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Impact of Feed Additives on Growth Performance, Nutrient Digestibility and Economics of Production of Broiler Chickens

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ABSTRACT
This study evaluated the effect of supplementation of three different feed additives which included phytogenic premix, probiotics and multienzymes in a maize based diet in broiler chicken production. The study evaluated the different feed additives on growth performance, nutrient digestibility and economics of production of 120 unsexed one-day-old broiler chicks. The chicks were randomly divided into four groups with thirty chicks in each group in a completely randomized design. Feed and water were provided *ad libitum* and the quantity of feed intake and weekly weight gain were recorded weekly. The groups are the control group, phytogenic premix group, probiotics groups and multienzyme group. Groups fed the different feed additives reflected significantly ($P<0.05$) higher body weight and improved feed conversion ratio than group not supplemented with a feed additive. In comparison to the control group, the phytogenic premix, probiotics and multienzyme groups improved ($P<0.05$) dry matter, crude protein and crude fibre digestibility. The result of economics of production showed that birds fed the diets supplemented with probiotics and multienzyme was 8.90% more efficient than the group fed diets without feed additives and group fed diets supplemented with phytogenic premix was 7.76% more efficient compared with the control group. Based on the result obtained in the present study, it can be concluded that by using non-antibiotic feed additive in the diets of broiler chickens, phytogenic premix, probiotics and multienzymes are recommended in view of improved growth performance, nutrient digestibility and good economical return in the broiler production.

Keywords: Broiler chickens, Feed additives, Growth performance, Nutrient digestibility

INTRODUCTION

The poultry industry has been recorded to be one of the most important and fastest growing agricultural industries in the world. It provides a substantial amount of protein via egg and meat to ensure sustainable food security especially to the rising global population (FAO, 2023; United Nations, 2019). To continue to improve the amount and quality of poultry meat through broiler production, it is essential to focus on optimal feed efficiency, health and disease management, optimized nutrition while maximizing profit.

The use of antibiotics in the poultry industry is mainly for treatment, control and growth promotion and with the fast-rising global population, the use of antibiotics is increasing so as to meet up with the demand of protein (WHO, 2004; Andrew *et al*., 2020). There are concerns on the excessive use of antibiotic in livestock and this has contributed to the emergence of organisms that are resistant to most or all antibiotics hence the ban in the year 2006.

Feed additives are added ingredients not normally consumed as feed by themselves, whether or not they have nutritional value, which affect the characteristics of feed or animal products (FAO, 2020). The inclusion of feed additives has played very important role in poultry diets and is used in lower inclusion levels compared to other feed ingredients to improve growth efficiency, gut health, feed efficiency and cost of production.

Phytogenic feed additives also known as phytogenic premix are subset of plant –derived bioactive compounds which have been identified in fruits, vegetables, spices and herbs, and essential oil (Yadav *et al*., 2016). The use of phytogenic additives or premix has been investigated in poultry research and several studies have shown to be of beneficial effect while other has shown no positive effect. A positive impact of phytogenic additives in some few studies have proven a normal gut function and overall positive performance of poultry based on feed intake, body weight gain, feed conversion ratio, nutrient digestibility and cost saving (Bosetti *et al*., 2020; Ghanima *et al*., 2020; Youssef *et al*., 2021 and Millam *et al*., 2024). Other trial showed no significant positive impact on growth performance (Ahsan *et al*., 2018).

Probiotics are dietary supplements that are used to improve the immune system and the gut health of chickens through different mode of action, like competitive exclusion of pathogens and enhancement of gut barrier function (Yousaf *et al*., 2022). The use of probiotics has shown to be of beneficial effect irrespective of the kind of strains used in supplementing the diet of poultry birds. Some researchers have proposed positive effect of probiotics on broiler growth performance and nutrient digestibility (Al-Sagan *et al*., 2020; Rahman *et al*., 2021).

The combination of amylase, xylanase, and protease enzymes to make a multienzyme has proven to be effective. They act together to cleave various bond types in indigestible portions of feed ingredients, leading to increased levels of energy available for growth and/or egg production (Alshelmani *et al*., 2024)

The inclusion of exogenous enzymes in broiler chicken diets enables reduction in feed cost, sustainability pressure, antibiotic reduction and demand for consistent bird performance (Dunaway and Adedokun, 2021; Oladipo *et al*., 2023). Majority of conducted research aimed at investigating the effects of exogenous enzymes in poultry have shown to improve performance and this have been linked to an increased digestibility and availability of nutrients for absorption and inactivation of anti-nutritional factors. (Arczewska-Wlosek *et al*., 2019; Anwar *et al*., 2023).

