

Effects of phyto-additives blend (garlic, ginger, clove, and turmeric) on growth performance, egg production, and egg characteristics of laying birds

Eden Olusegun Okanlawon¹, Tirimisiyu Adewale Rafiu¹, Mariam Opeyemi Garuba¹, Lailah Kehinde Azeez¹, Peter Ayodeji Ogokunle¹ & Nifemi Esther Taiwo¹

¹ Department of Animal Production and Health, Ladoke Akinola University of Technology, Ogbomoso, Oyo State, Nigeria

Correspondence: Tirimisiyu. Adewale Rafiu, Department of Animal Production and Health, Faculty of Agricultural Science, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. E-mail: tarafiu@lautech.edu.ng

Submitted: May 20, 2026

DOI: 10.14295/bjs.v5i12.921

Accepted: July 08, 2026

URL: <https://doi.org/10.14295/bjs.v5i12.921>

Published: July 09, 2026

Abstract

This study evaluated the effects of dietary supplementation with a phyto-additive blend containing garlic (*Allium sativum*), ginger (*Zingiber officinale*), clove (*Syzygium aromaticum*), and turmeric (*Curcuma longa*) on growth performance, egg production, and egg quality of Isa Brown laying hens. A total of 150 day-old chicks were randomly assigned to five dietary treatments in a completely randomized design, with three replicates of 10 birds each. The experimental diets consisted of a control (T1) and four phyto-additive combinations: T2 (garlic, ginger, and clove; 3 g kg⁻¹), T3 (garlic, clove, and turmeric; 3 g kg⁻¹), T4 (turmeric, ginger, and clove; 3 g kg⁻¹), and T5 (garlic, ginger, clove, and turmeric; 4 g kg⁻¹). Growth performance, egg production, and egg quality parameters were evaluated throughout the experimental period. Dietary treatments significantly affected ($P < 0.05$) growth performance, egg production, and selected egg quality traits. Birds fed T2 showed the greatest weight gain (0.64 kg) and the lowest feed conversion ratio (7.17), indicating superior growth performance. During the later production phase, hens receiving T3 exhibited the highest total egg weight (1,196.04 g), egg number (31.38), egg mass per kilogram of feed (400.04 g), egg number per kilogram of feed (8.98), and hen-day egg production (89.87%), demonstrating enhanced laying performance despite similar feed intake among treatments. Egg internal quality was also influenced by dietary supplementation, with T5 producing the highest Haugh Unit (85.66), indicating improved albumen quality.

Keywords: albumen quality, feed efficiency, Isa Brown, laying hens, phytogenic feed additives.

Efeitos da mistura de fitoaditivos (alho, gengibre, cravo e cúrcuma) sobre o desempenho produtivo, a produção de ovos e a qualidade dos ovos de aves poedeiras

Resumo

Este estudo avaliou os efeitos da suplementação da dieta com uma mistura de fitoaditivos contendo alho (*Allium sativum*), gengibre (*Zingiber officinale*), cravo-da-índia (*Syzygium aromaticum*) e cúrcuma (*Curcuma longa*) sobre o desempenho produtivo, a produção de ovos e a qualidade dos ovos de poedeiras Isa Brown. Um total de 150 pintainhas de um dia de idade foi distribuído aleatoriamente em cinco tratamentos alimentares, em delineamento inteiramente casualizado, com três repetições de 10 aves cada. As dietas experimentais consistiram em um tratamento controle (T1) e quatro combinações de fitoaditivos: T2 (alho, gengibre e cravo; 3 g kg⁻¹), T3 (alho, cravo e cúrcuma; 3 g kg⁻¹), T4 (cúrcuma, gengibre e cravo; 3 g kg⁻¹) e T5 (alho, gengibre, cravo e cúrcuma; 4 g kg⁻¹). Os parâmetros de desempenho produtivo, produção de ovos e qualidade dos ovos foram avaliados durante todo o

período experimental. Os tratamentos alimentares influenciaram significativamente ($P < 0,05$) o desempenho produtivo, a produção de ovos e características selecionadas da qualidade dos ovos. As aves alimentadas com T2 apresentaram o maior ganho de peso (0,64 kg) e a menor conversão alimentar (7,17), indicando melhor desempenho de crescimento. Durante a fase final de produção, as poedeiras que receberam T3 apresentaram o maior peso total de ovos (1.196,04 g), maior número de ovos (31,38), maior massa de ovos por quilograma de ração (400,04 g), maior número de ovos por quilograma de ração (8,98) e maior produção de ovos por ave por dia (89,87%), demonstrando melhor desempenho produtivo, apesar do consumo de ração semelhante entre os tratamentos. A qualidade interna dos ovos também foi influenciada pela suplementação dietética, sendo que T5 apresentou a maior Unidade Haugh (85,66), indicando melhor qualidade do albúmen. Nas condições deste estudo, a suplementação da dieta com misturas de fitoaditivos não apresentou efeitos adversos sobre o desempenho das poedeiras. A combinação de alho, cravo e cúrcuma (T3) melhorou a eficiência da produção de ovos, enquanto a combinação de alho, gengibre e cravo (T2) promoveu maior ganho de peso corporal, sugerindo que combinações específicas de aditivos fitogênicos podem aumentar a produtividade de poedeiras.

Palavras-chave: qualidade do albúmen, eficiência alimentar, Isa Brown, galinhas poedeiras, aditivos fitogênicos para alimentação animal.

