EFFECT OF DIFFERENT INCLUSION LEVELS OF GINGER (*Zingiber officinale* Roscoe) MEAL ON PERFORMANCE, COST IMPLICATION AND CARCASS CHARACTERISTICS OF BROILER CHICKENS.

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ABSTRACT
The ban on the use of antibiotic growth promoters in the European countries in January, 2006 gave rise to the use of phytogenic feed additives (PFAs) in livestock and poultry production. Phytogenic feed additives including ginger have been reported to improve performance and health in animals. In this study, one hundred and thirty-two broilers of Abor-acre strain were used from day-old until they were fifty-six days of age to investigate the effects of ginger meal on performance, cost implication and carcass characteristics of broiler chickens. The birds were weighed on arrival at day-old and divided into four treatment diet groups with each group having three replicates. Each diet group comprised thirty-three (33) birds divided into three replicates of eleven (11) birds each in a completely randomized design. Each replicate group was housed in a pen measuring 1 m x 1 m. Weighing of birds continued weekly and on day 30 in the starter phase; day 35 and then weekly in the finisher phase until the birds were fifty-six (56) days of age. Birds were fed T1, T2, T3 and T4 diets which contained ginger meal at levels of 0.0, 0.5, 1.0 and 1.5 % respectively with T1 (0.0 % ginger meal diet) serving as the control diet in both starter and finisher phases. They were managed on deep litter and fed broiler starter diets from day-old until they were thirty (30) days of age and broiler finisher diets from thirty days of age until they were fifty-six days of age. Feed and water were provided *ad-libitum.* At the end of the feeding trial, twelve (12) birds (one from each replicate) were selected (weight range of 2300 – 2500 g) and slaughtered to obtain the effect of treatment on carcass and organ weights. Results obtained showed that daily feed intake per bird was significantly ($P < 0.05$) higher in birds fed ginger meal at the starter phase while other performance parameters were similar compared to the control group. All the performance parameters were similar in the finisher phase though numerically higher values were observed in the final live-weight and feed intake in birds fed ginger diets. Feed cost per kilogram weight gain was significantly ($P < 0.05$) increased and abdominal fat percentage significantly ($P < 0.05$) reduced in the 1.5 % ginger meal group. It was concluded that broiler chickens could be fed 0.5 % ginger meal in their diet to increase weight gain at reduced cost and up to 1.5 % level to achieve reduced fat content in the meat.

Key words: Ginger meal, performance, cost implication, carcass characteristics, broiler chickens

INTRODUCTION

The ability of in-feed additives/growth promoters such as antibiotics to enhance growth in livestock and poultry promoted their use at sub-therapeutic doses in poultry production. However, the in-feed antibiotics have been banned in European countries since January 1, 2006 (Mansoub, 2010) because antibacterial resistance of many pathogenic bacteria in farm animals and humans was linked to their use (Donogue, 2003). The ban gave rise to the search for economically viable alternatives to antibiotics which can be sustained for a long time, improve performance, protect animal health and maintain profit margins (Yegani and Korver, 2008). This led to the use of phytogenic feed additives (PFAs) in livestock and poultry production.

Balunas and Kinghorn (2005) and Athanasiadou *et al.* (2007) noted that phytogenic feed additives otherwise called phytobiotics, phytogenics or botanicals are herbs or plant derived products which if incorporated in livestock feeds have the ability to enhance livestock performance through the improvement of digestibility, nutrient absorption and elimination of pathogenic microbes resident in the animal gut. PFAs are readily available, have comparative efficacy, less side effect, and more economical when compared to synthetically produced growth promoters (Ganapathi *et al*., 2019). Spices such as ginger, garlic and turmeric are PFAs which have been used in poultry production with interesting results. Research findings indicated that ginger enhances weight gain, meat yield, has anti-inflammatory, anti-cholesterolemic and immunomodulatory effects on broiler chickens, these properties being attributable to the chemical compositions in the rhizome (Aji *et al*., 2011). Ginger is composed of a mixture of non-volatile oils, namely, gingerols, shogaols and zingerone, and a great amount of volatile oils including camphene, phellandrene, citral and zingiberine. Al-Amin *et al.* (2006) had reported these ginger compounds to have pharmacological effect on broiler chickens' health.

