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Harnessing Organic Phytogenic Feed Additives for Sustainable Rabbit Production: Effects of *Syzygium aromaticum* on Growth, Physiological and Biochemical Performance of Rabbit Bucks

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ABSTRACT

Organic livestock production plays a vital role in building resilient and sustainable food systems, particularly in developing countries where access to expensive synthetic inputs is limited. Rabbit farming represents a promising pathway for improving food security due to its high reproductive rate, efficient feed conversion, and the nutritional quality of rabbit meat. However, productivity in rabbit production systems remains constrained by poor reproductive performance, inadequate nutrition, and limited adoption of natural growth enhancers. This study evaluated the effects of *Syzygium aromaticum* (clove) as a phytogenic feed additive on the growth performance, morphometric traits, serum biochemistry, lipid profile, antioxidant status, and physiological parameters of 36 rabbit bucks. Four dietary treatments were formulated with graded levels of clove powder: T1 (control), T2 (5 g/kg), T3 (7.5 g/kg), and T4 (10 g/kg). Results showed significant improvements in growth performance, particularly in the T3 group, which recorded the highest final body weight (2093.88 g), weekly weight gain (71.46 g), and the lowest feed conversion ratio (1.34). Serum biochemical analysis indicated enhanced protein metabolism and improved liver function at moderate inclusion levels. Lipid profile results demonstrated decreased triglycerides, LDL, and VLDL levels, alongside increased HDL concentrations. Antioxidant markers revealed reduced malondialdehyde levels and increased activities of superoxide dismutase and catalase, indicating improved oxidative stability. Physiological parameters such as heart rate, respiratory rate, rectal temperature, and pulse rate remained largely stable across treatments. The findings indicate that moderate inclusion of *Syzygium aromaticum* (7.5 g/kg) optimizes growth performance, metabolic efficiency, and antioxidant capacity in rabbit bucks. The use of plant-based feed additives aligns with the principles of organic agriculture by reducing reliance on synthetic inputs while enhancing sustainable livestock productivity.

Keywords: *Organic agriculture, rabbit production, phytogenic additives, Syzygium aromaticum, sustainable livestock.*

INTRODUCTION

Sustainable agricultural production remains central to addressing the challenges of food insecurity, malnutrition, and environmental degradation across developing countries. Nigeria, like many African nations, faces increasing pressure to produce sufficient food for a rapidly growing population while maintaining ecological sustainability (Assan, 2023). Livestock production contributes significantly to household nutrition and economic development; however, conventional livestock production systems often rely heavily on synthetic inputs, antibiotics, and chemical growth promoters. These inputs may pose risks to human health, animal welfare, and environmental sustainability.

Small livestock species such as rabbits offer a promising alternative for sustainable animal production. Rabbits possess several advantageous characteristics, including rapid reproductive rates, short gestation periods, efficient feed conversion, and the ability to thrive under relatively low-input management systems. Rabbit meat is rich in high-quality protein, low in fat and cholesterol, and easily digestible, making it a valuable component of human diets. Despite these advantages, rabbit production in Nigeria remains largely underdeveloped and is often practiced on a small subsistence scale. Low productivity has been attributed to inadequate

nutrition, poor management practices, and limited adoption of improved feeding technologies. (Mailafia *et al.,* 2010; Iheukwumere *et al.,* 2018). Addressing these constraints is essential for unlocking the full potential of rabbit production in improving food security and rural livelihoods. One promising strategy for improving livestock productivity while maintaining environmental sustainability is the use of phytogenic feed additives derived from medicinal plants. Phytogenic additives contain bioactive compounds such as phenolics, flavonoids, and essential oils that exhibit antimicrobial, antioxidant, and growth-promoting properties. These natural additives are increasingly being explored as alternatives to synthetic antibiotics and growth enhancers. Syzygium aromaticum, commonly known as clove, is a medicinal plant widely recognized for its strong antioxidant, antimicrobial, and anti-inflammatory properties. The major bioactive compound present in clove is eugenol, which contributes to its therapeutic and nutritional value. Previous studies have reported that clove supplementation may improve nutrient utilization, enhance physiological functions, and reduce oxidative stress in animals. Incorporating phytogenic feed additives such as clove into rabbit diets may therefore enhance productivity while supporting organic and sustainable livestock production systems. This study was designed to evaluate the effects of Syzygium aromaticum bud powder supplementation on growth performance, physiological responses, serum biochemical characteristics, and antioxidant status of rabbits.

