International Journal of Applied and Advanced Multidisciplinary Research (IJAAMR)
Vol.3, No.1, 2025: 13-24

Effect of Heliotropium Indicum Leaf Powder Supplemented Diets on Growth Performance and Carcass Characteristics of Weaned Pigs

Alagbe John Olujimi
Sumitra Research Institute, Gujarat
Corresponding Author: Alagbe John Olujimi dralagbe@outlook.com

A R T I C L E I N F O

Keywords: Antibiotics, Growth, Heliotropium Indicum, Phytocomponents, Performance

Received : 5 November
Revised : 17 December
Accepted: 23 January

A B S T R A C T

A 60 day experiment was carried out at Sumitra Research Institute, Gujarat, India to examine the effect of Heliotropium indicum leaf powder supplemented diets on growth performance and carcass characteristics of weaned pigs. A total of 50 crossbred male pigs (Landrace × Duroc) with initial body weight of 9.06 ± 0.44 kg weaned at 30 days of age were randomly divided into five treatments with six replicates (1 pig per replicate) and fed three experimental diets. Treatment 1; corn-soybeal mean (regular diet) without Heliotropium indicum leaf powder (control), treatment 2: regular diet with 0.50 g neomycin/kg diet while treatment 3, 4 and 5 received regular diet supplemented with Heliotropium indicum leaf powder at 100 g, 200g and 300 g per kg diet. A completely design was adopted and animals had unrestricted access to clean water and feed. Experimental results revealed that average daily body weight and average daily feed consumption varied from 0.14 to 0.26 kg and 0.71 to 0.82 kg respectively were higher among pigs in treatment 3, 4 and 5, intermediate in treatment 2 and lower in treatment 1 ($p<0.05$). Increasing the dietary supplementation of Heliotropium indicum leaf powder decreased the feed to gain ratio from 5.25 to 3.15 ($p<0.05$). Dressing percentage and weights of hind limbs, fore limbs, head, back, belly, heart, lungs and kidney were significantly ($p<0.05$) influenced except for the spleen ($p>0.05$). It was concluded that supplementing Heliotropium indicum leaf powder up to 300 g/kg in the diet of weaned pigs influenced their growth and pose no negative effect on the health status of animals

DOI: https://doi.org/10.59890/ijaamr.v3i1.310
ISSN-E: 3026-2437
https://journal.multitechpublisher.com/index.php/ijaamr

INTRODUCTION

Global concern over potential antibiotic resistance risks related to human health has driven interest in pig nutrition over the adoption of antibiotic free feeding systems (Caroline, 2022). Despite these debates on the role of antibiotics use in conferring antimicrobial resistance to human pathogens, many countries in Europe have issued a ban on the approval for antibiotics as growth promoters since January 2006 on precautionary grounds (Woodward, 2005; Jenny, 2022). Currently, there is an increasing interest to find alternative substances and strategies to improve the health status of farm animals for human consumption and the use of medicinal plant is considered as one of the potential alternative with no withdrawal period, no drug resistance, no environmental pollution and no toxic residue in final products (Jenny, 2021; Alagbe, 2024).

LITERATURE REVIEW

Heliotropium indicum is one of the underutilized perennial medicinal plant belonging to the family Boraginaceae and order Boraginales consisting of over 200 species distributed globally (Roy, 2015; Owolabi et al., 2015). The plant is found in many countries including, India, Pakistan, Bangladesh, Philippines, Nigeria, Kenya, Zambia, South Africa amongst others (Boye et al., 2012; Kumar et al., 2012). Heliotropium indicum can reach up to about 50 cm in height and its leaves are opposite or sub-opposite, alternate or sub-alternate and straight forward, sheet-shaped from ovate to elliptical, hairy, and sharp and 5 to 10 cm long in length (Pianowski et al., 2011; Kumar et al., 2014).In traditional system of medicine, the aqueous leaf extract and stem bark of Heliotropium indicum are used for the treatment of fever, stomach ache, arthritis, malaria, diarrhea, snake bite, kidney disease, sexually transmitted disease, urinary disease, cough, asthma, high blood pressure, epilepsy, convulsion, dysentery, cancer and general body pain (Ghosh et al., 2018; Suroowan et al., 2019).