1. Introduction

The poultry industry is a rapidly expanding sector of global animal agriculture, contributing significantly to food security, employment, and rural economies. According to the Food and Agriculture Organization (FAO), poultry meat and eggs represent one of the most affordable and accessible sources of animal protein. However, intensification of poultry production systems has also brought challenges, including disease outbreaks, environmental stressors, and the need for efficient feed utilization to maintain profitability. Antibiotic growth promoters (AGPs) have been widely used in poultry diets to enhance growth performance, improve feed conversion ratio, and reduce disease incidence (Gadde et al., 2017).

However, increasing concerns over antimicrobial resistance (AMR) and its public health implications have led to regulatory restrictions and outright bans on AGP use in many countries, including the European Union since 2006 and, more recently, in several parts of Asia and Africa (Landers et al., 2012). This policy shift has driven a search for alternative feed additives that can maintain or enhance productivity without contributing to AMR. Phyto-additives can enhance nutrient digestibility, modulate gut microflora, and improve immune function, making them valuable tools in antibiotic-free poultry production systems (Hashemi et al., 2011; Okanlawon et al., 2024).

Among these alternatives, phytogenic feed additives have attracted considerable attention because they contain a wide variety of bioactive compounds capable of exerting complementary biological effects. Rather than acting independently, combinations of phytogenic ingredients may exhibit synergistic interactions, in which different phytochemicals target multiple physiological pathways simultaneously. Such synergism can enhance digestive enzyme activity, improve intestinal integrity, promote beneficial microbial populations, reduce oxidative stress, and strengthen immune responses, resulting in greater productive performance than that achieved by individual additives alone. Therefore, evaluating combinations of phytogenic compounds may provide a more effective nutritional strategy than assessing single plant additives (Hashemi; Davoodi, 2011; Nisa et al., 2025; Wang et al., 2024; Windisch et al., 2008).

Ginger (*Zingiber officinale*) contains active compounds such as gingerols and shogaols, which possess strong antioxidant, anti-inflammatory, and antimicrobial properties (Hu et al., 2023; Shalaby et al., 2023). In poultry, ginger supplementation has been shown to improve feed intake, nutrient digestibility, and growth rates, likely due to enhanced enzyme secretion and improved gut health (Herawati et al., 2010; Jyotirmayee et al., 2024). Turmeric (*Curcuma longa*) is rich in curcumin, a polyphenolic compound with potent antioxidant and anti-inflammatory effects. Curcumin can stimulate bile secretion, improving fat digestion, and has been linked to improved feed efficiency and immune response in poultry (Albaqami et al., 2022; Durrani et al., 2006; Gururani et al., 2022). Cloves (*Syzygium aromaticum*) contain eugenol as a major bioactive compound, which exhibits broad-spectrum antimicrobial activity and antioxidant capacity. In-feed clove supplementation could be used to improve the growth rate without affecting the health of the liver and intestines of broilers (Al-Mufarrej et al., 2029; Ayub et al., 2023; Maggini et al., 2024).

Garlic (*Allium sativum*) is rich in organosulfur compounds such as allicin, which possess antimicrobial,

hypolipidemic, and immunomodulatory properties (Abbasi et al., 2023; Faqer et al., 2026). Garlic supplementation in poultry diets has been associated with improved feed conversion, enhanced immunity, and reduced pathogenic bacterial loads in the gastrointestinal tract (Toghyani et al., 2011).

The beneficial effects of these phytogetic additives are associated with multiple mechanisms of action. Their bioactive compounds can stimulate digestive secretions, improve nutrient digestibility, increase antioxidant enzyme activity, reduce lipid peroxidation, and modulate the intestinal microbiota by suppressing pathogenic microorganisms while favoring beneficial bacteria. In addition, phytochemicals such as curcumin, allicin, eugenol, gingerols, and shogaols contribute to the regulation of inflammatory responses and oxidative balance, improving intestinal functionality and nutrient utilization. These complementary mechanisms may ultimately enhance growth performance, feed efficiency, and reproductive performance in laying hens (Gadde et al., 2017; Lillehoj et al., 2018; Nisa et al., 2025; Platel; Srinivasan, 2004; Wanget al., 2024).

Although numerous studies have evaluated the effects of garlic, ginger, turmeric, or clove individually, and a few have investigated binary combinations, information regarding the use of multiple phytogetic blends in laying hens remains limited. Moreover, the potential synergistic effects of combining these four phytogetic ingredients on growth performance, egg production, and egg quality have not been fully elucidated. Addressing this knowledge gap is essential for developing effective natural feed additives capable of replacing antibiotic growth promoters while maintaining productivity and egg quality under commercial production conditions (Gadde et al., 2017; Hashemi; Davoodi, 2011; Lillehoj et al., 2018; Wang et al., 2024).

Therefore, this study aimed to evaluate the effects of different combinations of garlic, ginger, turmeric, and clove as phyto-additives in the diets of growing pullets on growth performance, egg production, and egg quality. It was hypothesized that synergistic interactions among these phytogetic ingredients would improve productive performance and egg quality compared with the control diet.

2. Materials and Methods

2.1 Experimental site

The experiment was carried out at the poultry unit of the Teaching and Research Farm, Faculty of Agricultural Science, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomoso is situated in the derived savanna zone of Nigeria on the Longitude 4051 East of Greenwich meridian and 80151 North East of the equator, Google Earth Map (2025).

2.2 Collection and preparation of test ingredients

Fresh turmeric, garlic, ginger, and cloves were purchased from Oja Jagun Market, Ogbomoso, Oyo State. Ginger and turmeric were washed using clean water to remove the dirt completely. They were poured into a clean basket to drain off water and later sliced into flakes in order to increase the surface area to aid drying. Thereafter, each of the test ingredients was dried (under the shade) until the weight remained constant. The test ingredients were reduced into lentil-size part with the aid of a mortar and pestle and milled into a fine powdery form with the use of an electric blender following the method described by Okanlawon et al. (2024). Thereafter, it was sieved and stored in an airtight container until use.

