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Original Article

Beneficial effect of phytobiotic and synbiotic feed additives on growth performance, carcass characteristics and meat quality of broiler chicken

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Abstract
Phytobiotic and synbiotic feed additives are commonly used in animal diets to stimulate growth performance, and improve welfare, health, and quality of meat. Thus, this study was designed to examine the effect of phytobiotic (Superliv powder®, SP) and synbiotic (Bacflora-F®, BF) feed additives on growth performance, carcass characteristics, and meat quality of broiler chickens. A total of 120 day-old Arbor Acres broiler chicks were randomly allotted to four dietary treatments, with three replicates of 10 birds per treatment as follows, Diet 1 (basal/control diet), Diet 2 (basal + 0.05 g/kg SP), Diet 3 (basal + 1g/kg *BF) and Diet 4 (basal* + 0.05g/kg SP and 1g/kg *BF).* The dietary supplementation of SP and BF feed additives significantly ($p < 0.05$) increased the body weight gain of the broiler chickens compared to the control. The broiler chickens fed diets supplemented with SP and BF had higher ($p < 0.05$) slaughter weights and dressing percentages compared to the control. No significant differences ($p > 0.05$) were observed in the weight of the internal organs of the broiler chickens across the treatments. However, the supplementation of SP and BF additives in the diets significantly ($p < 0.05$) lowered the cholesterol content in the breast muscle of the broiler chickens compared to the control group. This study has showed that SP and BF could be used as potential feed supplements in a broiler diet to enhance growth performance, maintain the carcass traits and reduce meat cholesterol levels in chicken.

INTRODUCTION

Nowadays, with advancements in genetic selection, management, biosecurity and nutrition, modern broiler chickens are raised to reach a live weight of 2.5 - 3.5kg at less than eight weeks of age. Particularly, the inclusion of feed additives in broiler nutrition plays a significant role in accelerating growth, ensuring protection against pathogenic infections and improving the quality of meat within a short production cycle (Van der Aar *et al*., 2017). However, the continuous use of antibiotic growth promoters/feed additives in poultry nutrition has been reported to cause antibiotic resistance to pathogenic bacteria

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and the deposition of antimicrobial residues in meat products, which are detrimental to consumer health (Lipiński *et al.*, 2019). Because of this, the inclusion of natural substances such as phytobiotic, symbiotic, enzymes and other feed additives have been promoted as a potential replacement for antibiotic growth promoters in poultry production, since its ban in 2006 (Kim *et al*., 2019; Flees *et al*., 2020).

Phytobiotics are plant-derived products, such as herbs, spices and their extracts, that possess growth-promoting potential, huge antioxidant capacity and high immune-modulatory properties (Van der Aar *et al.,* 2017). Synbiotics, on the other hand, contain a blend of both probiotics and prebiotics which are used to improve the survival and implantation of beneficial live microbial dietary supplements in the gastro-intestinal tract in order to stimulate the growth and/or activate the metabolism of one or a certain number of health-promoting bacteria, and thus improving host welfare (Markowiak and Śliżewska, 2018)

Among the examples of phytobiotics and synbiotics that can be utilized in poultry nutrition to improve birds' performance are Superliv® powder and Bacflora-F® feed additives, respectively. Superliv® herbal powder is made from a mixture of 18 different medicinal plant leaves which are rich in bioactive compounds with a high ability to exert antioxidant, antimicrobial, hypo-lipidemic, hypo-cholesterolemic, immune-modulatory and digestive stimulatory activities in a biological system (Pandey, 2019). It is a natural growth promoter for poultry broilers due to its lever tonic properties. Bacflora-F® is a feed additive that contains probiotic, prebiotic and acidifier that can promote optimum digestion, increase weight gain, improve feed conversion, and overall performance of birds (Agboola *et al.,* 2021).

Reports on the dietary supplementation of Superliv® powder have shown that it could increase the growth rate, carcass yield and meat antioxidants of broiler chickens (Orlowski *et al.*, 2018; Lipiński *et al*., 2019). However, little or no work has been reported on the effect of Bacflora-F® as a feed additive on broiler performance. The use of the combination of phytobiotic and synbiotic feed additives could produce synergistic effects on performance and health status of broiler chickens during production. Therefore, this study aimed to determine the effect of Suplerliv® and Bacflor-F® feed additives on the growth performance and meat quality of broiler chicken.

