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White ginger (*Zingiber officinale*) powder as feed additive in the diet of broiler chicks

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Abstract
White ginger (Zingiber officinale) powder as feed additive in the diet of broiler chicks was investigated. Feeding trial was conducted using one hundred and forty-four (144) day-old Abor acre plus strains broiler chicks. The birds were randomly assigned to four (4) dietary treatments with thirty six (36) birds per treatment divided into three (3) replicates of twelve (12) birds each in a completely randomized designed. The trials lasted for 28 days. Four experimental diets were formulated for the broiler chicks as T1, T2, T3 and T4 of 0, 0.20, 0.25 and 0.30 % white ginger powder respectively. Data were collected on growth performance, nutrient digestibility and production cost. Data collected were subjected to analysis of variance and the means were separated using Duncan's Multiple Range Test. The results shown that white ginger powder contains 92.70% dry matter, 8.20% ash, 13.90% crude fibre, 1.89 % fats, 12.60 % crude protein and 55.41 % carbohydrate. There were significant ($p<0.05$) improvements in final weight, weight gain, feed intake and feed conversion as the level of white ginger powder increased above T2 (0.20 %). Nutrient digestibility was not significantly differs across the treatment. Production cost was better at inclusion level 0.20 %. Therefore, use of white ginger powder as feed additive in broiler chicks up to 0.30 % is recommended while considering growth performance and nutrient digestibility and 0.20 % when production cost is considered.

Key words
Feed additives, Growth, Nutrients digestibility, Cost.

Introduction
Increase in regulations regarding the use of antibiotic growth promoters and the rise in consumer demand for poultry products, the quest for alternative products or approaches has intensified in recent years (Gadde et al., 2017). In the last decade, herbs and phytogenic compounds have attracted a lot of attention due to their potential role as an alternative to antibiotic growth promoters in monogastric animals (Khan and Naz, 2013). The interest to use the medicinal plants is associated to its safety, healthy for human and less cost compared with synthetic chemical drugs. Some decrease the level of serum lipids which lead to improve immune function in animals (Yadgar and Yavuz, 2015). Several studies conducted on the use of herbs and phytogenic compounds as natural alternative to synthetic antibiotics in broilers have revealed its potential benefits on the health of broiler birds as well as functions as enhancing digestion by stimulating endogenous enzymes (Brugali 2003), improve synthesis of digestive enzymes, increase in body weight and better feed conversion ratio (Greathead, 2003).

Ginger, one of such comparable natural alternatives, is a perennial herb belonging to the family *Zingiberaceae*. Ginger is rich in beneficial biologically active compounds (Ogbuewu et al., 2017). Study conducted by Zhao et al. (2011) revealed that ginger is advantageous for the greater productivity of poultry by improving the quality of feed and birds appetite, enhance the nutrient absorption and facilitates gastric enzymes flow. Onu (2010) reported that addition of ginger at 0.25 % in the basal diet of broiler chicks resulted in improved weight gain and feed conversion ratio. Al-Homidan (2005) observed reduced growth rate in starter broilers (1 to 4 wk) when ginger was fed at the rate of 6 g/kg diet and at 6th week of age (Moorthy et al., 2009).

FAO (2008) rated Nigeria as the fifth world producer of ginger with an estimated annual output of 138,000 tons. Ginger can be considered as one of the best options to fill the gap in preference to antibiotics. In Nigeria, white and yellow gingers are some of the varieties that are cheaply available whereas, yellow ginger had only been extensively researched on in broiler chicken production FAO (2008); information is lacking on the use of white ginger as feed additive in broiler chickens. Therefore, this study investigated the potential effect of white ginger powder as feed additives on growth performance, nutrient digestibility and production cost on broiler chicks.

Materials and Methods
Experimental Site
The study was conducted at the Poultry unit of the Livestock, Teaching and Research Farm, Joseph Sarwuan Tarka University Makurdi, (JOSTUM) Benue State, Nigeria. Makurdi is located between latitude 7^{0}44′ 1.50" N and longitude 8^0 31′ 17.00" E in the Guinea Savanna Zone of Nigeria. The area has an annual rainfall season of between 6 - 8 months (March - October) ranging from 508 to 1016 mm with minimum and maximum temperatures of 22.8^{0}C and maximum temperature of 40.03 ^{0}C respectively. The relative humidity ranges between 37.3 % and 59.2 % (TAC, 2021).