2.3 Experimental birds and design

A total of 150-day-old Isa Brown chicks, 12 weeks old, were obtained from a reputable commercial hatchery, and they were randomly allocated to five treatments. Each treatment was subdivided into 3 replicates of 10 birds per replicate in a completely randomized design (CRD). Five experimental diets were compounded such that: Ginger, Cloves, and Turmeric were added at 1:1 (3 g to 1 kg feed) for all the treatments, treatment 1 was control, T2-3 g/kg of garlic, ginger and clove, T3- 3 g/kg of turmeric, garlic and clove, T4- 3 g/kg of Turmeric, ginger and clove, T5-4 g/kg of Turmeric, garlic, ginger and clove. Each replicate was allocated to a separate partition equipped with a feeder and drinker. A lighting program of 24 h per day was maintained. Feed and clean water were provided ad libitum throughout the experiment. Standard vaccination and medication protocols for pullets were also ensured.

2.4 Data collection

2.4.1 Growth performance

Weight gain (g) = Final weight (g) - Initial body weight (g)

Feed Intake (g) = Quantity served – Leftover

Feed Conversion Ratio (FCR) = feed intake (g)/weight gain(g)

2.4.2 Percentage day production:

This was calculated as the number of eggs produced as

$$\% \text{ Day production} = \frac{\text{Total number of eggs produce} \times 100}{\text{Total number of laying birds}}$$

Feed consumed to produce eggs = feed intake/no of eggs produced x 30

Feed cost per tray: Feed consumed to produce an egg x cost per kg of feed

Egg Quality Analysis: The underlisted parameters were determined during egg analysis.

Egg weight: This was determined using the sensitive weighing scale. The egg samples were weighed individually, and the average weight was estimated.

Egg Dimension: This was measured using a Vernier caliper in cm. Width was determined at three different points (Narrow end, Broad end, and at the Centre).

Shell Weight: It was determined with the aid of a sensitive scale in grams after breaking and removal of the shell membrane.

Shell Thickness: The micrometer screw gauge was used to measure the thickness at the broad end, middle, and narrow end, and then the average was determined in mm.

Albumen Height: A spherometer was used to determine the height of the albumen.

Albumen Weight: The weight of the albumen was determined after the removal of the yolk from a broken egg.

Yolk Index: The weight of the separated yolk was estimated by subtraction of the weight of albumen from the weight of albumen + yolk.

HDP(%): It is used to measure the rate of egg production per bird per day, usually expressed as a percentage.

2.5 Statistical analysis

Data collected were analysed using ANOVA as contained in (SAS,2002). Significant means were separated using the Duncan Multiple Range Test as contained in (SAS, 2002).

3. Results

3.1 Growth performance of growing pullets fed a phytobiotics blend

Growth performance of growing pullets fed a phytobiotics blend (garlic, ginger, clove, and turmeric) is shown in Table 3.1. There was a significant ($P < 0.05$) difference in weight gain. Highest ($P < 0.05$) weight gain (0.64 kg) was recorded with layer birds fed a diet containing (3 g/kg) of garlic, ginger, and clove (T2), while layers fed a diet containing garlic, clove, and turmeric (3 g/kg) (T3) had the least (0.50 kg). The highest ($P < 0.05$) feed conversion ratio (9.51 kg) was recorded with layer birds fed a diet containing (3 g/kg) garlic, clove, turmeric (T3), while birds fed a diet containing (3 g/kg) T2 ginger, garlic, clove had the least (7.17 kg). Layers fed containing ginger, clove, turmeric (T4), ginger, garlic, clove, turmeric (T5), and control diets (0 g/kg) had similar values of (8.19 kg), (8.25 kg), and (8.59 kg). There was a significant ($P < 0.05$) difference in final weight (kg), feed intake (k), and average daily intake (kg).

Table 1. Growth performance of growing pullets fed a phytobiotics blend.

Parameters	T1	T2	T3	T4	T5	SEM
Initial Weight (kg)	0.86	0.85	0.87	0.84	0.83	0.011
Final Weight (kg)	1.40	1.43 ^a	1.37	1.40	1.37	0.011
Weight gain (kg)	0.54 ^{ab}	0.64 ^a	0.50 ^b	0.57 ^{ab}	0.56 ^{ab}	0.017
Feed Intake (FI)	4.60	4.55	4.62	4.64	4.57	0.008
ADFI	82.05	81.23	82.57	82.79	81.53	0.136
FCR	8.59 ^{ab}	7.17 ^b	9.51 ^a	8.19 ^{ab}	8.25 ^{ab}	0.282

Note: ^{ab}Means on the same row with different superscripts are significantly different ($P > 0.05$). SEM - Standard Error of the Mean, ADFI - Average Daily Feed Intake, FCR – Feed Conversion Ratio, T1 (Control) - Basal Feed, T2 - Ginger, Garlic & Clove, T3 - Garlic, Clove & Turmeric, T4 - Ginger, Clove & Turmeric, T5– Ginger. Source: Authors, 2026.