MATERIALS AND METHODS

The study was conducted at the Poultry Unit of the Teaching and Research Farm, Adekunle Ajasin University, Akungba Akoko, Nigeria. Akungba-Akoko is situated at 326m above sea level and lies at a latitude of 07° 28' 11″ North and longitude of 5° 44'10″ East (NGIA, 2020). It has a mean minimum and maximum temperature of 21 and 32 °C, and precipitation of 1500 - 2000 mm per annum. The annual relative humidity range is 41 - 91% (Olabode, 2014). The entire study was carried out for eight weeks following the research ethics and guidelines of the Animal Science Department of the institution.

Experimental diets and animals

The feed additives, Superliv powder® and Bacflora-F®, were obtained from Farm Support Services Ltd., Akure, Nigeria. The

Superliv powder® (SP) contains a mixture of 18 different plant leaves while Bacflora-F® (BF) contains a mixture of probiotic, prebiotic and acidifier blends. Two basal diets [starter (0-28 days) and finisher phase (28-56 days)] were formulated to meet the broiler's nutritional requirement (Table 1). At each phase, the experimental diets were divided into four treatments and designated as Diet 1 (basal/control diet), Diet 2 (basal + 0.05 g/kg SP), Diet 3 (basal +. 1g/kg *BF) and Diet 4 (basal* + 0.05g/kg SP and 1g/kg *BF).* One hundred and twenty 1-day-old Arbor Acres broiler chicks were randomly distributed to four dietary treatments. Each treatment was replicated three times. Thirty birds were assigned to each treatment (10 birds/replicate) in a completely randomized design (CRD)**.** The birds were housed in their respective pen (200 x 100 cm) with the floor covered with wood shavings. The temperature of the house was maintained within 31°C ± 2 for the first 7 days and reduced by 2°C after each consecutive 7 days until the house temperature was 26 ± 2 °C. Light was provided 23 hours/day while feed and water were provided *ad libitum* throughout the eight weeks feeding trial.

Experimental procedures and analysis

At the beginning of the experiment, birds in each replicate were weighed individually and subsequently on weekly basis using a 10.1kg capacity precision weighing scale (Model A and D weighing GF-10k industrial, balance, Japan). Also data on feed intake, body weight (BW) gain and feed conversion ratio (FCR) were obtained from the experimental birds. Feed intake was calculated as the difference between feed given and feed not consumed. The final body weight was calculated as the

Table 1. Composition and nutrient contents of experimental basal diets

Ingredients (%)	Starter (1 to 28 days)	Grower (29 to 56 days)
Maize	52.35	59.35
Wheat offal	7.0	0
Rice bran	0	6.00
Soybean meal	30	24.00
Fish meal	3.00	3.00
Vegetable oil	3.00	3.00
Bone meal	3.00	3.00
Limestone	0.50	0.50
Premix	0.30	0.30
Methionine	0.30	0.30
Lysine	0.25	0.25
Salt	0.3	0.3
Total	100	100
Chemical analysis (% DM)		
Crude protein	22.18	20.03
Crude fibre	3.35	3.17
Calculated analysis (% DM)		
Metabolizable energy (kcal/kg)	3018.10	3108.89
Ca	1.01	0.99
Available P	0.70	0.73
Methionine	0.68	0.66
Lysine	1.36	1.24

Kcal/Kg-Kilocal/Kilogram Ca= Calcium, P= Phosphorus

maximum weight attained by the animals before slaughter. The feed conversion ratio was calculated as grams of feed consumed divided by body weight.

At 56 weeks of age, three birds per treatment were randomly selected and humanely slaughtered. Before slaughter, feed was withdrawn for the birds overnight. After slaughtering, birds were allowed to bleed for 5 min, scalded and eviscerated. After that, the weights of the slaughtered and dressed birds were determined with a sensitive scale and the chickens' dressed percentage was estimated as a percentage of the slaughtered weight. The internal organs, which include the liver, heart, gizzard, spleen, bile and lungs, were removed, cleaned, weighed and recorded. About 100g of fresh meat samples from breast muscle were excised for determination of cholesterol content (Allain *et al*., 1974), level of lipid peroxidation (Botsoglou *et al*., 1994), catalase activity (Hadwan and Khabt, 2018) and glutathione peroxidase activity (Cichoski *et al*., 2012).