Rabbit farming holds significant promise within the realm of animal agriculture, particularly in addressing global food security and nutritional challenges. Due to their rapid reproductive cycles, efficient feed conversion rates, and high-quality meat, rabbits provide a sustainable approach to meat production (Siddiqui *et al*., 2023; Wongnaa *et al.,* 2023). Their meat is rich in protein, low in fat, and highly digestible, making it a valuable component of human diets. Rabbit production also requires minimal land and capital investment, making it suitable for smallholder farmers (Moce and Santacreu, 2010; Vandu *et al.,* 2020). Additionally, rabbits contribute to organic farming systems through manure production, which serves as an excellent organic fertilizer (Paladan, 2022; Mbutu, 2013). These natural products possess bioactive compounds that enhance fertility, improve metabolism, and support animal health (Egba *et al.,*2014; Ahmed *et al.,* 2021)

Among the promising phytogenic additives, *Syzygium aromaticum* (clove) has attracted considerable interest due to its rich phytochemical composition. Cloves contain essential oils, tannins, carbohydrates, vitamins, and minerals, as well as bioactive compounds such as eugenol, gallic acid, and eugenol acetate (Krishna, 2024). Eugenol, the principal component of clove, has demonstrated antioxidant, antimicrobial, anti-inflammatory, and metabolic regulatory properties (Haro-Gonzalez *et al.,* 2021; Zhelyazkov *et al.,* 2022).

Research indicates that phytogenic feed additives improve nutrient digestibility, metabolic efficiency, and reproductive performance in livestock (Abdelnour *et al.,* 2021). However, optimal inclusion levels must be established to avoid potential metabolic imbalances associated with excessive supplementation (Amao *et al.,* 2023). The exploration of locally available plant-based additives such as *Syzygium aromaticum* is particularly important in developing countries where synthetic fertility drugs are expensive and often inaccessible (Chibundu, 2005; Ahaotu and Mbaegbu, 2017)

Therefore, this study investigated the effects of dietary inclusion of *Syzygium aromaticum* on the growth performance, physiological responses, serum biochemistry, lipid profile, and antioxidant status of rabbit bucks. The findings contribute to the development of sustainable feeding strategies that align with the principles of organic agriculture and climate-resilient livestock production.

2. Materials and Methods

36 Rabbit bucks were randomly assigned to four treatment groups with graded inclusion levels of *Syzygium aromaticum* in their diets:

- **T1:** Control (0 g/kg clove powder)
- **T2:** 5 g/kg clove powder
- **T3:** 7.5 g/kg clove powder
- **T4:** 10 g/kg clove powder

Dried *Syzygium aromaticum* (clove) buds were purchased from the local market in Umuahia Abia State, Nigeria. The cloves were thoroughly selected to remove stones and foreign matter, milled using a hammer milled into powder, and stored in an air tight containers then incorporated into the experimental diet.

Data Collection

Data were collected on growth performance,

physiological responses, serum biochemical characteristics, and antioxidant status of rabbit bucks. Growth parameters measured included body length, ear length, limb length, and body circumference**.** Physiological parameters such as pulse rate, respiratory rate, and rectal temperature were also recorded. Blood samples were collected for laboratory analysis. Serum biochemical parameters measured included total protein and liver enzyme activities**,** while antioxidant indicators such as superoxide dismutase (SOD), catalase (CAT), and malondialdehyde (MDA) were determined using standard laboratory procedures.

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA**)** using appropriate statistical software. Where significant differences occurred, treatment means were separated using Duncan's Multiple Range Test at a 5% level of significance**.**

Results and Discussion

Growth Performance of Rabbit Bucks

Significant differences were observed in feed intake, final body weight, weekly weight gain, and feed conversion ratio ($p < 0.05$). Rabbits in T3 recorded the highest growth performance**,** confirming that moderate clove inclusion improves nutrient utilization and metabolic efficiency. Similar findings were reported by Mahrous *et al.* (2017) and Şehitoğlu and Kaya (2021).

Table 1: **GROWTH PERFORMANCE OF RABBITS BUCKS FED VARIED LEVELS OF *SYZYGIUM AROMATICUM***

Parameters	T_1	T_2	T_3	T_4	SEM
Feed intake (g/rabbit/day)	93.39^{c}	94.87^{b}	95.03^{b}	97.46^{a}	0.34
Initial body weight(g/rabbit)	662.33	664.78	664.67	662.33	3.24
Final body weight(g/rabbit)	1901.14^{b}	1992.67	2093.88	1995.11^{ab}	22.59
Weight gained (g/rabbit/week)	61.89^{b}	66.39^{ab}	71.46^{a}	66.64^{ab}	1.16
Feed Conversion Ratio	1.55^{a}	1.43^{ab}	1.34^{b}	1.47^{ab}	0.03

