.14301-14308.

[3] D. Místa, B. Króliczewska, M. Marounek, E. Pecka, W. Zawadzki, and J. Nicpoń, “In vitro study and comparison of caecal methanogenesis and fermentation pattern in the brown hare (Lepus europaeus) and domestic rabbit (Oryctolagus cuniculus),” *PLoS One*, 2015, doi: 10.1371/journal.pone.0117117.

[4] P. R. Cheeke, “Feedstuffs for Rabbits,” in *Rabbit Feeding and Nutrition*, 1987.

[5] A. Bourguet *et al.*, “Conjunctival bacterial and fungal flora and cutaneous fungal flora in healthy domestic rabbits (Oryctolagus cuniculus),” *J. Small Anim. Pract.*, 2019, doi: 10.1111/jsap.12989.

[6] M. Gonzalez Ronquillo and J. C. Angeles Hernandez, “Antibiotic and synthetic growth promoters in animal diets: Review of impact and analytical methods,” *Food Control*, 2017, doi: 10.1016/j.foodcont.2016.03.001.

[7] M. S. Rana, S. Y. Lee, H. J. Kang, and S. J. Hur, “Reducing veterinary drug residues in animal products: A review,” *Food Science of Animal Resources*. 2019, doi: 10.5851/kosfa.2019.e65.

[8] M. D. Mund, U. H. Khan, U. Tahir, B. E. Mustafa, and A. Fayyaz, “Antimicrobial drug residues in poultry products and implications on public health: A review,” *International Journal of Food Properties*. 2017, doi: 10.1080/10942912.2016.1212874.

[9] G. E. S. Batiha *et al.*, “Chemical constituents and pharmacological activities of garlic (Allium sativum L.): A review,” *Nutrients*. 2020, doi: 10.3390/nu12030872.

[10] S. A. Petropoulos, Â. Fernandes, G. Ntatsi, K. Petrotos, L. Barros, and I. C. F. R. Ferreira, “Nutritional value, chemical characterization and bulb morphology of Greek Garlic landraces,” *Molecules*, 2018, doi: 10.3390/molecules23020319.

[11] J. Botas, Â. Fernandes, L. Barros, M. J. Alves, A. M. Carvalho, and I. C. F. R. Ferreira, “A Comparative Study of Black and White Allium sativum L.: Nutritional composition and bioactive properties,” *Molecules*, 2019, doi: 10.3390/molecules24112194.

[12] M. L. P. Cunha, L. A. Aquino, R. F. Novais, J. M. Clemente, P. M. de Aquino, and T. F. Oliveira, “Diagnosis of the nutritional status of garlic crops,” *Rev. Bras. Cienc. do Solo*, 2016, doi: 10.1590/18069657rbcs20140771.

[13] S. H. Omar and N. A. Al-Wabel, “Organosulfur compounds and possible mechanism of garlic in cancer,” *Saudi Pharm. J.*, 2010, doi: 10.1016/j.jsps.2009.12.007.

[14] H. M. Yun *et al.*, “Potential therapeutic effects of functionally active compounds isolated from garlic,” *Pharmacology and Therapeutics*. 2014, doi: 10.1016/j.pharmthera.2013.12.005.

[15] A. Shang *et al.*, “Bioactive compounds and biological functions of garlic (allium sativum L.),” *Foods*. 2019, doi: 10.3390/foods8070246.

[16] I. Koca and B. Tasci, “Garlic as a functional food,” in *Acta Horticulturae*, 2016, doi: 10.17660/ActaHortic.2016.1143.20.

[17] “Radix glycyrrhizae,” *React. Wkly.*, 2019, doi: 10.1007/s40278-019-68407-x.