Statistical analysis

All data obtained on growth performance, organ weight and meat quality were subjected to a one-way analysis of variance (ANOVA) using SPSS version 20 for a Completely Randomised Design. The differences between treatment means were examined by Duncan's Multiple Range Test of the same package. For all statistical tests, significance was determined at $p < 0.05$.

RESULTS

Table 2 shows the results of the growth performance of the broiler chickens fed diets containing Superliv powder® (SP) and Bacflora-F® (BF) feed additives at both starter and finisher phases. At the starter

Table 2. **Growth performance of broiler chickens fed diets supplemented with Superliv powder® and Bacflora-F® feed additives**

Parameters	Diet 1 Control	Diet 2 0.05g/kg SP	Diet 3 1g/kg BF	Diet 4 0.05g/kg SP+ 1g/kg BF	SEM	*P value*
Starter Phase (1-28days)						
IBW (g)	35.16	35.84	34.78	34.89	0.40	0.84
BWG (g)	807.82	854.55	840.97	818.42	14.17	0.71
FI (g)	1558.61	1415.75	1336.35	1490.04	65.05	0.72
FCR	1.92	1.66	1.59	1.82	0.07	0.47
Finisher Phase (29- 56d)						
BWG (g)	1698.83^{c}	1890.90^{b}	1878.28^{b}	1912.81^{a}	28.62	0.03
FI (g)	3110.46	2924.40	3164.41	3073.88	149.71	0.96
FCR	1.82	1.55	1.69	1.60	0.08	0.75
Overall period (0 - 56days)						
BWG (g)	2506.65^{c}	2745.46^{a}	2719.25^{ab}	2731.29^{b}	33.42	0.05
FI (g)	4669.08	4340.15	4500.77	4563.93	191.99	0.96
FCR	1.86	1.58	1.65	1.66	0.07	0.65

IBW: initial body weight; BWG: body weight gain; FI: feed intake; FCR: feed conversion ratio; Means within a row with different letters and significantly different ($p < 0.05$). SEM Standard error. SP = Superliv powder®, BF = Bacflora-F®, SP+BF = Superliv powder® + Bacflora-F® feed additives.

phase, the results revealed no significant difference ($p > 0.05$) in the initial body weight (IBW), body weight gain (BWG), feed intake (FI) and feed conversion ratio (FCR). However, in the finisher phase, the broiler chickens fed diet supplemented with 0.05g/kg SP + 1g/kg BF (Diet 4) had significantly highest body weight gain (1912.81g) compared to other treatments ($p < 0.05$). While the BWG of broiler chickens fed Diet 2 (1890.90g) was statistically similar to chickens fed Diet 3 (1878.28) but higher than the control (1698.83g). At the overall feeding period (0 - 56 days), BWG of the broiler chickens were significantly different ($p < 0.05$) across treatments, with broiler chickens on Diet 2 having the highest BWG (2745.46g), followed by chickens on Diet 3 (1g/kg BF) and Diet 4 (0.05g/kg SP + 1g/kg BF) but least in Diet 1 (control diet). However, no significant effect ($p > 0.05$) of the diets was observed on feed intake and feed conversion ratio across the treatments, during the finisher phase and overall period.

As revealed in Table 3, the dietary supplementation of Superliv powder® and Bacflora-F® feed additives significantly ($p < 0.05$) influenced the slaughter and dressed weights of the broiler chickens across the treatments. Broiler chickens fed Diets 1, 2, and 3 recorded similar ($p > 0.05$) slaughter weight of 2534.81g, 2776.53g, and 2769.61g, respectively, which were significantly ($p < 0.05$) higher than those on Control diet. Similarly, broiler chickens fed diets supplemented with SP and BF feed additives recorded higher ($p < 0.05$) dressed weights than those on Control diets. However, supplementation of SP and BF feed additives did not show any significant effect ($p > 0.05$) on the dressing percentage and the internal organ weights (heart, liver, gizzard, lungs and spleen) of the broiler chickens across the treatments.