Several phytochemicals or bioactive compounds have been identified in the plant including, tannins, triterpenoids, alkaloids, (example: heleurine N-oxide, cynoglossine, retronecine, helindicine and indicine, indicinine), saponins, steroids, flavonoids, triterpenoids, volatile oils amongst others (Odugbemi et al., 2007). The presence of these compounds makes the plant act as antimicrobial, antioxidant (Dash and Murthy, 2011), anti-inflammatory, cytotoxic (Veda et al., 2016), antibacterial, anti-helminthic, anticancer (Reddy, 2002), anti-diabetic, immune stimulator (Boye et al., 2012), digestive stimulator, antinociceptive (Chunthorng- Orn et al., 2016), analgesic, anti-hyperglycemic, anti-cataract (Abdel-Sattar et al., 2009), anti-plasmodial, antitussive (Odugbemi et al., 2007), antitumor, anti-allergic (Boye et al., 2012), larvicidal and pesticidal properties.

Previous studies have shown that supplementation of herbs or medicinal plants in the diet of animals could enhance the activities of endogenous enzymes in the gastrointestinal tract, thereby promoting absorption of nutrients and efficiency of feed utilization (Shittu et al., 20024). However, outcome from most of these studies have not been consistent, these discrepancies could be influenced by several factors such as, levels of supplementation (Daniel et al., 2023), processing method (Musa et al., 2020), composition of phyto-components amongst others. For instance, a study carried out by Alagbe et al. (2024), revealed

that dietary supplementation of Heliotropium indicum leaf powder up to 80 g/kg in the diet of weaned pigs did not influence their growth performance. There is need to establish an optimum level and also provide scientific basis for the use of Heliotropium indicum leaf powder in animals feed. This research will not only address the increasing rate of antimicrobial resistance, it will also promote food safety and environmental sustainability.

Therefore this study was designed to evaluate the effect of Heliotropium indicum leaf powder supplemented diets on growth performance and carcass characteristics of weaned pigs.

METHODOLOGY

Experimental Location, Duration, Collection and Preparation of Heliotropium Indicum Leaf Powder

Sumitra Research Institute's Piggery unit in Gujarat, India was used for the experiment and animals were cared for following the guidelines and management procedures approved by Animal Production department of Sumitra Research Institute, Gujarat. The whole experimental period is eight weeks.

Heliotropium indicum leaves were collected within the premises of Sumitra Research Institute, Gujarat, India before it was sent to the institute's taxonomy department for proper identification and a registration number GH/008/2023 was assigned after authentication. Collected leaves were shade dried for 13 days until the leaves turns pale brown and a constant weight was achieved before it was grounded into powder using an electric blender. The powdered leaf was collected into a labeled air tight plastic bucket before it was taken to the laboratory for further evaluation.

Management of Experimental Animals, Diet and Design

A total of 50 crossbred male pigs (Landrace × Duroc) with initial body weight of 9.06 ± 0.44 kg weaned at 30 days of age were randomly divided into five treatments with six replicates (1 pig per replicate) and fed three experimental diets. The feed used for this experiment was corn-soy bean meal based diet which was consistent with the National Research Council's requirement for growing pigs (NRC, 2012) as presented in Table 1. Treatment 1; corn-soybeal mean (regular diet) without Heliotropium indicum leaf powder (control), treatment 2: regular diet with 0.50 g neomycin/kg diet while treatment 3, 4 and 5 received regular diet supplemented with Heliotropium indicum leaf powder at 100 g, 200g and 300 g per kg diet. The dietary treatment began on day eight after one week adjustment period and pigs were fed thrice daily (6:30, 12:00 and 15:00 H). They also had unrestricted access to clean fresh water and a completely randomized design model was adopted. Average initial body weight was taken immediately upon the arrival of pigs using a digital scale and thereafter on a weekly basis. Average body weight gain, daily weight gain, average total feed consumption and daily feed consumption were all calculated. Average body weight gain (expressed in kg) = Average final body weight minus average initial body weight.

- Daily weight gain (in kg) = Average final body weight minus average initial body weight divided by the experimental period in days.