3.2 Production performance at the early and late stages of the egg production phase

Table 3.2 shows egg production performance at the early and late stages of the egg production phase. At the onset of egg production, birds across all treatment groups (T1–T5) showed similar performance patterns, with no statistically significant differences ($P > 0.05$) in total egg weight, egg number, feed intake, or production efficiency. Total egg weight ranged from 726.44 g in T1 to 635.94 g in T4, with T1 producing the highest output. Similarly, T1 recorded the highest number of eggs (19.38), while T4 had the lowest (16.69). Average daily feed intake (ADFI), with all birds consuming approximately 85 g/day.

In terms of efficiency, T1 again led with the highest egg mass per kg feed (241.41 g) and egg number per kg feed (6.44), followed closely by T2 and T3. T4 and T5 lagged slightly, indicating slightly lower feed conversion performance. Hen-day production (HDP) also followed this trend, with T1 achieving the highest rate (55.36%), while T4 had the lowest (47.68%). Overall, while differences were not statistically significant, T1 showed consistently better egg production performance at the onset, with T4 and T5 trailing behind in productivity and efficiency.

During the late production phase, T3 recorded the highest total egg weight (1196.04 g) and egg number (31.38), which showed comparable performance. In contrast, T2 and T4 had lower values, indicating reduced productivity. Although all groups had equal feed intake (100 g/day; 3500 g total^l), feed efficiency varied. T3 also achieved the highest egg mass per kg feed (400.04 g) and egg number per kg feed (8.98), while T2 and T4 had the lowest in both categories. Hen-day production followed the same trend. T3 (89.87%) was highest, while T4 (78.93%) was lowest. The results must be presented in the text itself or with the help of Graphs, figures, and/or Tables

Table 2. Production performance at early and late stages of the egg production phase.

Parameters	Early stage						Late stage					
	T1	T2	T3	T4	T5	SEM	T1	T2	T3	T4	T5	SEM
TotalWeight of Eggs	726.44 ^a	709.25 ^a	684.81 ^a	635.94 ^a	660.93 ^a	29.031	1187.04 ^a	1084.13 ^b	1176.13 ^a	1110.21 ^{ab}	1179.67 ^a	11.836
TotalNo. of Egg	19.38 ^a	18.56 ^a	18.31 ^a	16.69 ^a	17.47 ^a	0.772	31.38 ^a	28.29 ^{bc}	30.96 ^a	27.63 ^c	29.75 ^b	0.324
ADFI Bird Day	85.00 ^a	85.00 ^a	85.00 ^a	85.00 ^a	85.33 ^a	0.985	100.00	100.00	100.00	100.00	100.00	0.000
Egg mass (kg) feed	241.41 ^a	235.47 ^a	226.80 ^a	210.29 ^a	217.73 ^a	8.392	339.16 ^a	309.75 ^b	336.04 ^a	317.20 ^{ab}	337.05 ^a	3.382
Egg No. (kg) feed	6.44 ^a	6.16 ^a	6.08 ^a	5.52 ^a	5.75 ^a	0.225	8.96 ^a	8.08 ^{bc}	8.85 ^a	7.89 ^c	8.50 ^{ab}	0.093
HDP	55.36 ^a	53.04 ^a	52.32 ^a	47.68 ^a	49.90 ^a	2.207	89.64 ^a	80.83 ^{bc}	88.45 ^a	78.93 ^c	85.00 ^{ab}	0.927

Note: ^{ab}Means on the same row with different superscripts are significantly ($P > 0.05$) different. SEM - Standard Error of Mean, ADFI - Average Daily Feed Intake, HDP - Hen Day Production, T1 (Control) - Basal Feed, T2 - Ginger, Garlic & Clove, T3 - Garlic, Clove & Turmeric, T4 - Ginger, Clove & Turmeric, T5 - Ginger, Garlic, Turmeric & Clove. Source: Authors, 2026.

3.3 Egg quality at the early and late phases of egg production of layers fed a diet containing varying of phytobiotics blends

The egg quality characteristics at the early and late phases of egg production are shown in (Table 3). The early egg quality parameters of birds across treatments (T1–T5) showed no significant differences ($P < 0.05$) in most traits. Egg weight, shell thickness, yolk weight, yolk index (YI), egg shape index (ESI), yolk-to-albumen ratio, and Haugh unit were similar across all groups, indicating that dietary treatments had minimal impact on these parameters. However, albumen weight showed a significant difference: T2 had a higher albumen weight than T4 (65.97 g and 58.58 g), respectively, suggesting some dietary influence on albumen formation. Overall, egg quality remained high and consistent among the treatments during the early laying phase.

In the late laying phase, most egg quality parameters across treatments (T1–T5) remained statistically similar ($P > 0.05$), showing no significant dietary effects. Egg weight, shell thickness, yolk weight, albumen weight, yolk index (YI), egg shape index (ESI), and yolk-to-albumen ratio were comparable across all groups. However, Haugh Unit showed a significant difference: T5 recorded a higher value (85.66) than T1 (83.90), indicating improved internal egg quality in T5.

Table 3. Egg quality at the early and late phases of egg production of layers fed a diet containing varying of phytobiotics blends.