^{abc} values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

Linear Morphometric Characteristics

Table 2: linear morphometric characteristics of rabbit bucks fed varied levels of *syzygium aromaticum*

Parameter s (cm)	T_1	T_2	T_3	T_4	SEM
Body length	42.11^{ab}	41.44^{ab}	42.67^{a}	40.62^{b}	0.32
Ear length	11.55	11.56	12.22	11.11	0.18
Ear width	7.00	7.00	7.44	7.00	0.15
Shoulder to tail drop	30.97	28.82	34.44	31.86	1.94
Body circumference	29.87	31.57	31.75	29.62	2.13
Head to shoulder	10.13^{ab}	9.58^{b}	10.19^{a}	9.78^{ab}	1.99
Tail length	9.28	9.14	9.37	9.16	1.95
Length of fore limb	14.47	14.38	15.64	14.79	1.90
Length of hind limb	20.73^{ab}	20.56^{b}	22.17^{a}	20.65^{b}	2.14
Height of withers	29.46	32.56	28.29	32.13	1.86

^{ab}values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

Table 2 shows that moderate inclusion of clove improved skeletal growth parameters, particularly body length and hind limb length. T3 consistently exhibited the best morphometric development, suggesting improved nutrient absorption and physiological efficiency.

Serum Biochemistry and Lipid Profile

Table 3: Effect of feeding different levels of *Syzygium aromaticum* on serum biochemistry and lipid profile of rabbit bucks

Parameters	T_1	T_2	T_3	T_4	SEM
Total protein (g/dl)	7.03^{c}	7.45^{b}	7.77^{a}	7.48^{b}	0.08
AST (IU/L)	82.41^{a}	82.49^{a}	80.33^{b}	81.01^{b}	0.30
ALT (IU/L)	41.02^{a}	40.96^{a}	39.79^{b}	39.70^{b}	0.20
ALP (IU/L)	66.86^{a}	65.08^{b}	65.38^{ab}	65.92^{ab}	0.28
Bilirubin (g/dl)	0.46	0.45	0.45	0.42	0.01
Urea (mg/dl)	21.52	21.08	20.59	20.92	0.22
TC (mg/dl)	56.19	76.55	69.83	66.06	3.72
TG (mg/dl)	55.47^{a}	51.67^{b}	45.59^{c}	41.49^{d}	1.64
HDLC (mg/dl)	41.65^{d}	45.50^{c}	47.34^{b}	48.69^{a}	0.81
LDLC (mg/dl)	28.44^{a}	20.72^{b}	13.37^{c}	9.06^{d}	2.25
VLDLC (mg/dl)	11.09^{a}	10.33^{b}	9.12^{c}	8.29^{d}	0.33

^{abcd} values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment neans. **AST:** Aspartate aminotransferase; **ALT:** Alanine aminotransferase; **ALP:** Alkaline phosphatase. **TC:** Total cholesterol; **TG:** Triglyceride; **HDLC:** High-density lipoprotein cholesterol; **LDLC:** Low-density lipoprotein cholesterol; **VLDLC:** Very-low-density lipoprotein cholesterol.

Table 3 illustrates that moderate inclusion of *Syzygium aromaticum* improved total protein levels while reducing liver enzymes (AST and ALT), indicating improved metabolic health. Triglycerides, LDL, and VLDL decreased significantly, whereas HDL increased with clove inclusion. These results suggest improved lipid metabolism and cardiovascular health, supporting findings by El-Kholy *et al.* (2022) and Abdel-Azeem *and* Abd-El-Kader (2022).

Antioxidant and Electrolyte Responses

Table 4. Effect of feeding different levels of *Syzygium aromaticum* on antioxidants and electrolytes of rabbit bucks.

Parameters	T_1	T_2	T_3	T_4	SEM
MDA (nm/mol)	4.45^{a}	4.19^{b}	4.09^{c}	4.03^{d}	0.05
SOD (IU/ml)	2.46^{b}	2.45^{b}	3.75^{a}	2.72^{b}	0.16
CAT (IU/ml)	41.08^{b}	42.51^{a}	43.61^{a}	43.43^{a}	0.33
Sodium (mmol/l)	131.53^{b}	132.77^{ab}	132.35^{ab}	134.21^{a}	0.38
Chloride (mmol/l)	91.38^{ab}	92.34^{a}	92.53^{a}	90.65^{b}	0.27
Potassium (mmol/l)	4.14	4.15	4.09	4.13	0.02
Bicarbonate (mmol/l)	23.66	23.20	23.50	23.10	0.33