- Total feed consumption = Left over minus feed served (expressed in kg)
- Daily feed consumption (kg) = Left over minus feed served divided by the experimental period in days

Carcass Characteristics Evaluation

At the end of the experiment five pigs were selected per treatment and their average body weight was measured. Pigs were feed starved for 12 hours and given access to water before they were stunned, bled and their hair was removed after using sharp kitchen knife, eviscerated and cut into different parts. Weights of head, belly, fore limb, hind limb, back and those of organs (heart, lungs, kidney and spleen) were measured. Dressing percentage was estimated using the following formula:

Dressing % = Carcass weight divided by Live weight multiplied by 100

Phytocomponents in Heliotropium Indicum Leaf Powder

Portable GriffinTM G510 gas chromatograph mass spectrometer was used to evaluate the various phytocomponents in Heliotropium indicum leaf powder. Quantification of various compounds was carried out at different optical densities. For tannins, saponins, alkaloids, flavonoids, steroids, glycosides, triterpenoids and anthraquinones at 310 nm, 450 nm, 280 nm, 520 nm, 660 nm, 360 nm, 570 nm and 640 nm respectively.

Proximate Determination of Experimental Diet

Determination of proximate components was carried out using Perkin Elmer benchtop near infra-red analyzer (Netherlands). Kit was adjusted at an optical bandwidth, spectral resolution, wavelength range, and wavelength precision of 10.44 nm, 0.5 nm/data point, 1700 nm and 0.5 nm respectively according to the manufacturers' recommendation.

Statistical Analysis

Data obtained on growth performance and carcass characteristics was subjected to one -way analysis of variance using Statistical Package for Social Sciences (version 25). Significant differences among the treatments were subjected to comparisons using the Duncan multiple range test of the same software. All differences were considered to be statistically significant when $p < 0.05$.

RESULT

Composition and nutrient levels of experimental diets is presented in Table 1. The diet contains crude protein (23.18 %), crude fibre (5.05 %), ether extract (3.98 %), ash (3.62 %) and energy (2800.6 Kcal/kg).

As presented in Table 2, phytocomponents in Heliotropium indicum leaf powder. Result revealed the presence of flavonoids (609.7 mg/g), triterpenoids (258.9 mg/g), tannins (196.7 mg/g), alkaloids (102.6 mg/g), steroids (90.50 mg/g), saponins (85.31 mg/g), anthraquinones (30.65 mg/g) and glycosides (25.11 mg/g) in their order of abundance.

As displayed in Table 3, growth performance of weaned rabbits fed with Heliotropium indicum leaf powder. Average daily weight gain and average daily feed consumption of pigs fed treatment 3 (100 g Heliotropium indicum leaf powder/kg diet), treatment 4 (200 g Heliotropium indicum leaf powder/kg diet) and treatment 5 (300 g Heliotropium indicum leaf powder/kg diet) were similar

($p>0.05$) but significantly higher ($p<0.05$) than those which received treatment 2 (0.25 g neomycin/kg diet) and treatment 1 (without Heliotropium indicum leaf powder/kg diet). Increase in the dietary supplementation of Heliotropium indicum leaf powder significantly decreased ($p<0.05$) feed to gain ratio of pigs compared with treatment 2 and treatment 1.

Carcass characteristics of weaned rabbits fed with Heliotropium indicum leaf powder (Table 4). Carcass and dressing percentage follow similar trend as Heliotropium indicum leaf powder increased these parameters compared to the other groups. Dressing percentage values were lowest in treatment 1, intermediate in treatment 2 and highest in treatment 3, 4 and 5 ($p<0.05$). Weights of head, back, fore limb, hind limbs, belly, kidney, lungs and heart were highest in treatments supplemented with Heliotropium indicum leaf powder (treatment 3, 4 and 5), intermediate in treatment 2 and lower in treatment 1 except for those values recorded for spleen which was not influenced ($p>0.05$) by the treatment.