Collection and Processing of White Ginger
Fresh white ginger rhizomes were procured from the local market within Makurdi town, Benue State, Nigeria. The rhizomes were thoroughly washed in clean water to remove the adhering soil and chopped into smaller pieces using sharp knives. The chopped fresh white ginger rhizomes were sun-dried on a flat and clean concrete floor to a saved moisture content (>12 %). Dried white ginger was ground using a hammer mill of 2mm to obtain white ginger powder. The sample was airtight and properly stored for subsequent laboratory analysis and feed additive usage.

Experimental Birds and Management
One hundred and forty four day old broilers chicks were used for this study. The birds were procured from a reputable hatchery in Ibadan, Oyo state Nigeria. Before the arrival of the birds, all sanitary procedures such as cleaning, washing and disinfection of the pen and other equipment were observed. The chicks were individually weighed at the commencement of the study to ensure no bias was introduced in weight among the treatment groups. The broiler chicks were randomly assigned to four dietary treatments replicated three times containing 12 birds per replicate in a completely randomized design. The birds were raised in a deep litter system; feed and water were provided *ad libitum* throughout the period of the experiment which lasted for 4 weeks.

Experimental diets
Four experimental diets were formulated to meet the minimum nutrient requirements of the experimental birds (Table 1). T_1 served as control contained 0 % white ginger while T_2, T_3 and T_4 had 0.20, 0.25 and 0.30 % inclusion levels respectively. Four experimental diets were formulated to meet the minimum nutrient requirements of the experimental birds (Table 1). T_1 served as control contained 0 % white ginger while T_2, T_3 and T_4 had 0.20, 0.25 and 0.30 % inclusion levels respectively. The mixed feed using the formula in Table 1 were divided into four places as T_1, T_2, T_3 and T_4 of the same quantity. The test ingredient (white ginger powder) was weighed separately using a sensitive scale of 2 kg (Metler scale) for each treatment. Each treatment was pre-mix with 1 kg of the total mixed diet to ensure uniformity before mixing with each of the compounded feed. After mixing, each group was replicated into three and separately packed in a saved bag, well labeled and kept for subsequent feeding trial

Data collection
Initial weights of the birds were taken at the beginning of the study and weekly thereafter. Average final weights were taken at the end of the experiment by the ratio of total final weight to the number of birds in a group. Average daily feed intake was measured as the average feed given minus the left over feed divided by the number of the experimental days.

Table 1. Gross composition of the experimental starter broiler diets (kg)

Treatments	T_1	T_2	T_3	T_4
Ingredients				
Yellow maize	53.00	53.00	53.00	53.00
Soya bean meal	30.50	30.50	30.50	30.50
Groundnut cake	4.00	4.00	4.00	4.00
BDG	2.60	2.50	2.50	2.50
Rice bran	2.00	2.00	2.00	2.00
Bone meal	3.00	3.00	3.00	3.00
Blood meal	3.00	3.00	3.00	3.00
Palm oil	1.00	1.00	1.00	1.00
L-Lysine	0.15	0.15	0.15	0.15
Herbo-Methionine	0.20	0.20	0.20	0.20
Vit./min. premix*	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
White ginger powder	0.00	0.20	0.25	0.30
Total	100	100	100	100
Calculated analysis				
ME (Kcal/kg)	2941	2941	2941	2941
Crude protein (%)	23.20	23.20	23.20	23.20
Crude fibre (%)	4.03	4.03	4.03	4.03
Ether extract (%)	4.75	4.75	4.75	4.75
Lysine (%)	1.49	1.48	1.48	1.48
Methionine (%)	0.54	0.54	0.54	0.54
Calcium (%)	1.29	1.29	1.29	1.29
Available Ph (%)	0.71	0.71	0.71	0.71

**To provide the following per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E- 30,000IU, Vitamin K3,000mg, Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B6- 5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg, Folic acid 2,000mg, choline 300,000mg, Iron 60,000mg, manganese 80,000mg, copper 25,000mg, Zinc 80,000mg cobalt 150mg, Iodine 500mg. (feed formulation was done using the feedwin software application); Ctrl = control, ME – metabolizable energy, BDG - Brewer dried grain, Ph – Phosphorus, Vit./min. – vitamin/mineral*

The feed conversion ratio is the quantity of the daily feed consumed per bird divided by daily weight gain per bird. The daily weight gain per bird was computed by dividing the difference between the average final weights minus the average initial weight divided by number of experimental days.