Parameters	Early Phase						Late Phase					
	T1	T2	T3	T4	T5	SEM	T1	T2	T3	T4	T5	SEM
Egg Weight	47.91 ^a	48.26 ^a	48.75 ^a	50.28 ^a	49.24 ^a	0.428	50.25	51.25	51.34	52.66	52.66	0.38
Shell Thickness	0.43 ^a	0.44 ^a	0.45 ^a	0.44 ^a	0.44 ^a	0.007	44.88	47.75	47.00	47.25	41.13	0.66
Yolk	26.39 ^a	26.66 ^a	25.81 ^a	28.45 ^a	24.97 ^a	0.656	26.66	24.66	25.35	26.52	54.99	0.57
Albumen	60.26 ^{ab}	65.97 ^a	61.74 ^{ab}	58.58 ^b	63.21 ^{ab}	0.947	58.49	62.35	60.07	58.33	61.29	0.65
Yolk Index	0.41 ^a	0.43 ^a	0.41 ^a	0.38 ^a	0.39 ^a	0.009	0.39	0.43	0.41	0.40	0.41	0.020
Egg Shape Index	53.31 ^a	54.93 ^a	53.03 ^a	55.05 ^a	52.38 ^a	0.900	58.09	57.87	56.11	56.87	56.88	0.40
Yolk Alb	0.46 ^a	0.41 ^a	0.42 ^a	0.49 ^a	0.40 ^a	0.017	0.47	0.40	0.43	0.46	0.41	0.02\
Haugh Unit	80.56 ^a	82.06 ^a	81.38 ^a	82.58 ^a	82.46 ^a	0.648	83.90 ^b	85.47 ^{ab}	85.05 ^{ab}	85.56 ^{ab}	85.66 ^a	0.26

Note: ^{ab}Means on the same row with different superscripts are significantly ($P > 0.05$) different. SEM - Standard Error of Mean, YAR - Yolk-To-Albumen Ratio, T1 (Control) - Basal Feed, T2 - Ginger, Garlic & Clove, T3 - Garlic, Clove & Turmeric, T4 - Ginger, Clove & Turmeric, T5 - Ginger, Garlic, Turmeric & Clove. Source: Authors, 2026.

4. Discussion

The significantly higher weight gain in Treatment 2 suggests a synergistic effect of garlic, ginger, and clove on nutrient utilization and growth performance. Similar results have been reported by Al-Mufarrej et al. (2019) and Okanlawon et al. (2024), who found that turmeric and ginger enhance digestive enzyme activity and nutrient absorption in broilers. The improvement in body weight gain and feed intake achieved with a mixture of turmeric, garlic, ginger, and clove in the diets suggests the positive beneficial growth-enhancing synergetic effects of these herbs. It could be that a mixture of these herbs may have controlled and limited the growth and colonization of numerous pathogenic and nonpathogenic species of bacteria in the gut, leading to improved translation of feed to meat.

The enhanced body weight observed in this study strengthens the findings of Ademola et al. (2009) and Okanlawon et al. (2024), who reported a significant increase in body weight gain of broilers and rabbits fed a mixture of turmeric, clove, garlic, and ginger. Although average daily intake was higher in the treated groups, this translated into enhanced weight gains. The increased feed intake observed in this study is in agreement with the reports of Okanlawon et al. (2024). This might be because they contain phytochemicals (tannin and flavonoids), which make the feed more palatable.

The feed conversion ratio (FCR) was significantly lower (better) in the control group, highlighting its superior efficiency. Similarly, observations were made by Al-Kassie et al. (2011), who concluded that while herbal additives can stimulate feed intake, their effects on feed conversion are highly dose-dependent and influenced by the composition of the blend. On the other hand, the laying hens will decrease their feed intake because phytobiotics optimize the absorption of nutrients and energy and affect the faster fulfillment in the gut of laying hens. This circumstance was affected by the increasing non-pathogenic bacteria population in the digestibility of laying hens. Presented the encapsulated feed increased the population of non-pathogenic bacteria compared to non-encapsulated feed (Natsiret al 2010; Natsir et al., 2013)

There was a significant effect on egg production performance at early and late stages, whereas the use of phytobiotic treatments numerically increased egg mass of laying hens. Sunder et al. (2013) reported that the addition of phytobiotic increases egg weight, since the phytobiotics used in this study contain phytochemicals that will boost the reproductive and physiological state of birds, as reported by Okanlawon et al. (2023). Phytobiotics have been demonstrated to have various bioactive compounds such as antioxidants and antimicrobials (Kafi et al., 2017; Zhao et al., 2011; Wen et al., 2017).

These favorable effects have contributed to the increase in egg weight of laying hens. The result of the effect of the inclusion of the blend on performance of layers shows that T3 had a positive effect on production performance and this is in agreement with the report of Malekizadeh et al. (2012) who concluded in their study that egg production increased ($P < 0.05$) with the addition of phyto-additives powder to laying hen diets since they can improve the performance of the digestive tract in laying hens, resulting in improved egg production. Based on our experiment, a diet supplemented with turmeric, garlic, ginger, and clove improved the laying performance and physical condition and is in line with the report of Olayeni et al. (2025).

According to Sreenivasa et al. (2012) who stated that phytobiotics contain steroids that help to improve the reproductive performance of livestock, so this study has shown that the inclusion of the phytobiotic in the diet of layers improves the production level. This study also presents the complementary action of the test ingredients that are used, and it helps to improve the productive performance of layers. Overall, egg quality remained high and consistent, with only slight variation in albumen quality among treatments. Phytobiotics contain phytochemical which stimulates the growth of tubular gland cells and epithelial cells in the magnum to secrete and synthesize albumen, and increase the albumen weight (Saraswati et al., 2013).

This result is similar to previous research, which reported that the addition of phytobiotic (ginger) enhanced the YI of laying hens (Mousa et al., 2019). This indicates that the combination has a positive influence on egg quality, which is in line with the report of Amir et al. (2022), who obtained positive effects of turmeric supplementation observed in laying hens, which presented higher egg quality when compared with the control. Layers fed a diet containing a blend numerically increases in terms of egg quality, and this increase may be attributed to the main components that have antioxidant activity (Sherif et al., 2017).