^{abcd}

[abcd] values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

MDA: Malondialdehyde; **SOD:** Superoxide Dimutase; **CAT:** Catalase

Table 4 indicates that dietary inclusion of *Syzygium aromaticum* significantly affected antioxidant parameters and some electrolytes in rabbit bucks. Malondialdehyde (MDA) decreased significantly ($p < 0.05$) from 4.45 nmol/ml (T1) to 4.19 nmol/ml (T2), 4.09 nmol/ml (T3) and 4.03 nmol/ml (T4), indicating reduced lipid peroxidation and oxidative stress. This supports reports that phytogenic additives reduce oxidative damage (Mahasen, 2023), while Bai *et al.* (2022) also observed reduced MDA in rabbits supplemented with 100–150 mg eugenol nano-emulsion/kg diet under heat stress.

Superoxide dismutase (SOD) activity was significantly higher ($p < 0.05$) in T3 (3.75 IU/ml) compared with T1 (2.46 IU/ml), T2 (2.45 IU/ml) and T4 (2.72 IU/ml), suggesting that moderate inclusion enhanced antioxidant enzyme activity, consistent with findings by Rahman Alizadeh *et al.* (2017). Catalase (CAT) activity also increased significantly in T2 (42.51 IU/ml), T3 (43.61 IU/ml) and T4 (43.43 IU/ml) compared with T1 (41.08 IU/ml), indicating improved antioxidant defense, similar to reports by Suliman *et al.* (2023).

Among electrolytes, sodium increased significantly from 131.53 mmol/l (T1) to 134.21 mmol/l (T4), suggesting improved electrolyte regulation (Madlala *et al.,* 2012). Chloride ranged from 91.38 to 92.53 mmol/l, with higher values in T2 and T3, agreeing with Ahmad *et al.* (2012). However, potassium (4.09–4.15 mmol/l) and bicarbonate (23.10–23.66 mmol/l) were not significantly affected, indicating stable electrolyte and acid–base balance.

These findings agree with previous studies showing that phytogenic compounds enhance antioxidant defense and reduce oxidative stress (Gülçin *et al.,* 2004; Askari *et al.,* 2022; Alrashedi *et al.,* 2024). Elevated MDA is widely associated with oxidative stress (Bas *and* Kalender, 2016; Antwi-Boasiako *et al.,* 2020; Adegbola *et al.,* 2022), while herbal supplementation can reduce lipid peroxidation (Effert *et al.,* 2001). Phytochemicals such as flavonoids and saponins in *Syzygium* species contribute to these antioxidant effects (Sharma *et al.,* 2012; Batiha *et al.,* 2020; Lakshmi *and* Manasa, 2021), and related species such as *Syzygium cumini* have also shown lipid-lowering properties (Sharma *et al.,* 2008b).

Overall, *Syzygium aromaticum* supplementation improved antioxidant status by reducing MDA and increasing SOD and CAT activities, with T3 showing the best antioxidant response, while T4 recorded the highest sodium level (134.21 mmol/l). Potassium and bicarbonate remained stable, indicating maintained electrolyte and acid–base balance. These findings confirm the strong antioxidant properties of clove and its major compound eugenol (Gülçin et al., 2004).

Physiological Responses:

The physiological responses of rabbit bucks fed different inclusion levels of *Syzygium aromaticum* are presented in Tables 5. The parameters evaluated included heart rate, respiratory rate, rectal temperature, and pulse rate over a 20-week experimental period.

Heart Rate

Table 5: Effect of feeding different levels of *Syzygium aromaticum* on heart rates of rabbit bucks

	T_1	T_2	T_3	T_4	SEM
Baseline heart rate	150.29	149.76	151.05	151.85	0.50
Week 4	149.79	148.66	150.19	150.89	0.50
Week 8	150.54	149.78	149.00	150.56	0.48
Week 12	147.94^{b}	150.91^{a}	148.76^{ab}	148.25^{ab}	0.46
Week 16	148.78	149.80	149.70	150.49	0.42
Week 20	150.03	149.12	149.29	151.25	0.47

[abc] values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

In table 5 it is seen that the heart rate of rabbit bucks ranged from 147.94 to 151.85 bpm throughout the experiment. At baseline, the heart rates of all treatment groups were similar, indicating uniform physiological status of the animals prior to dietary treatment. Across the experimental period, heart rates remained relatively stable with only minor fluctuations among treatments.

A significant difference ($p < 0.05$) was observed at week 12, where T2 (150.91 bpm) recorded a higher heart rate compared with T1 (147.94 bpm), while T3 and T4 showed intermediate values. However, this difference was not sustained in subsequent weeks, suggesting that the observed variation may have been temporary rather than a consistent physiological response to dietary inclusion of *Syzygium aromaticum*.