Studies have shown the beneficial responses of feed additives and their responses are largely dependent on their natural components and supplementation

The misuse of antibiotics in poultry diet especially broilers usually result in antibiotic residues in their tissues and cause antimicrobial-resistance leading to serious drop in production performance, treatment failure and affecting food safety. Therefore, the aim of our study was to evaluate the effectiveness of supplementing broiler chicken diet with phytogenic feed additive, probiotics and multienzyme on growth performance indices, nutrient digestibility and economics of production.

MATERIALS AND METHODS

Study Location

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm, Federal College of Forestry, Jos-Plateau State. The farm is located on latitude 90 56'49.0" N and longitude 80 53'34.1" E, at an altitude of 1250 m above sea level. The temperature of the area ranges between 21 and 25ºC depending on the season. The wet period in Jos is between April and November with annual rainfall between 1200 and 1500 mm (Federal College of Forestry, Jos, 2023; Google Earth Pro, 2025).

Feed Additive

The phytogenic premix used in this study is Herbanoplex CP® (BV Science, Inc. Lenexa, KS 66219) it is a combination of natural herb-based product, extracted and modified from *Humulus lupulus* (hops), *Cichorium* (chicory) as its main components and *Triticum germ* (wheat). It has been developed to be added in the feed of birds during the entire fattening period or during the critical phases, for modulation of the microbiota and control of C. perfringens (Jurkovich *et al*., 2011). Herbanoplex CP® contains known bioactive components such as lupulon and xanthohumol from hops, and inulin from chicory.

The probiotic is a commercial *B. amyloliquefaciens* (CML. *B. amyloliquefaciens*) by Yungstrong, Vetnostrum Animal Health Co., Ltd, (Hsinchu, Taiwan) and adjusted to the content of 1×10^9 CFU/g**.** and the multienzyme (Axtra® XAP TPT Danisco Animal Nutrition/IFF) used is a multi-enzyme complex for poultry consisting of xylanase, amylase, and protease. The enzyme combination in Axtra® XAP TPT targets the anti-nutritional effects of key feed components in mixed grain poultry diets containing plant protein sources. endo-1,4-beta-xylanase (EC 3.2.1.8) 20000 U/g, alpha-amylase (EC 3.2.1.1) 2000 U/g, subtilisin (protease) (EC 3.4.21.62) 40000 U/g.

Experimental Diets

Four (4) treatment diets were formulated, it is as shown in Table 1

Diet 1: Control diet without feed additives
Diet 2: 0.10% of Phytogenic premix/100kg diet
Diet 3: 0.10% of Probiotics/100kg diet
Diet 4: 0.02% of multienzyme/100kg diet

Experimental Design and Layout

One hundred and twenty (120) one-day old Ross broiler chicks were allotted to four (4) dietary treatments with three (3) replicates and each having ten (10) birds in a completely randomized design (CRD). The birds were raised on a deep litter system with wood shavings serving as a source of litter. Feed and water provided *ad libitum*. Immediately after arrival, all the chicks were provided with glucose through drinking water for a day. The vitamin supplements were continued for 3 days along with drinking water. Heat and light were provided throughout the brooding period.

Table 1: Composition of Experimental Diet

Feed ingredients (Kg)	**Treatments**			
	Control	**Phytogenic premix**	**Probiotics**	**Multienzyme**
Maize	55.85	55.85	55.85	55.85
Soya bean meal	25.00	25.00	25.00	25.00
Groundnut cake	15.00	15.00	15.00	15.00
Bone meal	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40
Common salt	0.25	0.25	0.25	0.25
Vit/Mineral Premix	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05
*****Phytogenic premix	0.00	0.10	0.00	0.00
*Probiotics	0.00	0.00	0.10	0.00
*Multienzymes	0.00	0.00	0.00	0.02
TOTAL	100.00	100.00	100.00	100.00
ME (Kcal/Kg DM)	2906	2906	2906	2906
Crude protein (%)	23.40	23.40	23.40	23.40
Crude fibre (%)	4.00	4.00	4.00	4.00
Ether extract (%)	3.37	3.37	3.37	3.37
Calcium (%)	1.28	1.28	1.28	1.28
Phosphorus (%)	0.84	0.84	0.84	0.84
Lysine (%)	1.31	1.31	1.31	1.31
Methionine (%)	0.50	0.50	0.50	0.50

Feed ingredients (Kg)	Treatments			
	Control	**Phytogenic premix**	**Probiotics**	**Multienzyme**
Cost/kg diet (N/kg)	703.90	709.90	707.90	708.50

*All feed additives used are exclusive of 100kg diet

Growth Performance Trial

Body weights of the birds were documented weekly during the feeding trial. Feed intake and body weight gains were estimated weekly. Feed conversion ratio and cost per Kg gain were also computed from the feed intake and weight gain data.