DISCUSSION

The outcome on average daily body weight showed that pigs which received Heliotropium indicum leaf powder had higher values compared to the other group. This suggests that the presence of phytocomponents in Heliotropium indicum leaf powder could stimulate or enhance digestive enzyme activities and absorption of nutrients leading to a better nutrient utilization which in turn translates to a higher weight gain in pigs (Alagbe, 2024). Though there was similarity in average weight gain among pigs fed diet supplemented with Heliotropium indicum leaf powder (treatment 3, 4 and 5) followed by those which received neomycin (treatment 2) and lowest in treatment 1 suggesting that neomcycin was also an effective synthetic growth promoter. Previous reports by shown that phytocomponents in medicinal plants possess vital nutritional and medicinal properties (Singh et al., 2022; Ojediran et al., 2024a). The presence of flavonoids, tannins, alkaloids, saponins, triterpenoids, steroids, amthraquinones and glycosides in Heliotropium indicum leaf powder indicates multiple pharmacological functions such as, anti-inflammatory (Musa et al., 2020), antioxidant, antiviral, antifungal (Ojediran et al., 2024b), immune-stimulators (Adewale et al., 2021), gastro-protective (John, 2024e), anticancer, anti-diabetic, antimicrobial (Daniel et al., 2023), anti-helminthic, antidiarrheal (John, 2024d), antibacterial amongst others. Result on average weight gain was similar to the earlier report by (). Conversely, (Alagbe et al., 2024) found out supplementation of Heliotropium indicum leaf powder at 30 g/kg diet did not influence daily body weight of growing pigs. The discrepancies in results could be attributed to levels of supplementation, nature of bioactive compounds in the test material as well as method of preparation (Adewale et al., 2021). Increase in daily feed consumption especially among pigs fed with Heliotropium indicum leaf powder aligns with the notion that dietary supplementation of medicinal plants can improve palatability of diet thereby facilitating taste receptors in pigs. This result conforms to the earlier report by (John, 2024a; Omokore and Alagbe, 2019) when phytogenics was fed to growing rabbits. Feed to gain ratio which varied from 3.15 to 5.25 decreased as the level of Heliotropium indicum leaf powder increased

in the diet of pigs suggesting efficiency in feed utilization in the treatment. This further reaffirms that phytocomponents in Heliotropium indicum leaf powder have the capability to stabilize gut against proliferation by pathogenic organisms (Shittu et al., 2024; John, 2024b). Result obtained is in agreement with the reports by Upadhaya (2016a, 2016b) who discovered that growing pigs fed blend of phytogenics had a feed to gain ratio of 3.23 - 5.50.

Dressing percentage are useful indices to determine meat yield in animals. Findings of this present study (62.62 to 73.94 %) was similar to the result of a study by Zhou et al. (2013) who showed that dressing percentage of growing pigs fed Coptis chinensis herb extract varied from 61.94 to 74.05 % as well as those reported by Yan et al. (2012) who discovered that dressing percentage of weanling pigs fed diet supplemented with Houttuynia cordata and Taraxacum officinale varied from 60.09 to 73.00 %. The present experiment revealed that weights of back, belly, fore limb, hind limb, kidney, lungs and heart was influenced by Heliotropium indicum leaf powder in the diet which was a result of the increase in dressing percentage. This result suggests that Heliotropium indicum leaf powder is non-toxic and can modulate the retention time of feed in the gastro intestinal tract of pigs (Muritala et al., 2022). Lei et al. (2018); Ao te al. (2020); Jeong and Kim (2015), discovered that weights of head, back, fore limb and hind limb varied from 2.00 - 3.80 kg, 3.00 -5.00 kg, 3.80 - 5.50 kg and 3.90 - 5.70 kg respectively in growing pigs fed diet supplemented with natural and fermented herbs. The higher values recorded in heart and lungs of pigs fed Heliotropium indicum leaf powder compared to the other group suggests sufficient supply of oxygen in the system of pigs (Olafadehan et al., 2020). The kidney plays a key role in the waste removal as well as extra water to make urine (John, 2024d). Supplementation of Heliotropium indicum leaf powder did not influence weight of spleen suggesting that the integrity of the immune system was not compromised (Daniel et al., 2023). Heliotropium indicum leaf powder is known to contain flavonoids which possess antioxidant properties and scavenging the activities of free radicals (Singh et al., 2022).

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that Heliotropium indicum leaf powder has both nutritional and medicinal properties. It also contains compounds that has no toxic side effects. Results on growth revealed that supplementing Heliotropium indicum leaf powder up to 300 g/kg had no deleterious effect on the growth performance as well as organs in the animal's body. The supplementation of Heliotropium indicum leaf powder can also help to address multidrug resistance and promote food safety.