The general stability of heart rate across treatments indicates that the inclusion of *Syzygium aromaticum* did not exert a significant effect on cardiovascular activity in rabbit bucks. Similar transient increases in heart rate have been reported in rabbits administered plant extracts. For example, Iwuji et al. (2024) observed a

temporary rise in heart rate in rabbits treated with Panax ginseng extract**,** which was attributed to increased metabolic activity requiring enhanced blood circulation for oxygen transport. The findings in the present study therefore suggest that *Syzygium aromaticum* supplementation did not adversely affect cardiac function in the animals.

Respiratory Rate

Table 6: Respiratory Rates of Rabbit Bucks Fed Varied Levels of *Syzygium Aromaticum* .

Parameters (min)	T_1	T_2	T_3	T_4	SEM
Baseline	51.92	49.16	50.33	48.82	0.53
Week 4	50.29	50.15	50.76	50.93	0.47
Week 8	48.91	49.39	49.66	48.61	0.45
Week 12	49.03	49.28	51.05	50.43	0.48
Week 16	50.33	50.01	50.14	50.24	0.46
Week 20	50.28^{ab}	48.20^{ab}	47.79^{b}	50.81^{a}	0.48

^{abc} values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

Table 6 demonstrates that the respiratory rate values ranged from 47.79 to 51.92 breaths per minute during the study. At baseline, there were no significant differences among the treatment groups, confirming that the rabbits had comparable physiological conditions before the commencement of the feeding trial.

Respiratory rates remained relatively consistent across the experimental weeks, with slight fluctuations around 50 breaths per minute. A significant difference ($p < 0.05$) occurred at week 20 where T4 (50.81 bpm) recorded a higher respiratory rate compared with T3 (47.79 bpm), while T1 and T2 remained intermediate. Despite this difference, the values still fell within the normal physiological range for healthy rabbits, indicating that the dietary treatments did not induce respiratory distress.

The slight increase observed in T4 at week 20 may be linked to metabolic stimulation associated with higher inclusion levels of *Syzygium aromaticum*. Previous studies have shown that essential oils derived from clove may influence respiratory activity. ElGindy et al. (2021) reported variations in respiratory rate of rabbits fed diets containing clove and rosemary oils, attributing the effect to bioactive compounds such as α-caryophyllene and β-caryophyllene with antioxidant and circulatory-enhancing properties. However, the lack of consistent differences across earlier weeks in the present study indicates that the effect of *Syzygium aromaticum* on respiratory function was minimal.

Rectal Temperature

Table 7: Rectal Temperature of Rabbit Bucks Fed Varied Levels of *Syzygium Aromaticum*

	T_1	T_2	T_3	T_4	SEM
Baseline	39.01	38.97	39.01	38.83	0.05
Week 4	39.08	39.10	39.15	39.00	0.04
Week 8	39.91	39.18	39.04	38.96	0.05
Week 12	39.06	38.89	38.98	38.91	0.05
Week 16	38.95	38.99	38.96	38.89	0.04
Week 20	38.82	39.00	38.88	38.92	0.05

Table 7 shows rectal temperature values ranged between 38.82°C and 39.91°C throughout the experiment. At baseline, all treatment groups recorded similar temperatures (38.83–39.01°C), confirming comparable physiological conditions among the animals at the start of the study.

Across the 20-week period, rectal temperatures remained relatively stable, and no significant differences were observed among treatments. The values recorded were within the normal physiological range for rabbits, suggesting that the inclusion of *Syzygium aromaticum* did not interfere with thermoregulation.

Environmental conditions may also have contributed to the stability of rectal temperature. The ambient temperature during the study ranged from 18°C to 28°C, which is below the heat stress threshold for rabbits reported by ElRaffa (2014)**.** Since body temperature is strongly influenced by environmental conditions, the moderate climate during the experimental period likely helped the animals maintain thermal homeostasis. Consequently, the results indicate that *Syzygium aromaticum* supplementation had no adverse effect on body temperature regulation.

Pulse Rate

Table 8: Pulse Rates of Rabbit Bucks Fed Varied Levels of *Syzygium Aromaticum*

	T_1	T_2	T_3	T_4	SEM
Baseline	78.49	81.22	70.68	79.99	0.45
Week 4	80.34	78.15	80.19	79.07	0.47
Week 8	80.48	79.59	79.55	79.95	0.44
Week 12	80.80	79.73	79.56	79.80	0.51
Week 16	78.80^{b}	79.27^{ab}	81.88^{a}	79.70^{ab}	0.48
Week 20	78.83	79.64	80.48	80.68	0.46

^{ab} values in a row with different superscript are significantly different ($p < 0.05$) and SEM: Standard error of treatment means.