Nutrient Digestibility

Digestibility trial was carried out when the chickens were fifty-six (56) days old. Two birds per replicate were randomly selected (total of six birds per treatment group) and housed in individual metabolic cages with individual feeding troughs, water trough and trays for separate faecal collection. The chickens were given three days adjustment period prior to the commencement of four days metabolic trial. Known weight of feed (slightly above the respective daily requirements) was fed to the birds housed in individual metabolic cages. Droppings collected per bird per day (for four days collection period) were oven dried (60^{o}C) until a constant weight is reached and used for subsequent laboratory analyses. Proximate compositions of feed and dried dropping samples were determined using the method described by (AOAC, 2005)

Economics of Broiler Chicken Production

The economics of production of broiler chickens was analysed using the gross margin analysis to determine the costs and returns of broiler production. Gross margin and return on investment were calculated using prevailing 2025 market prices in Jos, Plateau State, Nigeria.

This is given as:

Gross margin (₦) = Revenue (R) – Total Variable Cost (TVC)

Return/naira invested = Revenue / Total Variable Cost

Where

Revenue (₦) = Cost of live chicken (₦/kg) × Average weight (kg/bird)

Total Variable Cost (₦) = Summation of total cost of production

Data Analysis

Data obtained in the experiment were statistically analyzed using the General Linear Model Procedure of SAS (SAS, 2012) and significant differences between treatments means was separated by the Tukey Range Test.

RESULTS AND DISCUSSION

Growth Performance

Table 2 results showed the growth performance of the experimental birds. Weight gains were significantly higher in chickens which received feed supplemented with feed additives (phytogenic premix, probiotics and multi enzyme) in comparison with the control chickens ($p < 0.05$). In contrast, with that of the control, feed intake was significantly lower in chickens fed phytogenic premix, probiotics and multi enzyme. The feed conversion ratio and feed cost/kg gain of birds fed diet supplemented with feed additives were significantly ($p < 0.05$) better compared with those in the control group.

The feed additives used in this study have different mode of actions in improving broiler performance. These actions could involve the promoting of beneficial microorganisms by enhancing gut health, maintenance of balanced intestinal microbiota, feed palatability enhancer and enhanced nutrient absorption (Nipuna *et al*., 2025).

Our study confirms that the supplementation of phytogenic premix, probiotics and multi enzyme in broiler diets improved broiler performance by improving weight gain and feed conversion ratio. The superior or better performance of these groups over the control group can be attributed to their well-established roles. As their digestive systems become more effective, the birds would be able to convert their feed to available nutrient and gain weight more efficiently (Oladipo *et al*., 2015, Ferdous *et al*., 2019 and Khurajog *et al*., 2026**).**

The increased feed intake recorded in the group of experimental birds fed phytogenic premix could be attributed to the properties of the phytogenic premix (Herbanoplex® CP) used, which is formulated to be highly palatable for poultry**.** It is a mixture of plant extracts specifically hops (*Humulus lupulus*) and chicory (Vecchi., 2021, Jiang *et al*., 2020).

Table 2: Growth Performance of Broiler Chickens

Parameters	Treatments				SEM
	Control	**Phytogenic premix**	**Probiotics**	**Multi enzyme**	
Initial weight (g/bird)	41.00	41.05	41.00	41.03	0.48
Final weight (g/bird)	2210.06^{b}	2340.58^{a}	2357.91^{a}	2314.75^{a}	71.15
Weight gain	2169.06^{b}	2299.53^{a}	2316.91^{a}	2273.72^{a}	52.33
Feed intake	4447.41^{a}	4287.86^{ab}	4224.95^{b}	4115.22^{b}	159.09
Feed conversion ratio	2.05^{a}	1.86^{b}	1.82^{b}	1.80^{b}	0.04
Fc/kg gain	1442.99^{a}	1320.41^{b}	1288.37^{b}	1275.3^{b}	48.21

^{ab}Means with different superscripts on the same row are significantly different (P<0.05); SEM: Standard error of means

Effects of Feed Additives in the Diet of Broiler Chickens on Nutrient Digestibility

The result of nutrient digestibility in Table 3 revealed that the digestibility values of dry matter, crude protein and crude fibre were significantly ($p < 0.05$) affected for broiler chickens fed the different treatment diets (maize based diet with phytogenic premix, probiotics and multi enzymes individually). High digestibility values reported for the different treated groups could be due to high nutrients released in the treatment groups. The high values recorded for crude protein for groups fed multienzymes shows that feed/exogenous enzymes act by breaking down anti-nutritional factors that typically limit nutrient uptake making available amino acids for absorption. With the agreement of multienzyme action on nutrient digestibility, Amerah *et al.* (2017) reported that the supplementation of feed enzymes

improved nutrient digestibility of broiler chickens fed a corn-soy diet.