Nutrient digestibility

Nutrient digestibility evaluation was done at the end of week three (3) and terminated at the end of week four. Two birds per replicate group were selected and transferred into metabolic cages. A 3-days acclimatization period was allowed for the birds, and the respective diets were offered to the birds. Daily feed intake and daily faecal output were recorded for 4 days. The droppings were collected per replicate once daily at 8:00 am, weighed and dried in an oven at 70° C to constant weight. Dried excreta were bulked and ground, experimental diets and feacal samples were used to determine their respective proximate constituent according to AOAC (2006)

Production cost

The cost of each experimental diet was calculated according to the prices of ingredients, based on quotes obtained in July 2022 when the study was carried out. The prices of ingredients/kg used to establish feed costs were: yellow maize, ₦250.00k; soybean meal, ₦325.00k; groundnut cake, ₦250.00k; brewer dried grain, ₦170.00k; rice bran, ₦100.00k; bone meal, ₦100.00k; blood meal, ₦180.00k; palm oil ₦650.00k; L-lysine, ₦1000.00k; vitamin and mineral supplements, ₦1800.00k and white ginger powder, ₦2300.00k. Feeding cost was determined based on total feed intake per animal multiplied by the cost of the diet used. For initial bird value, the unit price per day-old chick (₦220.00k) was used. The final value received for each bird was obtained by dividing the final total weight of the bird by the average price per kg of live broiler (₦1200.00k), as practiced in Makurdi, Benue state, North-central Nigeria in October 2022. Cost of feed was calculated from the cost of ingredients used in feed preparation. Feed cost per weight gain was calculated by multiplying the feed cost per kg by total feed intake divided by total weight gain. Feed cost/chick was calculated by multiplying feed intake per day by the number of days multiplied by the feed cost per kilogram. Operational cost per bird was calculated by adding all other expenses except expenses on feed and purchasing price of chicks. Total cost of production was calculated by adding cost of day-old chick, feed cost per chick and operational cost. Cost saving due to addition of white ginger powder was calculated by subtracting the respective total cost of production from control. Feed cost as a percentage of total production cost was calculated by dividing cost of feed per kg with total cost of production multiplied by hundred.

Statistical analysis

Data collected from the study were subjected to analysis of variance (ANOVA), where significant differences occurred; the means were separated using Duncan Multiple Range Test. The results were considered significant at 5 % level of probability.

Results and Discussions

The result in Table 2 shows that white ginger powder contains 92.70% dry matter, 8.20% ash, 13.90% crude fibre, 1.89 % fats, 12.60 % crude protein and 55.41 % carbohydrate. The dry matter content of a material determined it shelf-life, it revealed stable duration of the feed material during storage. The value obtained is within the range values of 89 % to 95 % reported by Edmond et al. (2018). The crude protein 12.60 % observed is higher than 7.70% reported by Nuhu et al. (2018) but lower compared to 14.00 % reported by Oshomoh et al. (2016). The sample contains protein below 20 %; this may imply that the relative dietary importance of this spice is to improve the nutritive value of the feed material (Hashemi and Davoodi, 2010). The ether extract is lower than those reported by Nuhu *et al.* (2018); Oshomoh et al. (2016) and Ikpeama et al. (2014) which ranged from 3.30 % to 12.00 %. The differences observed may probably reflect the varietal difference of the samples. The crude fibre obtained from the sample may pose no threat since they are not usually fed in isolation but as additives with other feedstuff. Hence, the fibre contents may also serve as a boost to the total dietary fibre of the diet. Minerals are important elements of the diet because of their physiological and metabolic function in the body. Percentage ash content recorded for white ginger implies that it contains more minerals which may have dietary usefulness such as copper, zinc, iron, selenium which can make it a dietary antioxidant enzyme activator. Proximate analysis revealed that white ginger (*Zingiber officinale*) can be ranked as carbohydrate rich due to their high calorie content 55.41 %. The sample was found to be relatively good dietary component of carbohydrate.