Table 3. Carcass characteristics and organ weights of broiler chickens fed diets supplemented with Superliv powder® and Bacflora-F® feed additives

Parameters	Diet 1 Control	Diet 2 0.05g/kg SP	Diet 3 1g/kg BF	Diet 4 0.05g/kg SP+ 1g/kg BF	SEM	*P value*
Slaughter weight (g/b)	2534.81[b]	2776.53[a]	2769.61[a]	2789.74[a]	35.77	0.004
Dressed weight (g/b)	1854.00[b]	2094.33[a]	2118.66[a]	2080.33[a]	37.18	0.009
Dressing %	73.12	75.41	76.51	74.55	0.55	0.153
Heart (g)	0.35	0.33	0.31	0.33	0.01	0.634
Liver (g)	1.33	1.15	1.43	1.39	0.15	0.89
Gizzard (g)	1.95	2.03	1.77	1.89	0.05	0.223
Lung (g)	0.41	0.38	0.42	0.38	0.02	0.771
Spleen (g)	0.87	0.10	0.08	0.07	0.01	0.222

Means within a row with different letters and significantly different ($p < 0.05$). SEM Standard error.
SP = Superliv powder®, BF = Bacflora-F®, SP+BF = Superliv powder® + Bacflora-F® feed additives.

Table 4 shows the results of the meat antioxidant status and cholesterol levels/concentartions of broiler chickens fed with or without SP and BF supplemented diet. The results showed dietary supplementation of SP and BF additives did not significantly ($p > 0.05$) influence the production of catalase, glutathione peroxidase, and lipid oxidation in the breast muscle of the broiler chickens across the treatments ($p < 0.05$). However, the inclusion of SP and BF additives in

broiler diets significantly ($p < 0.05$) lowered the cholesterol contents in the breast muscle compared to the control group (42.45±3.58mg/dl).

Table 4. Meat cholesterol levels and antioxidant status of broiler chickens fed diets supplemented with Superliv powder® and Bacflora-F® feed additives

Parameters	Diet 1 Control	Diet 2 0.05g/kg SP	Diet 3 1g/kg BF	Diet 4 0.05g/kg SP+ 1g/kg BF	SEM	*P value*
Catalase (mM/ml/min)	18.33	30.19	38.18	39.45	3.46	0.09
Glutathione peroxidase (µg/g)	183.59	213.48	236.74	239.33	35.58	0.18
Lipid oxidation (mgMDA/g)	0.61	0.34	0.25	0.16	0.06	0.12
Cholesterol (mg/dl)	42.45[a]	19.65[b]	18.86[b]	19.34[b]	3.58[b]	0.02

[a, b, c] Means within a row with different letters and significantly different ($p < 0.05$). SEM Standard error of mean. SP = Superliv powder®, BF = Bacflora-F®, SP+BF = Superliv powder® + Bacflora-F® feed additives.

DISCUSSION

The use of phytobiotic and synbiotic are considered a potential alternative for antibiotic growth promoters in animal nutrition because of their ability to improve growth, feed utilization, gut health, immune system and meat quality of broiler chicken (Abdelli *et al.,* 2021; Poberezhets and Kupchuk, 2021) . The results from this study showed that dietary supplementation of phytobiotic (Superliv powder®) and synbiotic (Bacflora-F®) feed additives significantly increased the body weight gain (BWG) of the broiler chickens compared to the control group during the feeding trial. This observed increase in BWG in birds fed the Superliv powder® supplemented diets could be attributed to the combined mechanism of action of different bioactive compounds (such as phenol, flavonoids, saponins and terpenoids) resident in the powder meal. Numerous studies have demonstrated that plant meal high in bioactive compounds can increase feed intake, promote nutrient digestion and absorption in the gut through the secretion of endogenous digestive enzymes, and enlargement of villi diameters, thereby improving the BWG of broiler chicken (Mohiti Asli and Ghanaatparast-Rashti, 2017; Oloruntola *et al.,* 2018). These findings are in line with the report of Bhattacharyy *et al*. (2012) that supplementation of Superliv powder® significantly increased the body weight gain of broiler chickens compared to the control.

On the other hand, the effectiveness of Bacflora-F® (probiotic, prebiotic and acidifier) feed additives to improve BWG has been attributed to their ability to inhibit pathogens and increase beneficial microbial population in the gut to facilitate nutrient digestion and absorption, and stimulate intestinal mucosa immunity (Liu *et al*., 2012; Pourakbari *et al*., 2016). The result in this study is similar to the findings of Ahmat *et al.* (2021) that broiler chickens fed diets supplemented with probiotics had significantly higher body weight than the control. However, the observed similarity in values of feed intake and FCR of broiler chickens across the treatments showed that supplementation of SP, BF and their mixtures at these levels did not tamper with the taste and palatability of the diets compared to the control. It also showed that

diets supplemented with SP, BF and their mixtures contained moderate fibre contents, since consumption of higher fiber diets has been reported to decrease feed intake and feed digestibility in poultry (Simol *et al*., 2012; Downs *et al*., 2022).