Groups fed with diet supplemented with probiotics showed that probiotics aid in the production of digestive enzymes, which improve nutrient digestibility and overall feed utilization while the use of phytogenic additives have been reported to improve nutrient utilization and reduce nutrient losses. These reports are in line with and *Obianwuna et al. (2023) and* Ding *et al*. (2017) who reported improvement in amino acid digestibility of laying birds fed dietary clostridium butyricum and fructooligosaccharides and also improved protein digestibility in birds fed essential oil (phytogenic additive) respectively.

Table 3: Nutrient digestibility of broiler chickens

Parameters	Treatments				SEM
	Control	Phytogenic premix	Probiotics	Multienzyme	
Dry matter (%)	75.02 [b]	82.26 [a]	79.82[a]	80.56 [a]	1.81
Crude protein (%)	76.04 [b]	81.52 [a]	82.79[a]	84.92 [a]	1.95
Ether extract (%)	66.57	66.21	65.98	66.17	0.93
Crude fibre (%)	41.76 [b]	69.64 [a]	59.22 [a]	63.66 [a]	5.20
Ash retention (%)	53.22	66.75	61.38	61.76	3.20

[ab]Means with different superscripts on the same row are significantly different (P<0.05); SEM: Standard error of means

Effects of Feed Additive in the Diet of Broiler Chickens on Economics of Production

Table 4 shows the data on economics of production of broiler chickens fed maize based experimental diets supplemented with three different feed additives. The findings showed that birds fed the different feed additives were more economical compared to the broiler chickens fed the control diet (maize based diet only). Groups fed maize based diet with probiotics and groups fed maize based diet with multi enzyme had the same and higher return/naira invested (₦1.76) compared with group fed diet supplemented with phytogenic premix (₦1.74) and group fed diet without feed additive supplementation (₦1.61). The result showed that the groups with higher return/naira invested are more profitable and efficient at generating revenue from its expenses. This means that for every ₦1 invested, groups fed probiotics and multi enzyme generated ₦1.76 in total value covering the original ₦1 cost plus ₦0.76 in profit. Group fed phytogenic premix generated ₦1.74 in total value and group without feed additive generated ₦1.61 in total value. Making the group fed diets supplemented with probiotics and multi enzyme 8.90% more efficient than the group fed diets without feed additives and group fed diets supplemented with phytogenic additive was 7.76% more efficient compared with the control group. Though all groups were profitable, but the groups fed probiotics and multienzyme were more superior in converting capital into gain. Subsequent researches have also proven that targeted feed additives used increased nutrient utilization and feed conversion efficiency by directly impacting production economics (*Attia et al., 2022).*

Table 4: Economics of Production of Broiler Chickens

Parameters	Treatments			
	Control	Phytogenic premix	Probiotics	Multienzyme
Variable costs				
Day-old chicks	1500.00	1500.00	1500.00	1500.00
feed cost/kg (₦/kg)	703.90	709.90	707.90	708.50
feed intake (kg)	4.44	4.28	4.22	4.11
Feeding cost (₦)	3125.31	3038.37	2987.33	2911.93
Wood shaving (₦)	87.50	87.50	87.50	87.50
Brooding (₦)	690.62	690.62	690.62	690.62
Vaccination (₦)	62.50	62.50	62.50	62.50
TVC (₦)	5465.93	5378.99	5327.95	5252.55
Revenue (R)				
Average weight (kg/b)	2.21	2.34	2.35	2.31
Cost of live chicken (₦/kg)	4000.00	4000.00	4000.00	4000.00
Revenue per chicken (₦)	8840	9360	9400	9240
Gross margin (R-TVC)	3374.07	3981.01	4072.05	3987.45
Return/naira invested	1.61	1.74	1.76	1.76

Kg: kilogram, kg/b: kilogram/ bird, TVC: total variable cost, Gross margin: Revenue-TVC, Return/naira invested: Revenue/TVC

CONCLUSION

This study leads to the conclusion that phytogenic premix, probiotics and multienzyme significantly improved broiler performance, nutrient digestibility and economics of production. The finding from our work is crucial for poultry nutritionists seeking alternatives to antibiotic growth promoters. Results revealed that the different feed additives used in the study were equally effective in enhancing production efficiency and optimize nutrient utilization of broiler chickens. Furthermore, the advantageous effect of the different feed additives could be cost effective and bring more value to broiler chicken producers.

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