Table 8 shows that Pulse rate values ranged from 70.68 to 81.88 bpm during the study period. Although slight variations were observed at baseline, these differences were within normal biological variability. Generally, pulse rates across treatments remained relatively consistent throughout the experiment.

A significant difference ($p < 0.05$) occurred at week 16, where T3 recorded the highest pulse rate (81.88 bpm), which was significantly higher

than T1 (78.80 bpm), while T2 and T4 showed intermediate values. Despite this difference, the pulse rate remained within the normal physiological range for rabbits, suggesting that the variation did not indicate any adverse cardiovascular effect.

The transient increase observed in T3 may be associated with physiological responses such as metabolic stimulation or temporary stress from animal handling. Similar findings have been reported in studies evaluating clove-based feed additives. Olateju *et al.* (2023) observed improved performance in rabbit bucks fed diets containing clove leaf meal without adverse physiological effects.

Overall, the physiological parameters measured heart rate, respiratory rate, rectal temperature, and pulse rate remained within normal ranges throughout the study. Although occasional significant differences were observed at specific time points, these variations were not consistent across the experimental period.

The results therefore indicate that dietary inclusion of *Syzygium aromaticum* did not negatively affect the cardiovascular, respiratory, or thermoregulatory functions of rabbit bucks. This suggests that *syzygium aromaticum* can be safely incorporated into rabbit diets at the tested levels without causing physiological stress or adverse health effects.

Conclusion

The findings of this study demonstrate that *Syzygium aromaticum* is an effective phytogenic feed additive for improving rabbit productivity under sustainable farming systems. Moderate inclusion levels (7.5 g/kg feed) significantly enhanced growth performance, metabolic efficiency, antioxidant status, and lipid profile without adversely affecting physiological parameters.

These results highlight the potential of plant-based feed additives in supporting organic livestock production, reducing dependence on synthetic inputs, and promoting climate-resilient agricultural systems. The integration of phytogenic additives into rabbit nutrition can contribute to sustainable food systems and improved rural livelihoods in Nigeria.

References

Abdel-Azeem, A. S., and Abd-El-Kader, I. A. (2022). Growth performance, carcass attributes, blood hematology, and biochemical constituents of growing rabbits supplemented with cinnamon and clove powder. *Animal Science Papers and Reports, 40*(3), 351–370.

Abdelnour S.A, Al-Gabri N. A, Hashem N. M and Gonzalez-Bulnes A. (2021). Supplementation with proline improves haemato-biochemical and reproductive indicators in male rabbits affected by environmental heat-stress. Animals. 11(2):373 -373

Adegbola, M. V., Anyim, G., Ntwasa, M., Ayeleso, A. O., and Oyedepo, T. A. (2022). Potential Effect of *Syzygium aromaticum* (Cloves) Extract on Serum Antioxidant Status and Lipid Profiles in Wistar Rats with Artesunate Toxicity. *Applied Sciences*, *12*(16), 8216. https://doi.org/10.3390/app12168216

Ahaotu E. O. and Mbaegbu I. (2017). Effects of Water Leaf (*Talinum triangulare*) Shoot Meal on the Performance of Weaner New Zealand White Rabbits. Greener Journal of Animal Breeding and Genetics, 3(3): 018-024, http://doi.org/10.15580/GJABG.2017.3.071217084.

Ahmed K. E., Anele U. .Y, Patra A. K. and Varadyova Z. (2021). The Use of Phyogenic Feed Additives to Enhance Productivity and Health in Ruminants. *Front. Vet. Sci.* 8:685262.doi: 10.3389/fvets.2021.685262.

Alrashedi, S. S., Almasmoum, H. A., and Eldiasty, J. G. (2024). The effect of dietary eugenol nano-emulsion supplementation on growth performance, serum metabolites, redox homeostasis, immunity, and pro-inflammatory responses of growing rabbits under heat stress. *Open Veterinary Journal*, *14*(3), 830.

Amao, E. A., Amao, O. D., Adelegan, T. M., Tiamiyu, W. A., Busari, Z. O., *and* Yunus, M. O. (2023). Haematological and serum biochemical indices of cocks drenched with varying levels of clove powder (*Syzygium aromaticum*). *ADAN Journal of Agriculture, 4,* 64–70.