[18] F. Ferioli, E. Giambanelli, V. D’Alessandro, and L. F. D’Antuono, “Comparison of two extraction methods (high pressure extraction vs. maceration) for the total and relative amount of hydrophilic and lipophilic organosulfur compounds in garlic cloves and stems. An application to the Italian ecotype “Aglio Rosso di Sulmona,” *Food Chem.*, 2020, doi: 10.1016/j.foodchem.2019.126086.

[19] Y. P. Venkatesh, “Immunomodulatory Attributes of Aged Garlic Extract and Its Components,” in *Immunology: Immunotoxicology,*

Immunopathology, and Immunotherapy, 2018.

[20] L. D. Lawson and S. M. Hunsaker, “Allicin bioavailability and bioequivalence from garlic supplements and garlic foods,” *Nutrients*, 2018, doi: 10.3390/nu10070812.

[21] R. Arreola *et al.*, “Immunomodulation and anti-inflammatory effects of garlic compounds,” *Journal of Immunology Research*. 2015, doi: 10.1155/2015/401630.

[22] P. M. Chandrashekara and Y. P. Venkatesh, “Immunostimulatory properties of fructans derived from raw garlic (Allium sativum L.),” *Bioact. Carbohydrates Diet. Fibre*, 2016, doi: 10.1016/j.bcdf.2016.11.003.

[23] D. Al-Hamad and V. Raman, “Metabolic syndrome in children and adolescents,” *Translational Pediatrics*. 2017, doi: 10.21037/tp.2017.10.02.

[24] M. B. Lanktree and R. A. Hegele, “Metabolic Syndrome,” in *Genomic and Precision Medicine: Primary Care: Third Edition*, 2017.

[25] M. G. Saklayen, “The Global Epidemic of the Metabolic Syndrome,” *Current Hypertension Reports*. 2018, doi: 10.1007/s11906-018-0812-z.

[26] E. McCracken, M. Monaghan, and S. Sreenivasan, “Pathophysiology of the metabolic syndrome,” *Clin. Dermatol.*, 2018, doi: 10.1016/j.clindermatol.2017.09.004.

[27] K. Charu, S. Yogita, and S. Sonali, “Neutraceutical potential of organosulfur compounds in fresh garlic and garlic preparations,” *International Journal of Pharma and Bio Sciences*. 2014.

[28] K. Chen *et al.*, “Preventive effects and mechanisms of garlic on dyslipidemia and gut microbiome dysbiosis,” *Nutrients*, 2019, doi: 10.3390/nu11061225.

[29] G. Gebreyohannes and M. Gebreyohannes, “Medicinal values of garlic: A review,” *Int. J.*, 2013, doi: 10.5897/IJMMS2013.0960.

[30] F. Shahidi and A. Hossain, “Bioactives in spices, and spice oleoresins: Phytochemicals and their beneficial effects in food preservation and health promotion,” *J. Food Bioact.*, 2018, doi: 10.31665/jfb.2018.3149.

[31] C. Rodrigues and S. S. Percival, “Immunomodulatory effects of glutathione, garlic derivatives, and hydrogen sulfide,” *Nutrients*. 2019, doi: 10.3390/nu11020295.

[32] I. A. Schepetkin, L. N. Kirpotina, A. I. Khlebnikov, N. Balasubramanian, and M. T. Quinn, “Neutrophil immunomodulatory activity of natural organosulfur compounds,” *Molecules*, 2019, doi: 10.3390/molecules24091809.

[33] P. N. Onu and P. M. Aja, “Growth Performance and Haematological Indices of Weaned Rabbits Fed Garlic (Allium Sativum) and Ginger (Zingiber Officinale) Supplemented Diets,” vol. 1, no. 1, pp. 51–59, 2011.

[34] A. Xu, J. Shang-Guan, Z. Li, Z. Gao, Y. Huang, and Q. Chen, “Effects of garlic powder on feeding attraction activity, growth and digestive enzyme activities of Japanese seabass, Lateolabrax japonicus,” *Aquac. Nutr.*, 2020, doi: 10.1111/anu.13001.