Table 1. Composition and Nutrient Levels of Experimental Diets

Ingredients	Inclusion (%)
Maize	50.00
Rice bran	5.50
Soy bean meal	33.00
Oyster shell	3.00

Bone meal	6.00
HL-Lysine	0.25
DL-Methionine	0.25
*Growers premix®	0.25
TNRoxin binder®	0.02
Sodium chloride	0.30
Total	100.0
Determined analysis (expressed in %)	
Crude protein	23.18
Crude fibre	5.05
Ether extract	3.98
Ash	3.62
Metabolizable energy (Kcal/kg)	2800.6

Table 2. Phytocomponents in Heliotropium Indicum Leaf Powder

Phytocomponents	Composition (expressed in mg/g)
Tannins	196.7
Alkaloids	102.6
Saponins	85.31
Flavonoids	609.7
Steroids	90.50
Glycosides	25.11
Anthraquinones	30.65
Triterpenods	258.9

Table 3. Growth Performance of Weaned Rabbits Fed with Heliotropium Indicum Leaf Powder

Parameters	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	SEM
Initial body weight (kg)	9.09	9.08	9.06	9.07	9.06	
Final body weight (kg)	17.21^{c}	19.58^{b}	24.10^{a}	24.45^{a}	24.67^{a}	
Average body weight gain (kg)	8.12^{c}	10.50^{b}	15.04^{a}	15.38^{a}	15.61^{a}	
Average daily weight gain (kg)	0.14^{c}	0.18^{b}	0.25^{a}	0.26^{a}	0.26^{a}	
Average feed consumption (kg)	42.65^{c}	44.32^{b}	49.33^{a}	49.04^{a}	49.22^{a}	
Average daily consumption (kg)	0.71^{c}	0.74^{b}	0.82^{a}	0.82^{a}	0.82^{a}	
Feed: gain ratio	5.25^{a}	4.22^{b}	3.27^{c}	3.18^{c}	3.15^{c}	

Values followed by different letters were significantly different ($p<0.05$); treatment 1: basal/regular diet without Heliotropium indicum leaf powder (control); treatment 2 (Neomycin 0.25 g/kg diet), treatment 3, 4 and 5: basal diet supplemented with Heliotropium indicum leaf powder at 100 g, 200 g, and 300 g per kg respectively; SEM: standard error of mean.

Table 4. Carcass Characteristics of Weaned Rabbits Fed with *Heliotropium Indicum* Leaf Powder

Variables (kg)	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	SEM
Live weight (kg)	18.06^{c}	20.76^{b}	25.87^{a}	25.90^{a}	25.98^{a}	
Carcass weight	11.31^{c}	13.87^{b}	19.10^{a}	19.15^{a}	19.21^{a}	
Dressing percentage	62.62^{c}	66.81^{b}	73.83^{a}	73.93^{a}	73.94^{a}	
Head	2.41^{b}	2.67^{b}	3.39^{a}	3.42^{a}	3.48^{a}	
Back	3.04^{b}	3.56^{b}	4.04^{a}	4.11^{a}	4.15^{a}	
Hind limb	4.02^{b}	4.56^{b}	5.00^{a}	5.02^{a}	5.05^{a}	
Fore limb	3.97^{b}	4.43^{b}	5.06^{a}	5.18^{a}	5.26^{a}	
Belly	2.11^{b}	2.53^{b}	3.07^{a}	3.18^{a}	3.22^{a}	
Kidney	0.03^{c}	0.12^{b}	0.19^{a}	0.20^{a}	0.21^{a}	
Lungs	0.18^{b}	0.20^{b}	0.37^{a}	0.40^{a}	0.41^{a}	
Spleen	0.03	0.04	0.04	0.04	0.04	
Heart	0.16^{c}	0.25^{b}	0.42^{a}	0.48^{a}	0.49^{a}	

Values followed by different letters were significantly different ($p<0.05$); treatment 1: basal/regular diet without Heliotropium indicum leaf powder (control); treatment 2 (Neomycin 0.25 g/kg diet), treatment 3, 4 and 5: basal diet supplemented with Heliotropium indicum leaf powder at 100 g, 200 g, and 300 g per kg respectively; SEM: standard error of mean.