Antwi-Boasiako, C., Dankwah, G., Aryee, R., Hayfron-Benjamin, C., Aboagye, G., *and* Campbell, A. (2020). Correlation of lipid peroxidation and nitric oxide metabolites, trace elements, and antioxidant enzymes in patients with sickle cell disease. *Journal of Clinical Laboratory Analysis, 34*(12), e23294. https://doi.org/10.1002/jcla.23294

Askari, E., Fallah, A. A., Habibian Dehkordi, S.,

Bahadoran, S., Mohebbi, A., *and* Mohamadi, S. (2022). Effect of dietary clove (*Syzygium aromaticum*) essential oil on growth performance, oxidative indices, lipid profile, and cadmium accumulation in Cd-exposed quails. *Journal of Environmental Health and Sustainable Development, 7*(3), 1755–1766. http://jehsd.ssu.ac.ir/article-1-461-en.html

Assan N. (2023) Sustainable small-scale animal agriculture and food security in Africa. Sustainable Social Development; 1(2): 2342. doi: 10.54517/ssd.v1i2.2342 .

Bai, X., Shi, Y., Tang, L., Chen, L., Fan, H., Wang, H., Wang, J., Jia, X., Chen, S., *and* Lai, S. (2022). Heat stress affects faecal microbial and metabolic alterations of rabbits. *Frontiers in Microbiology, 12*, 817615. https://doi.org/10.3389/fmicb.2021.817615.

Bas, H., *and* Kalender, Y. (2016). Nephrotoxic effects of lead nitrate exposure in diabetic and nondiabetic rats: Involvement of oxidative stress and the protective role of sodium selenite. *Environmental Toxicology, 31*(10), 1229–1240. https://doi.org/10.1002/tox.22130.

Batiha E, G., Alkazmi, L. M., Wasef, L. G., Beshbishy, A. M., Nadwa, E. H., *and* Rashwan, E. K. (2020). *Syzygium aromaticum* L. (Myrtaceae): Traditional Uses, Bioactive Chemical Constituents, Pharmacological and Toxicological Activities. *Biomolecules*, *10*(2), 202. https://doi.org/10.3390/biom10020202

Chibundu, U. C. (2005). Responses of prepubertal rabbit Bucks to the administration of Estradiol β. Project reports Dept. of Animal Science and Technology, Federal Universityof Technology, Owerri pp.30.

Egba, S. I, Omeoga, H. C, Njoku and O. U. (2014). Oral administration of methanol extract of Gongronema latifolium (utazi) Up-Regulates cytokine expression and influences the immune system in wistar albino rats. World Appl. Sci. J. 31: 745-750.

El-Raffa, A.M. (2014). Rabbit production in hot climate. Proceedings of the 8th World Rabbit Congress; September 7-10, 2014. Puebla, Mexico

Iheukwumere, C.C., Ahaotu, E.O., Nwoye, E.O., (2018). Studies on benefits and problems of rabbit production in Abia state, Nigeria. Int J Vet Sci. 5:23-28.

Iwuji, T., Herbert, U., Oguike, M., Ejiofor, I., *and* Ahiwe, E. (2024). Body and rectal temperature changes, respiratory and heart rates of New Zealand White rabbits administered *Panax ginseng* extracts. *Nigerian Journal of Animal Production, 51*(?), 600–604. https://doi.org/10.51791/njap.vi.5199

Krishna, R. (2024). Studies Studies on the phytochemicals of clove and their biological activities. International Journal of Advanced Chemistry. 12. 35-46. 10.14419/8j86jz80.

Lakshmi, V. J., and Manasa, K. (2021). Various Phytochemical Constituents and Their Potential Pharmacological Activities of Plants of the Genus Syzygium. *Ajptr* 11 (2), 68–85. doi:10.46624/ajptr.2021.v11.i2.006

Madlala, H. P., Masola, B., Singh, M., *and* Musabayane, C. T. (2012). The effects of Syzygium aromaticum-derived oleanolic acid on kidney function of male Sprague-Dawley rats and on kidney and liver cell lines. *Renal failure*, *34*(6), 767–776. https://doi.org/10.3109/0886022X.2012.678172

Mahasen A.K (2023).Effect of cloves (*syzygium aromaticum*) on serum biomarkers of some common complications and oxidative stress on alloxan-induced diabetic rats. Research journal specific education.issue N0 73 page 1-25.

Mahrous, H.S., El-Far, A.H., Sadek, K.M. *and* Abdel-Latif, M.A.(2017). Effects of different levels of clove bud (Syzygium aromaticum) dietary supplementation on immunity, antioxidant status, and performance in broiler chickens. A.J.V.S. 54, 29-39.