Supplementation of phytobiotic and synbiotics in poultry diets are known to positively influence the carcass traits, prominent cut-up meat parts and quality of meat (Cheng *et al*., 2017; Flees *et al.,* 2020). In this study, the dietary supplementation of Superliv powder® and Bacflora-F® feed additives significantly increased the slaughter weight and dressing percentage of the broiler chickens compared to the control group. This increase could be due to the capacity of Superliv powder® and Bacflora-F® feed additives to prevent the colonization of intestinal pathogens and improved utilization of nutrients (protein and energy) in the diets to facilitate muscle development in the body (Agboola *et al*., 2021). These results are in line with the findings of Fasasi *et al.* (2020) and Rehman *et al.* (2020) that supplementation of phytobiotics and symbiotic (prebiotic and probiotic), respectively, significantly increase the carcass weight and dressing percentage of broiler chicken compared to control. However, in another study, Gurbuz *et al*. (2019) and El-Ashram and Abdelhafez (2020) did not find any significant difference in carcass characteristics of broiler chicken fed diet supplemented with phytobiotics.

Moreover, the observed similarity in weights of internal organs of broiler chicken fed diets supplemented with Superliv powder® and Bacflora-F® feed additives and the control group suggested that inclusion of the additives was not detrimental to the development and functions of the organs in the body. A similar result has been reported by Adeyeye *et al*. (2020) and Rehman *et al*. (2020) who found that dietary inclusion of phytobiotics and synbiotics did not influence the organ weights of the broiler chickens compared to the control treatment.

The significant decrease in meat cholesterol contents of the broiler chickens fed diets supplemented with Superliv powder® and Bacflora-F® feed additives compared to the control group suggested that these feed additives contained hypocholesterolemic compounds. Several studies have reported that phytobiotics possess bioactive compounds that can exert hypocholesterolemic activity in meat products (Adu *et al*., 2020; Oloruntola *et al*., 2021; Falowo, 2022). Also, the dietary inclusion of synbiotics has been reported to increase the short-chain fatty acid concentrations which inhibits or limits the cholesterol or triglyceride synthesis in the liver (Dev *et al*., 2020). The excessive intake of meat and meat products with high cholesterol and fat contents has been linked with the occurrence of cardiovascular and other related heart diseases in consumers (Bronzato and Durante, 2017). Thus, the application of phytobiotic and synbiotic feed additives in poultry can be used to reduce meat cholesterol content and improve human health.

CONCLUSION

Findings from this study have revealed that dietary inclusion of Superliv powder® and Bacflora-F® at 0.05g/kg and 1g/kg, respectively, would not impair feed intake, feed conversion ratio and organ weights but rather improve body weight gain and meat quality of the broiler chickens. This shows

that Superliv powder® and Bacflora-F® can be used as feed additives to improve the performance of broiler chickens during production.

Conflict of Interest: The author states that no commercial funding was acquired for this study that may be construed as potential conflict of interest.

REFERENCES

Abdelli, N., Solà-Oriol, D. and Pérez J.F. (2021). Phytogenic feed additives in poultry: Achievements, prospective and challenges. *Animals,* 11 (12): 3471.

Adeyeye, S.A., Oloruntola, O.D., Ayodele, S.O., Falowo, A.B. and Agbede, J.O. (2020). Wild sunflower and goat weed leaf meals composite-mix supplementation in broiler chickens: effects on performance, health status and meat. *Acta Fytotechnica et Zootechnica,* 23 (4): 205–212.

Adu, O.A., Gbore, F.A., Oloruntola, O.D., Falowo, A.B. and Olarotimi, O.J. (2020). The effects of *Myristica fragrans* seed meal and *Syzygium aromaticum* leaf meal dietary supplementation on growth performance and oxidative status of broiler chicken. *Bulletin of the National Research Centre, 44: 149.*

Agboola, A.F., Awodoyin, O.R., Otunla, O.G. and Adebiyi, A.E. (2021). Influence of feed additive supplementation on growth response, gut health and meat quality of broiler chickens. *Global Journal of Animal Scientific Research*, (2):133-159.