The active ingredient in the phytobiotics may improve the small environment in the uterus (site of calcium deposition) and consequently have a positive effect on egg quality. Though the egg weight was influenced, no definite trend was followed, likewise the yolk proportion. The Haugh unit significantly increased as the phytobiotics is added to the diets. Likewise, the shell thickness. This indicates that the combined turmeric, clove, ginger, and garlic have a positive influence on egg quality.

5. Study Limitations

This study has some limitations that should be considered when interpreting the results. First, only one dietary inclusion level was evaluated for each phytobiotic combination, preventing the establishment of dose-response relationships or the identification of optimal inclusion levels. Second, the phytochemical composition of the blends, including the concentrations of major bioactive compounds such as allicin, curcumin, eugenol, and gingerols, was not determined.

Consequently, the biological responses observed could not be directly associated with the concentration of specific phytochemicals. Furthermore, intestinal microbiota, antioxidant status, digestive enzyme activity, and immune responses were not evaluated, limiting the understanding of the physiological mechanisms underlying the observed productive responses. Finally, an economic analysis was not performed; therefore, the cost-effectiveness of the phytobiotic blends for commercial egg production could not be assessed. Future studies should investigate different inclusion levels, characterize the phytochemical composition of the blends, evaluate the underlying physiological mechanisms, and include economic analyses to support practical recommendations for the poultry industry.

6. Conclusions

Under the experimental conditions of this study, dietary supplementation with phytobiotic blends did not adversely affect the growth performance, egg production, or egg quality of Isa Brown laying hens. The combination of garlic, clove, and turmeric (T3; 3 g kg⁻¹) was associated with improved egg production efficiency, whereas the combination of garlic, ginger, and clove (T2; 3 g kg⁻¹) promoted greater body weight gain and better feed conversion efficiency. These findings suggest that specific combinations of phytochemical feed additives may enhance productive performance in laying hens. However, because only one inclusion level was evaluated for each combination, further studies investigating different dietary inclusion levels, long-term effects, and economic feasibility are necessary before broader recommendations can be made for commercial poultry production.

7. Acknowledgments

I want to appreciate the Animal Use and Ethics Committee of the Department of Animal Production and Health of Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

8. Authors' Contributions

Trimisiyu Adewale Rafiu: project, laboratory analyses, article writing, project, experimental monitoring, laboratory analyses, post-evaluation revisions. *Eden Olusegun Okanlawon*: article writing, statistical analyses, revisions, project, laboratory analyses, statistics, post-evaluation revisions, publication. *Mariam Opeyemi Garuba*: laboratory analyses, statistical analysis, revisions, and publication. *Lailah Kehinde Azeez*: laboratory analyses, statistical analysis, revisions, and publication. *Peter Ayodeji Ogokunle*: laboratory analyses, statistical analysis, revisions, and publication. *Nifemi Esther Taiwo*: laboratory analyses, statistical analysis, revisions, and publication.

9. Conflicts of Interest

No conflicts of interest.

10. Ethics Approval

Yes applicable. Approval for this research was obtained from the Departmental Ethical Committee (LAUTECH-APH20-30) of the Faculty of Agricultural Science (Animal Welfare Board).

11. Artificial Intelligence Statement: Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors declare that generative AI-assisted tools were used solely for grammatical language editing and the preparation of the Graphical Abstract. All AI-generated content was carefully reviewed, verified, and approved by the authors, who assume full responsibility for the accuracy, integrity, and scientific content of the manuscript. The use of AI for the Graphical Abstract is disclosed in its figure caption. AI tools were not involved in the scientific design, data analysis, interpretation of results, or authorship of this manuscript.