Mailafia, S.,Onakpa, M. M.; Owoleke, O. E.(2010). Problems and prospects of rabbit production in Nigeria - A review. Bayero Journal of Pure and Applied Science, 3 (2): 20-25

Mbutu, E. M. (2013). Factors influencing rabbit farming: A case of rabbit production project in Abothuguchi West Division, Meru County, Kenya. University of Nairobi. Available at: https://erepository.uonbi.ac.ke/bitstream/handle/11295/63559/Mbutu_%20Factors%20influencing%20rabbit%20farming%

3A%20A%20case%20of%20rabbit%20production%20project%20in%20Abothuguchi%20West%20.pdf?sequence=2

Moce, M. L., and Santacreu, M. A. (2010). Genetic improvement of litter size in rabbit. In proceedings of 9th world Congress on Genetic Applied to Livestock Production. 1 - 6 August, Leipzig, Germany, 25.

Olateju, I., Adu, O., Akinsulure, O., Adeniran, C., *and* Chineke, C. (2023). Physiological responses of rabbit bucks fed diets supplemented with varied levels of nutmeg seed meal, clove leaf meal, and their composite mix. *Archiva Zootechnica, 26*(1), 36–51. https://doi.org/10.2478/azibna-2023-0013

Paladan, N. (2022). Rabbit Farming Management Practices: A Case Of An Emerging Rabbit Farmer/Producer. *International Journal of Science and Environment (IJSE)*, *2*(4), 127–137. https://doi.org/10.51601/ijse.v2i4.45

Rahman Alizadeh, M., Mahdavi, A. H., Rahmani, H. R., *and* Jahanian, E. (2017). Clove bud (*Syzygium aromaticum*) improved blood and hepatic antioxidant indices in laying hens receiving low n-6 to n-3 ratios. *Journal of animal physiology and animal nutrition*, *101*(5), 881–892. https://doi.org/10.1111/jpn.12502

Şehitoğlu, M., *and* Kaya, H. (2021). The Effect of Clove Oil Supplementation in Laying Hen Diets on Performance, Egg Quality, Some Blood Parameters, and Yolk TBARS. *Turkish Journal of Agriculture - Food Science and Technology*, *9*(12), 2213–2218. https://doi.org/10.24925/turjaf.v9i12.2213-2218.4482

Sharma B., Viswanath G., Salunke R., Roy P. (2008b). Effects of flavonoid-rich extract from seeds of *Eugenia jambolana* (L.) on carbohydrate and lipid metabolism in diabetic mice. *Food Chem.* 110 697–705. 10.1016/j.foodchem.2008.02.068 [DOI] [Google Scholar]

Sharma, A. K., Bharti, S., Kumar, R., Krishnamurthy, B., Bhatia, J., Kumari, S., *and* Arya, D. S. (2012). Syzygium cumini ameliorates insulin resistance and β-cell dysfunction via modulation of PPAR, dyslipidemia, oxidative stress, and TNF-α in type 2 diabetic rats. *Journal of pharmacological sciences*, *119*(3), 205–213. https://doi.org/10.1254/jphs.11184fp]

Siddiqui, S. A., Gerini, F., Ikram, A., Saeed, F., Feng, X., *and* Chen, Y. (2023). Rabbit Meat—Production, Consumption and Consumers' Attitudes and Behavior. *Sustainability*, *15*(3), 2008. https://doi.org/10.3390/su15032008

Suliman, M.A.E., Ahmed, F.G., El-Kholy, K.H.F., Mohamed, R.A.E. and Abdel-Mawla, L.F. (2023). Effects of clove (*Syzygium aromaticum*) on productive performance, nutrients value and digestibility, blood lipid profile, antioxidant status and immune response of growing rabbits. Online Journal of Animal and Feed Resource, 13(1): 01-09.

Vandu, R. A., Maya, V. P., *and* Wafar, R. J. (2020). Growth and reproductive performance of rabbit does fed replacement levels of fermented *Jatropha curcas* seed meal. *Nigerian Journal of Animal Science and Technology, 3*(4), 20-29.

Wongnaa, C.A., Sienso, G., Afful-Kwadam, K., Prah, S., (2023). Welfare impacts of commercialization of rabbit production in Ghana. Cleaner and Circular Bioeconomy 5, 100049. https://www.sciencedirect.com/science/article/pii/S277280132300143.

Zhelyazkov, S., Zsivanovits, G., Stamenova, E., Marudova, M. (2022). Physical and Barrier Properties of Clove Essential Oil Loaded Potato Starch Edible Films. *Biointerface Research in Applied Chemistry*. 12. 4603-4612. 10.33263/BRIAC124.46034612.

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