Effect of white ginger powder on growth performance of broiler chicks is presented in Table 3. There were significant ($p<0.05$) improvements in final weight, weight gain, feed intake and feed conversion as the level of white ginger powder increased above T_2 (0.20 %).

Table 2. Proximate composition of white ginger powder

Nutrients (%)	Compositions
Dry matter	92.70
Crude protein	12.60
Crude fibre	13.90
Ether extract	1.89
Ash	8.20
Nitrogen free extract	55.41

Table 3. Effect of White Ginger Powder on Growth Performance of Starter Broiler Chicks

Experimental Diets						
Parameter	T_1	T_2	T_3	T_4	**SEM**	**P-value**
AIW (g)	39.00	39.00	39.00	39.00	0.00	0.00
AFW (g)	817.00^{b}	815.00^{b}	830.00^{ab}	849.00^{a}	14.10	0.74
ADWG (g)	27.80^{b}	27.20^{b}	28.3^{a0b}	28.90^{a}	0.50	0.74
ADFI (g)	46.40^{a}	43.60^{b}	44.90^{ab}	45.80^{ab}	0.97	0.82
FCR	1.66^{b}	1.60^{ab}	1.58^{a}	1.58^{a}	0.04	0.72

AIW = average initial weight; AFW = average final weight; ADWG = average daily weight gain; ADFI = average daily feed intake; FCR = feed conversion ratio; SEM = standard error of mean. T_1 = Control diet; T_2 = 0.20 % white ginger powder; T_3 = 0.25 % white ginger powder; T_4 = 0.30 % white ginger powder

Improvement with increased in inclusion levels of white ginger in body weight, weight gain and feed conversion due to supplementation of ginger powder may be attributed to the beneficial effect of phytogenic substances found in ginger such as flavonoids, saponin Ikpeama et al. (2014) that possess antimicrobial, antifungal and antioxidant activities in broiler chicks; thereby improve the utilization of dietary nutrients (Kumari et al., 2007). On the other hand, Platel and Srinivasan (2000) reported that ginger had the ability to stimulate the digestive system, such as stimulation of intestinal lipase, sucrose and maltase activities as well as the secretion of pancreatic lipase, amylase, trypsin and chymotrypsin enzymes which enhances the feed utilisation. The improvement observed is in agreement with the report of several researcher Thejanuo et al (2019); Karangiya et al. (2016); Oleforuh et al. (2014) and Zomrawi et al. (2012) whom reported significant $p<0.05$ differences between the treatment means of birds on final weight, weight gain, feed intake and feed conversion ratio when fed phytogenic materials. There was an increase in average final weight that ranged from 815 g – 849 g. However, treatments T_4 (0.30 %) and T_2 (0.20 %) recorded the highest and least values of 849 g and 815 kg respectively. Feed intake and feed conversion ratio recorded ranged

from 43.6 g – 46.4 g and 1.58 – 1.66 respectively. It was observed that control recorded the highest mean values of feed intake and feed conversion ratio respectively compare to other treatments fed white ginger based diets. This result aligned with the reports of (Rebh et al., 2014 and Talukder et al., 2017) which stated that addition of ginger and its extract in the diet of broiler chick significantly improved feed conversion ratio.

Effect of white ginger powder on apparent digestibility coefficient of broiler chicks is presented in Table 4. There were no significant ($p>0.05$) differences for all the parameters observed across the dietary treatments. This could be attributed to the stimulation effect of digestive enzymes by bioactive compounds of ginger. Ginger was reported to enhance pancreatic lipase activity, intestinal lipase, disaccharides, sucrose and maltase activities which has favourable influence on gut function; which is the primary mode of action for growth in promoting feed additives (Windisch et al 2008). Zhao et al. (2011) reported that ginger enhances animal's nutrient digestion and absorption because of their positive effect on gastric secretion and digestive enzyme activities.