12. References

- Abassi, A., Sanej, K. D., Moradi, S., Bazzaz, S., Esmaeili, A., Ghafourian, K., Sabahi, S., Lahouty, M., Akrami, S., Aslani, R., & Hosseini, H. (2023). Bioactive compounds and biological activities of *Allium sativum* L. *Bioactive Compounds in the Storage Organs of Plants*, 1-40. https://doi.org/10.1007/978-3-031-29006-0_11-1
- Ademola, S. G., Farimu, G. O., & Babatunde, G. M. (2009). Serum lipid, growth and haematological parameters of broilers fed garlic, ginger and their mixtures. *World Journal of Agricultural Science*, 5(1), 99-104.
- Albaqami, J. J., Handi, H., Narayanankutty, A., Visakh, N., Sasidharan, A., Kuttihodi, A. M., Famurewa, A. C., & Pathrose, B. (2022). Chemical composition and biological activities of the leaf essential oils of *Curcuma longa*, *Curcuma aromatica* and *Curcuma angustifolia*. *Antibiotics*, 11(11), 1547. <https://doi.org/10.3390/antibiotics11111547>
- Amir, M. Z., Seyyed, A. M., Peyman, H., & Hossein, S. A. (2022). Effects of turmeric (*Curcuma longa*) powder supplementation in laying hens' diet on production performance, blood biochemical parameters and egg quality traits. *Journal of Animal Physiology and Animal Nutrition*, 7(2), 691-702.
- Al-Kassie, G. A. M., Mohseen, A. M., & Abd-Al-Jaleel, R. A. (2011). Modification of productive performance and physiological aspects of broilers on the addition of a mixture of cumin and turmeric to the diet. *Research Opinion in Animal and Veterinary Science*, 1, 31-34.
- Al-Mufarrej, S. I., Al-Baadani, H. H. & Fazea, E. H. (2019). Effect of level of inclusion of clove (*Syzygium aromaticum*) powder in the diet on growth and histological changes in the intestines and livers of broiler chickens. *South African Journal of Animal Science*.
- Ayub, M. A., Goksen, G., Fatima, A., Zubair, M., Abid, M. A., & Starowicz, M. (2023). Comparison of conventional extraction techniques with superheated steam distillation on chemical characterization and biological activities of *Syzygium aromaticum* L. essential oil. *Separations*, 10(1), 27. <https://doi.org/10.3390/separations10010027>
- Durrani, F. R., Mohammed, I., Asal, S., Shhail, S. M., Naila, C., & Durrani, Z. (2006). Effect of different levels of feed added turmeric (*Curcuma longa*) on the performance of broiler chicks. *American Journal of Agriculture and Biological Science*, 1, 9-11.
- El Fager, O., Fager, A., Elkoraichi, I., Ouadghiri, Z., Boughroud, H., Rais, S., Ouaddari, A. E., Amrani, A. E., & Mtairag, E. M. (2026). Phenolic composition and preliminary biological activities of Moroccan *Allium sativum* extracts: *In vitro* and *In silico* evidence. *Compounds*, 6(2), 33. <https://doi.org/10.3390/compounds6020033>
- Gadde, U., Kim, W. K., & Lillehoi, H. S. (2017). Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: a review. *Animal Health Research Reviews*, 18(1), 26-45. <https://doi.org/10.1017/S1466252316000207>
- Google Earth Map. (2025).
- Gururani, S., Gairola, K., Kumar, R., Prakash, O., & Dubey, S. K. (2022). Altitudinal and geodographical variations in phytochemical composition and biological activities of *Curcuma longa* accession from Uttarakhand, the Himalayan region. *Journal of Food Processing and Preservation*. <https://doi.org/10.1111/jfpp.16384>
- Hashemi, S. R., & Davoodi, H. (2011). Herbal plants and their derivatives as growth and health promoters in animal nutrition. *Veterinary Research Communications*, 35(3), 169-180. <https://doi.org/10.1007/s11259-010-9458-2>
- Herawati, H. (2010). The effect of feeding red ginger as phytobiotic on body weight gain, feed conversion and internal organs condition of broiler. *International Journal of Poultry Science*, 9(10), 963-967.
- Hu, W. Yu, A., Bai, Q., Tang, H., Yang, B., Wang, M., & Kuang, H. (2023). Extraction, purification, structural characteristics, biological activities, and applications of the polysaccharides from *Zingiber officinale*

- Roscoe. (Ginger): A review. *Molecules*, 28(9), 3855. <https://doi.org/10.3390/molecules28093855>
- Jyotirmayee, B., Nayak, S. S., Mohapatra, N., Sahoo, S., Mishra, M., & Mahalik, G. (2024). Bioactive compounds and biological activities of turmeric (*Curcuma longa* L.). *Bioactive Compounds in the Storage organs of Plants*, 395-423. https://doi.org/10.1007/978-3-031-44746-4_20
- Kafi, A., Uddin, M. N., Khan, M. M. H & Haque, M. E. (2017). Effect of dietary supplementation of turmeric (*Curcuma longa*), ginger (*Zingiber officinale*) and their combination as feed additives on feed intake, growth performance and economics of broiler. *International Journal of Poultry Science*, 16(7), 257-265. <http://www.dx.doi.org/10.3923/ijps.2017.257.265>
- Kinati, C., Ameha, N., & Nurfta, A. (2021). Effective microorganisms, turmeric (*Curcuma longa*) as feed additives on production performance and sensory evaluation of eggs from white leghorn hens. *Livestock Research for Rural Development*, 33(1).
- Landers, T. F., Cohen, B., Wittum, T. E., & Larson, E. L. (2012). A review of antibiotic use in food animals: Perspective, policy and potential. *Public Health Reports*, 127(1), 4-22.
- Lillehoj, H. S., Liu, Y., Calsamiglia, S., Fernandez-Miyakawa, M. E., Chi, F., Cravens, R. L., Oh, S., & Gay, C. G. (2018). Phytochemicals as antibiotic alternatives to promote growth and enhance host health. *Veterinary Research*, 49, 76. <https://doi.org/10.1186/s13567-018-0562-6>
- Maggini, V., Semenzato, G., Gallo, E., Nunziata, A., Fano, R., & Firenzuoli, F. (2024). Antimicrobial activity of *Syzygium aromaticum* essential oil in human health treatment. *Molecules*, 29(5), 999. <https://doi.org/10.3390/molecules29050999>
- Moeini, M. M., Malekizadeh, M., & Ghazi, S. (2012). The effects of different levels of ginger (*Zingiber officinale* Rosc) and turmeric (*Curcuma longa* Linn) rhizomes powder on some blood metabolites and production performance characteristics of laying hens. *Journal Agricultural Science Technology*, 14, 127-134. <https://doi.org/10.5897/jmpr11.131>
- Mousa, B. H. (2019). Inclusion of garlic (*Allium sativum*) and turmeric (*Curcuma longa* L.) powder to laying hens' diets on egg quality traits, bacterial population and intestinal histomorphology. *Annals of Tropical Medicine and Public Health*, 22(12), 231-240. <http://doi.org/10.36295/ASRO.2019.221224>
- Natsir, M. H., Sjöfjan, O., Umam, K., Manab, A., & Widodo, E. (2010). Effects of liquid and encapsulated lactic acid in broiler diets on performances, intestinal characteristics and intestinal microflora. *Journal. Poultry Science*, 47(3), 240-243. <https://doi.org/10.2141/jpsa.009099>
- Natsir, M. H., Sjöfjan, O., & Widodo, E. (2013). Effect of either powder or encapsulated form of garlic and *Phyllanthus niruri* L. mixture on broiler performances, intestinal characteristics and intestinal microflora. *International. Journal of Poultry Science*, 12, 676-680. <https://dx.doi.org/10.3923/ijps.2013.676.680>
- Nisa, N., Alam, J., Rahman, T., Ratul, M. A. R., & Borsha, R. P. (2025). Effects of combined dietary additives with commercial feed on broiler production. *Turkish Journal of Agriculture – Food Science and Technology*, 13(9), 2647-2654. <https://doi.org/10.24925/turjaf.v13i9.2647-2654.7758>
- Okanlawon, E. O., Bello, K. O., Akinola, O. S., Adeola, A. A., & Ademolue, R. O. (2023). Qualitative and quantitative screening of turmeric, garlic, ginger and clove blend. *International Journal of Traditional and Natural Medicines*, 1(2), 2167-1141.
- Okanlawon, E. O. Bello, K. O., Akinola, O. S., & Adeola, A. A. (2024). Effect of dietary phytobiotics blend (turmeric, garlic, ginger and clove) on growth performance, carcass yield, haematology and serum biochemistry of rabbits. *Egyptian Journal of Rabbit Science*, 34(1), 35-46.
- Olayeni, T. B., Rafiu, T. A., Okanlawon, E. O., Olakiitan, S., Hussain, R., Adegoke, S. O., Akinlabi, J. A., & Akinboade, F. T. (2025). Utilization of graded levels of Jimson weed (*Datura stramonium*) and Turmeric (*Curcuma longa*) blend additive in laying birds' diet; *Agricultural and Biological Research*, 2(2), 1-6, <https://doi.org/10.14295/cerrado.v2i2.704>
- Platel, K., & Srinivasan, K. (2004). Digestive stimulant action of spices: A myth or reality? *Indian Journal of Medical Research*, 119, 167-179.
- Saraswati, T. R. (2013). The role of turmeric powder in lipid metabolism and its effect on quality of the first quail's egg. *Journal of the Indonesian Tropical Animal Agriculture*, 38(2), 123-130. <https://doi.org/10.14710/jitaa.38.2.123-130>
- Shalaby, E. A., Shanab, S. M. M., Hafez, R. M., & El-Ansary, A. E. (2023). Chemical constituents and biological