Ahmat, M., Cheng, J., Abbas, Z., Cheng, Q., Fan, Z., Ahmad, B., Hou, M., Osman, G., Guo, H., Wang, J. and Zhang, R. (2021). Effects of *Bacillus amyloliquefaciens* LFB112 on growth performance, carcass traits, immune, and serum biochemical response in broiler chickens. *Antibiotics*, 10(11): 1427.

Allain, C.C., Poon, L.S., Chan, C.S.G., Richmond, W. and Fu, P.C. (1974). Enzymatic determination of total serum cholesterol. *Clinical Chemistry,* 20 (Suppl 4): 470–475.

Bhattacharyy, A., Garg, S.K, Kumar, V., Roy, D., Ravikanth K. and Maini, S. (2013). Effects of Superliv concentrate® on the growth, immunocompetence traits and nutrient retention of commercial broilers during extreme winter. *International Journal of Poultry Science,* 12: 51.

Botsoglou, N.A., Fletouris, D.J., Papageorgiou, G.E., Vassilopoulos, V.N., Mantis, A.J. and Trakatellis, A. (1994). Rapid, sensitive, and specific thiobarbituric acid method for measuring lipid peroxidation in animal tissue, food, and feedstuff samples. *Journal of Agriculture and Food Chemistry,* 42: 1931–1937.

Bronzato, S. and Durante, A. (2017). A contemporary review of the relationship between red meat consumption and cardiovascular risk. *International Journal of Preventive Medicine,* 2017: 8.

Cheng, Y., Chen, Y., Li, X., Yang, W., Wen, C., Kang, Y., Wang, A. and Zhou, Y. (2017). Effects of synbiotic supplementation on growth performance, carcass characteristics, meat quality and muscular antioxidant capacity and mineral contents in broilers. *Journal of the Science of Food and Agriculture,* 97(11): 3699-3705.

Cichoski, A.J., Rotta, R.B., Scheuermann, G., Cunha Junior, A. and Barin, J.S. (2012) Investigation of glutathione peroxidase activity in chicken meat under different experimental conditions. *Ciência e Tecnologia de Alimentos,* 32 (Suppl 3): 661–667.

Dev, K., Mir, N.A., Biswas, A., Kannoujia, J., Begum, J., Kant, R. and Mandala, A. (2020). Dietary synbiotic supplementation improves the growth performance, body antioxidant pool, serum biochemistry, meat quality, and lipid oxidative stability in broiler chickens. *Animal Nutrition,* 6(3): 325–332.

Downs, K.M., Gulizia, J.P., Stafford, E.K. and Pacheco, W.J. (2022). Influence of varying dietary kudzu leaf meal particle size on performance, breast weight, and organ weight of broiler chickens from 1 to 21 days of age. *Poultry,* 1(1): 30-39.

El-Ashram, S. and Abdelhafez, G. A. (2020). Effects of phytogenic supplementation on productive performance of broiler chickens. *Journal of Applied Poultry Research*, 29(4): 852-862.

Falowo, A B. (2022). Potential of medicinal plants as hypocholesterolemic agents in chicken meat production. *Science Letters,* 10(1): 24-31.

Fasasi, M.O, Bamgbose, A. M., Oso, A.O., Raji, M.O., Olayemi, W.A., Emmanuel, O.I., Raji,

B.A., George, E.K. and Sehubo, T.A. (2020). Carcass yield of broiler chickens as affected by varying dietary levels of phytogenic additives blend. *Proceedings of 25th Annual Conference of ASAN* , Abuja, Nigeria. pp. 363-366.

Flees, J., Greene, E., Ganguly, B. and Dridi, S. (2020). Phytogenic feed-and water-additives improve feed efficiency in broilers via modulation of (an) orexigenic hypothalamic neuropeptide expression. *Neuropeptides*, 81: 102005.

Gurbuz, Y., Abdullah, M. D. and Cetin, M. (2019). Effects of phytogenic feed additives as an alternative to antibiotic on broiler performance and carcass characteristics. *Journal of Poultry Research*, 16(2): 62-67.

Hadwan, M and Khabt, H. (2018). Simple spectrophotometric method for analysis of serum catalase activity. *Journal of Clinical and Diagnostic Research,* 12(Suppl 9):13-16.