Table 4. Effect of white ginger powder on apparent digestibility coefficient apparent digestibility coefficient of starter broiler chicks

Experimental Diets						
Parameter (%)	**T_1**	**T_2**	**T_3**	**T_4**	**SEM**	**P-value**
DM	70.5	72.8	69.6	72.6	1.43	0.52
CP	73.0	70.1	67.9	69.0	1.19	0.53
CF	69.2	65.8	65.3	70.2	1.11	0.35
EE	72.3	65.4	65.1	69.5	1.38	0.19
NFE	68.2	69.7	64.4	64.6	1.37	0.48

DM = Dry Matter; CP = Crude protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen Free Extract; SEM = standard error of mean; T_1 = Control diet; T_2 = 0.20 % white ginger powder; T_3 = 0.25 % white ginger powder; T_4 = 0.30 % white ginger powder

Non-significant differences observed across the treatments is in line with that of Kafi et al., 2017 who reported non-significant ($p>0.05$) differences on nutrient utilization of broiler chickens when included ginger powder in their diet. In contrary, Duwa (2020) observed significant differences when fed ginger at the inclusion levels between 0 - 6 %. Different results by difference authors may be attributed to difference in inclusion levels, botanical composition of the test ingredients, climatic variation and the general management of the birds.

Effect of white ginger powder on production cost of broiler chicks is presented in Table 5. The marginal increased in the amount of feed cost per kg diet recorded for broiler chicks fed diets containing white ginger powder was a function of the additional cost of test ingredients. Higher feed cost per chick recorded for birds fed the control diet resulted from the higher feed intake compared to other dietary groups fed white ginger powder. Higher feed cost per weight gain observed on birds fed T_2 (0.20 % white ginger) showed that the birds in the group less efficiently utilized the feed consumed than those in other group. The major concern of the farmer is how well the animals utilised or convert the feed consumed into the body flesh. Therefore, the lower the feed cost per weight gain, the better it is in terms of profit maximization. Total production cost was lower in the groups fed white ginger powder relative to control resulted from the higher feeding cost. Cost saving observed across the treatments with the best observed in T_2 (0.20 % white ginger) indicated that white ginger powder is economically beneficial in poultry feed as an additive. This finding confirmed the report of Duwa et al. (2020) who observed that the profits were made on all the birds fed diet containing turmeric powder. The higher feed cost as a percentage of the total cost of production observed for control is attributed to higher feed consumed lead to higher feed cost per kg by the group. The result of production cost obtained in this study confirm the report of Gerson et al. (2009) who stated that the use of the phytogenic feed additive in broiler chicken diets had an economic advantage when feed cost is considered. Minh et al. (2010) also reported that supplementation of dried ginger to broiler diets reduced feed costs.

Table 5. Effect of white ginger powder on production cost of starter broiler chicks

Experimental Diets				
Economic Indices	**T_1**	**T_2**	**T_3**	**T_4**
C of DOC (₦/chick)	220.00	220.00	220.00	220.00
FC (₦/kg)	273.00	277.00	278.00	280.00
FC (₦/chick)	357.00	343.73	345.16	349.38
FC/WG (₦/kg)	420.14	429.67	415.85	411.04
OPC (₦/chick)	80.00	80.00	80.00	80.00
TCP (₦/chick)	657.11	643.73	645.16	649.38
CS due to spices (₦/chick)	-	13.37	11.95	7.73
FC (% TCP)	54.34	53.39	53.50	53.80

FC = feed cost; CS = Cost savings; DOC = Day old chicks; C = Cost; TCP = Total cost of production; OPC = Operational cost; T_1 = Control diet; T_2 = 0.20 % white ginger powder; T_3 = 0.25 % white ginger powder; T_4 = 0.30 % white ginger powder;

Conclusion

From the findings of this study, it showed that white ginger powder possesses some nutrients adequately; which qualified it to be used as a nutritive feed additive in a broiler chick's diet. Supplementation of white ginger powder up to 0.30 % in broiler chicks' diet had beneficial effect on growth performance, nutrient utilization was not significantly affected by the test ingredient. Production cost was better at inclusion level of 0.30 % considering the feed cost per weight gain, the major concern of the poultry farmer is how well the birds utilised the feed consumed. Therefore, use of white ginger powder as feed additive in broiler chicks up to 0.30 % is recommended while considering growth performance, nutrient digestibility as well as production cost when feed utilisation is put into consideration at the starter phase. While 0.20 % white ginger powder is recommended when considering feed cost, saving cost due to the white ginger powder and total production cost

Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

The authors contributed equally to this manuscript.

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