REFERENCES

Abdel-Sattar, E., Harraz, F.M., Al-Ansari, S.M., El-Mekkawy, S., Ichino, C., Kiyohara, H., 2009. Antiplasmodial and antitrypanosomal activity of plants from the Kingdom of Saudi Arabia. J. Nat. Med. 63 (2), 232–239.

Adewale, A.O., Alagbe, J.O., Adeoye, Adekemi. O. (2021). Dietary Supplementation of Rauvolfia Vomitoria Root Extract as A Phytogenic Feed Additive in Growing Rabbit Diets: Haematology and serum biochemical indices. International Journal of Orange Technologies, 3(3): 1-12.

Alagbe O. J., Shittu, D. M., Ojediran T. K., Anorue, D. N., Anaso E. U and Ramalan, S. N. (2024). Heliotropium Indicum Leaf Powder Supplemented in the Diet of Weaned Pigs: Impact on Growth Performance, Heamatological and Serum Biochemical Indices. Journal of Web Technologies and Applied Agriculture, 1(1): 24-30.

Alagbe Olujimi John, Daniel Nnadozie Anuore, Shittu Muritala Daniel, Emiola Adewale, Akande Taiwo and Adegoke Adegbite Emmanuel (2023). Impact of dietary supplementation of Carica papaya essential oil on the blood chemistry of broiler chickens. Science Letters, 11(3): 105 - 110. 30.

Alagbe, J.O (2023). Investigating the effects of dietary supplementation of Eucalyptus camaldulensis essential oil on the growth performance, nutrient digestibility and caecal fermentation of weaned rabbits. Research in: Agricultural and Veterinary Sciences, 7(3): 139 - 148.

Alagbe, J.O. (2024). Impact of dietary supplementation of Rhamnus prinoides leaf extract on the growth performance, nutrient retention and intestinal microbial count of Japanese quails. Brazilian Journal of Science, 3(5), 40-50.

Anderson, G., Coee, F., 1996. Ethanobotany of the garifuna of East Nicaragua. Econ Bot 50, 71–107. Alwahibi, M., Bukhary, N., 2013. Anatomical study of four species of Heliotropium L. (Boraginaceae) from Saudi Arabia. Afr. J. Plant Sci. 7 (1), 35–42.

Ao, X., Lei, Y. and Kim, I.H. (2020) Effect of flavor supplementation on growth performance, nutrient digestibility, blood profiles, and carcass quality in growing-finishing pigs. Can. J. Anim. Sci., 100(1): 133-139.

Boye, A., G. A. Koffuor, P. Amoateng, E. O. Ameyaw, and A. K. Abaitey (2012). "Analgesic activity and safety assessment of Heliotropium indicum Linn. (Boraginaceae) in rodents," International Journal of Pharmacology, 8(2): 91–100.

Boye, A., Koffuor, G., Amoateng, P., Ameyaw, E., 2012. Abaitey A. Analgesic activity and safety assessment of Heliotropium indicum Linn. (Boraginaceae) in rodents. Int. J. Pharm. 8, 91–100

Caroline, J (2022). Improving feed efficiency and gut integrity of E.coli challenged weaned pigs. International Poultry Magazine, 8(7): 1-2.

Chunthorng-Orn, J., B. Dechayont, P. Phuaklee, O. Prajuabjinda, T. Juckmeta, and A. Itharat (2016). "Cytotoxic, anti-inflammatory and antioxidant activities of Heliotropium indicum extracts," Journal of the Medical Association of Failand, 99(4): S102–S109.

Daniel Nnadozie Anorue, Friday Ubong and Alagbe Olujimi John (2023). Investigating the effects of pawpaw (Carica papaya) essential oil dietary supplementation on the growth performance and carcass characteristics of broilers. Research in: Agricultural and Veterinary Sciences, 7(3): 164 - 174.

Dash, G.K and P. N. Murthy (2011). "Studies on wound healing activity of Heliotropium indicum Linn. leaves on rats," ISRN Pharmacology, vol. 2011, Article ID 847980, 2011

Ghosh, P. Das, C. Das, S. Mahapatra, and S. Chatterjee (2018). "Morphological characteristics and phytopharmacological detailing of hatishur (Heliotropium indicum Linn.): a concise review," Journal of Pharmacognosy and Phytochemistry, 7(5): 1900–1907.