- activities of different extracts from ginger plant (*Zingiber officinale*). *Chemical and Biological Technologies in Agriculture*, 10. <https://doi.org/10.1186/s40538-023-00385-9>
- Sherif, F., & Ismail, E.G. (2017). Effects of plant spacing and its association with humic acid application on the growth, yield and active composition in *Curcuma longa*. *American Journal of Plant Biology*, 2(4), 106-113. <https://doi.org/10.11648/j.ajpb.20170204.12>
- Sreenivasa, S., Vinay, K., & Mohan, N. R. (2012). Phytochemical analysis, antibacterial and antioxidant activity of leaf extract of *Datura stramonium*. *International Journal of Science Research*, 01(02), 83-86.
- Statistical Analysis System User's guide (SAS,2002). Statistics. SAS Institute Inc, Cary. No 27513 U.S.
- Sunder, J., Jeyekumar, S., Sujatha, T., & Kundu, A. (2013). Effect of feeding of morical (*Morinda citrifolia*) based herbal supplement on production and egg quality in Nicobari fowl. *Academic Journals*, 7(40), 2999-3002. <https://doi.org/10.5897/JMPR12.1120>
- Toghyani, M., Gheisari, A., & Ghalamkari, G. (2011). Evaluation of cinnamon and garlic as antibiotic growth promoter substitutions on performance, immune responses, serum biochemical and haematological parameters in broiler chicks. *Livestock Science*, 138(1-3), 167-173.
- Wang, J., Deng, L., Chen, M., Che, Y., Li, L., Zhu, L., Chen, G., & Feng, T. (2024). Phytogetic feed additives as natural antibiotic alternatives in animal health and production: A review on the literature of the last decade. *Animal Nutrition*, 17, 244-264. <https://doi.org/10.1016/j.aninu.2024.01.012>
- Wen, C., Gu, Y., Tao, Z., Cheng, Z., Wang, T., & Zhou, Y. (2019). Effects of ginger extract on laying performance, egg quality, and antioxidant status of laying hens. *Animals*, 9(11), 857. <https://doi.org/10.3390/ani9110857>
- Windisch, W., Schedle, K., Plitzner, C., & Kroismayr, A. (2008). Use of phytogenic products as feed additives for swine and poultry. *Journal of Animal Science*, 86(Suppl. 14), E140-E148. <https://doi.org/10.2527/jas.2007-0459>
- Zhao, X., Yang, Z. B., Yang, W. R., Wang, Y., Jiang, S. Z., & Zhan, G. G. (2011). Effects of ginger root (*Zingiber officinale*) on laying performance and antioxidant status of laying hens and on dietary oxidation stability. *Poultry Science*, 90, 1720-1727. <https://doi.org/10.3382/ps.2010-01280>

Funding

Yes applicable.

Institutional Review Board Statement

Yes applicable. Approval for this research was obtained from the Departmental Ethical Committee (LAUTECH-APH20-30) of the Faculty of Agricultural Science (Animal Welfare Board) of Ladoké Akintola University of Technology, Ogbomoso, Nigeria

Informed Consent Statement

Not applicable for human studies. Animal welfare and care protocols were approved and monitored by the Departmental Ethical Committee (LAUTECH-APH20-30) of the Faculty of Agricultural Science (Animal Welfare Board).

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).