Kim, S. A., Jang, M. J., Kim, S. Y., Yang, Y., Pavlidis, H. O. and Ricke, S. C. (2019). Potential for prebiotics as feed additives to limit foodborne Campylobacter establishment in the poultry gastrointestinal tract. *Frontiers in Microbiology*, 10: 91. https://doi.org/10.3389/fmicb.2019.00091

Lipiński, K., Antoszkiewicz, Z., Kotlarczyk, S., Mazur-Kuśnirek, M., Kaliniewicz, J. and Makowski, Z. (2019). The effect of herbal feed additive on the growth performance, carcass characteristics and meat quality of broiler chickens fed low-energy diets. *Archives Animal Breeding,* 62(1): 33-40.

Liu, X., Yan, H., Lv, L., Xu, Q., Yin, C., Zhang, K., Wang, P. and Hu, J. (2012). Growth performance and meat quality of broiler chickens supplemented with *Bacillus licheniformis* in drinking water. *Asian-Australasian Journal of Animal Sciences*, 25(5): 682.

Markowiak, P. and Śliżewska, K. (2018). The role of probiotics, prebiotics and synbiotics in animal nutrition. *Gut Pathogens*, 10(1): 1-20.

Mohiti-Asli, M. and Ghanaatparast-Rashti, M. (2017). Comparison of the effect of two phytogenic compounds on growth performance and immune response of broilers. *Journal of Applied Animal Research,* 45(1): 603–608.

National Geospatial-Intelligence Agency (NGIA) (2020). Geographical name data for Akungba in Nigeria, as supplied by the US military intelligence in electronic format. https://geographic.org/geographic_names/name.php″uni=783792&fid=4314&c=nigeria

Olabode, A.D. (2014). Awareness of climatic variation through indigenous knowledge in Akungba-Akoko, Ondo State, *Nigeria. Journal of Earth Science and Climatic Change,* S11: 004. https://doi.org/10.4172/2157-7617.S11-004

Oloruntola, O.D., Agbede, J.O., Ayodele, S.O. and Oloruntola, D.A. (2018). Neem, pawpaw, and bamboo leaf meal dietary supplementation in broiler chickens: Effect on performance and health status. *Journal of Food Biochemistry,* 43 (2): e12723.

Oloruntola, O.D., Adu, O.A., Gbore, F.A., Falowo, A.B. and Olarotimi, O.J. (2021). Performance of broiler chicken fed diets supplemented with *Irvingia gabonensis* kernel powder and *Ocimum gratissimum* leaf powder. *Slovak Journal of Animal Science,* 54 (1): 7–20.

Orlowski, S., Flees, J., Greene, E.S., Ashley, D., Lee, S.O., Yang, F.L., Owens, C.M., Kidd, M., Anthony, N. and Dridi, S. (2018). Effects of phytogenic additives on meat quality traits in broiler chickens. *Journal of Animal Science,* 96(9): 3757-3767.

Pandey A.M. (2019). Compensatory effect of Superliv® in feed with reduced energy in broilers. https://en.engormix.com/poultry-industry/articles/compensatory-effect-superliv-feed-t43972.htm

Poberezhets, J. and Kupchuk, I. (2021). Effectiveness of the use of probiotics in the diet of broiler chickens. *Scientific Annals of Polish Society of Animal Production*, 17 (4): 9-16.

Pourakbari, M., Seidavi, A., Asadpour, L. and Martínez, A. (2016). Probiotic level effects on growth performance, carcass traits, blood parameters, cecal microbiota, and immune response of broilers. *Anais da Academia Brasileira de Ciências*, 88: 1011-1021.

Rehman, A., Arif, M., Sajjad, N., Al-Ghadi, M.Q., Alagawany, M., Abd El-Hack, M.E., Alhimaidi, A.R., Elnesr, S.S., Almutairi, B.O., Amran, R.A. and Hussein, E.O.S. (2020). Dietary effect of probiotics and prebiotics on broiler performance, carcass, and immunity. *Poultry Science*, 99(12): 6946-6953.

Simol, C.F., Tuen, A.A., Khan, H.H.A., Chubo, J.K., King, P.J.H. and Ong, K.H. (2012). Performance of chicken broilers fed with diets substituted with mulberry leaf powder. *African Journal of Biotechnology*, 11(94): 16106-16111.

Van der Aar, P. J., Molist, F. V. and Van Der Klis, J. D. (2017). The central role of intestinal health on the effect of feed additives on feed intake in swine and poultry. *Animal Feed Science and Technology,* 233: 64-75.