Jenny, C. (2022). Effects of acidifier supplemented diets on egg quality and performance. International Poultry Magazine, 24(2): 3-6.

Jeong, J.S. and Kim, I.H. (2015) Effect of probiotic bacteria-fermented medicinal plants (Gynura procumbens, Rehmannia glutinosa, Scutellaria baicalensis) as performance enhancers in growing pigs. Anim. Sci. J., 86(6): 603-609.

John, A.O. (2024a). Impact of dietary supplementation of Rhamnus prinoides leaf extract on the growth performance, nutrient retention and intestinal microbial count of Japanese quails. Brazilian Journal of Science, 3(5): 40-50.

John, A.O. (2024b). Clerodendron splendens leaf extract supplementation in weaner rabbits: impact on growth performance, haematology and intestinal microbial population. Cerrado: Agricultural and Biological Research, 1(1): 21-31.

John, A.O. (2024c). Effect of coconut shell extract on the growth performance and some haemato-biochemical parameters of broiler chicken. Brazilian Journal of Science, 3(6): 82-95.

John, A.O. (2024d). Effect of performance, serum biochemistry and heamatological components of feeding Japanese quails phytogenic feed additions comprising Megaphrynium macrostachyum leaves. Brazilian Journal of Science, 3(5): 51-64.

John, A.O. (2024e). Growth performance, haemato-biochemical indices of broiler chicken fed Aristochia indica as a phytogenic feed additive. Cerrado: Agricultural and Biological Research, 1(1): 42-53.

Kumar, M.S., S. Chaudhury, and S. Balachandran (2014). "In vitro callus culture of Heliotropium indicum Linn. for assessment of total phenolic and flavonoid content and antioxidant activity," Applied Biochemistry and Biotechnology, 174(8): 2897–2909, 2014.

Kumar, S. Kumar, S. Balachandran, and S. Chaudhury, (2012). "Influence of incubation temperatures on total phenolic, flavonoids content and free radical scavenging activity of callus from Heliotropium indicum L," Asian Journal of Pharmaceutical Research, 2(4): 2231–5683, 2012.

Lei, X.J., Yun, H.M. and Kim, I.H. (2018) Effects of dietary supplementation of natural and fermented herbs on growth performance, nutrient digestibility, blood parameters, meat quality and fatty acid composition in growing-finishing pigs. Ital. J. Anim. Sci., 17(4): 984-993.

Muritala, Daniel Shittu., Alagbe, J.O., Ojebiyi, O.O., Ojediran, T.K and Rafiu, T.A. (2022). Growth performance and haematological and serum biochemical parameters of broiler chickens given varied concentrations of Polyalthia longifolia leaf extract in place of conventional antibiotics. Animal Science and Genetics 18(2): 57-71.

Musa, B., Alagbe, J.O., Adegbite Motunrade Betty, Omokore, E.A. (2020). Growth performance, caeca microbial population and immune response of broiler chicks fed aqueous extract of Balanites aegyptiaca and Alchornea cordifolia stem bark mixture. United Journal for Research and Technology, 2(2):13-21.

National Academies Press. (2012) Nutrient Requirements of Swine. National Academies Press, Washington, DC, USA

Odugbemi, T.O., O. R. Akinsulire, I. E. Aibinu, and P. O. Fabeku (2007). "Medicinal plants useful for malaria therapy in Okeigbo, Ondo state,

Southwest Nigeria," African Journal of Traditional, Complementary and Alternative Medicines, 4(2): 191–198, 2007.

Ojediran, T.K., Emiola, I.A., Durojaye, V and Alagbe, J.O. (2024b). Analysis of Kigellia africana fruit's powder antioxidant and phytochemical properties. Brazilian Journal of Science, 3(7): 38-49.

Ojediran, T.K., Emiola, I.A., Durojaye, V and John Alagbe (2024a). Proximate, vitamin and GC-MS profiling of Kigella africana powder. Cerrado: Agricultural and Biological Research, 1(1): 13-20.

Olafadehan, O.A., Oluwafemi, R.A and Alagbe, J.O. (2020). Carcass quality, nutrient retention and caeca microbial population of broiler chicks administered Rolfe (*Daniellia oliveri*) leaf extract as an antibiotic alternative. *Journal of Drug Discovery*. 14(33):146-154.

Oluwatoyin, S., G. I. Ndukwe, and A. Joseph, "Phytochemical and antimicrobial studies on the aerial parts of Heliotropium indicum Linn," Annals of Biological Research, 2(2): 129–136, 2011.

Omokore, E.O and Alagbe, J.O. (2019). Efficacy of dried Phyllantus amarus leaf meal as an herbal feed additive on the growth performance, haematology and serum biochemistry of growing rabbits. International Journal of Academic Research and Development. 4(3): 97-104.

Owolabi, M.A., O. O. Oribayo, G. E. Ukpo, G. O. Mbaka, and O. E. Akindehin (2015). "A 5-month toxicity study of the ethanol extract of the leaves of Heliotropium indicum in Sprague Dawley rats after oral administration," Nigerian Quarterly Journal of Hospital Medicine, 25(3): 184–192.

Pianowski, L.F., J. B. Calixto, and C. P. Chaves (2011). Pharmaceutical Oral Product Obtained from Parts of Heliotropium Plants, 2011

Rahman, M.A., M. Mia, and Shahid, I. (2011). "Pharmacological and phytochemical screen activities of roots of Heliotropium indicum Linn," PharmacologyOnLine, 1(1): 185–192, 2011.

Reddy, J.S., P. R. Rao, and M. S. Reddy. (2002). "Wound healing effects of Heliotropium indicum, Plumbago zeylanicum and Acalypha indica in rats," Journal of Ethnopharmacology, 79(2): 249–251.

Roy, A. (2015). "Pharmacological activities of Indian Heliotrope (Heliotropium indicum L.): a review," Journal of Pharmacognosy and Phytochemistry, 4(3): 101–104, 2015.

Shittu, M.D., Alagbe, J.O., Alaba, O., Okanlawon, E.O., Adelakun, F.A., Emmanuel, E.O and Adejumo, D.O. (2024). Effect of ginger, garlic and Negro pepper on the gut microbes, gut histomorphometry and pathological assessment of selected organs of broiler chickens. Association of Deans of Agriculture in Nigerian Universities, 5: 105-121.

Singh Sharma., Alagbe Olujimi John., Liu Xing., Sharma Ram and Kumar Amita (2022). Comparative analysis of ethanolic Juniperus thurifera leaf, stem bark and root extract using gas chromatography and mass spectroemetry. International Journal of Agriculture and Animal Production, 2(6): 18-27.

Suroowan, K. B. Pynee, and M. F. Mahomoodally (2019). "A comprehensive review of ethnopharmacologically important medicinal plant species from Mauritius," South African Journal of Botany, 12(2): 189–213, 2019

Upadhaya S.D., Kim S.J., Kim I.H. (2016 b). Effects of gel-based phytogenic feed supplement on growth performance, nutrient digestibility, blood characteristics and intestinal morphology in weanling pigs. Journal of Applied Animal Research, 44: 384–389.

Upadhaya S.D., Lee K.Y., Kim I.H. (2016 a). Effect of protected organic acid blends on growth performance, nutrient digestibility and faecal micro flora in growing pigs. Journal of Applied Animal Research, 44: 232–242. 27.

Veda, V.T., K. S. Sasi, B. R. Asokan, S. Sengottuvelu, and S. Jaikumar (2016). "Anticataract activity of ethanolic extract of Heliotropium indicum leaves on galactose induced cataract in rats," International Journal of Pharmacology & Toxicology, 5(1): 18–20.

Woodward, P. (2005). Impact of a ban on animal by-products and antibiotic growth promoters – European experience. Pages: 46-57. In: Proceedings, Thirty Second Annual Carolina Poultry Nutrition Conference, North Carolina, October, 26-27.

Yan L., Zhang Z.F., Park J.C., Kim I.H. (2012). Evaluation of Houttuynia cordata and Taraxacum officinale on growth performance, nutrient digestibility, blood characteristics and fecal microbial shedding in weaning pigs. Asian-Australas. Journal of Animal Science, 25: 1439– 1444.

Zhou T.X., Zhang Z.F., Kim I.H. (2013). Effects of dietary Coptis chinensis herb extract on growth performance, nutrient digestibility, blood characteristics and meat quality in growing-finishing pigs. Asian-Aust. J. Anim. Sci., 26: 108–115