Supplementing broilers ration with 0.2 % dried ginger meal increased body weight at six weeks of age (Arkan *et al*., 2012). Increased body weight of broilers had also been reported by Ademola *et al.* (2009) and Onimisi *et al.* (2005) by supplementing ginger up to 2 % level in broiler diets. Egg production, feed intake

and feed conversion ratio were improved by addition of ginger root powder at the level of 1 % in the diet of laying chickens (Malekizadeh *et al*., 2012). Zhang *et al*. (2009) reported no statistical significance between the feed intake of broilers fed ginger and the control group but numerically higher values were observed in the ginger groups. Also, feed intake of broilers fed ginger extract for a period of six weeks was not affected (Dooley *et al*., 2009) while Arkan *et al*. (2012) and Herawati (2010) reported a depressing effect on feed intake by broilers fed ginger extract.

Broilers fed diets containing ginger produced superior carcass weight, dressing percentages and carcass quality (Zhang *et al*., 2009). Eltazi *et al*. (2014) included ginger powder at levels of 0.0 %, 1.0 %, 1.5 % and 2.0 % levels as feed additive in the diet of broilers for a period of six weeks and reported that all carcass components measured were significantly improved by addition of ginger powder except the group that received 2.0 % level. Eltazi *et al.* (2014) also reported that addition of ginger powder significantly affected ($P < 0.05$) all non-carcass components measured except the heart percentage. Carcass characteristics improved in broilers fed different levels of powdered aqueous extract of ginger from 1 – 42 days of age (Ademola *et al*., 2009; Javed *et al*., 2009).

MATERIALS AND METHODS

Experimental Site

This research was conducted at the poultry unit of Teaching and Research Farm of Federal University of Technology, Owerri, Imo State, South-east, Nigeria. Owerri lies between latitudes $4^0$4' and $6^0$3' N and longitudes $6^0$15' and $7^0$28' E. It has an altitude of about 100 m above sea level. The average annual temperature is about 26.4^{o}C and average rainfall of 2219 mm (Climate-Data.Org, 2016). The relative humidity is about 98 % during the wet season of April to October (Imo ADP, 1990). The soil type is basically sandy loam with average pH of 5.5 and annual evapotranspiration of 1450 mm (MLS, 1984).

Collection and processing of ginger

Fresh ginger rhizomes were procured from Relief Market in Owerri. The fresh roots were washed and sliced into tiny pieces of about 5 mm thickness for effective drying. The sliced pieces were spread on polythene mats and sun-dried for seven (7) days when a constant weight was obtained. They were then milled into fine powdery mass (ginger meal) using a hammer mill fitted with a 0.01 mm sieve and stored at room temperature in plastic air-tight container until needed during feed formulation.

Experimental birds and treatment diets

One hundred and thirty-two (132) broilers of Abor-acre strain were procured from a reputable hatchery and used in this study from day old until they were 56 days of age. They were weighed on arrival and grouped into four treatment groups of thirty-three (33) birds per treatment and each treatment comprised of three (3) replicates of 11 birds in a completely randomized design. Each replicate group was housed in a pen measuring 1 m x 1 m and fed experimental broiler starter diets from day old until they were 30 days of age and experimental broiler finisher diets from 30 days until they were 56 days of age. Experimental diet 1 (T1) served as control diet in both starter and finisher diets and contained 0.0 % ginger meal. Experimental diet 2 (T2) contained 0.5 % ginger meal; experimental diet 3 (T3) contained 1.0 % ginger meal while experimental diet 4 (T4) contained 1.5 % ginger meal. The diets were iso-proteinous and iso-caloric containing 23.07 % crude protein (CP) and 2870.93 kcal/kg metabolizable energy in the starter diets and 20.37 % crude protein and 2898.42 kcal/kg metabolizable energy in the finisher diets respectively. The ingredient and calculated nutrient composition of the experimental starter and finisher diets are presented in Tables 1 and 2 respectively.

Experimental Procedure and management of birds

Birds were weighed at the beginning of the experiment when they were a day old. Weighing of birds continued weekly and then on the thirtieth day to get the final weight and weight gain for the starter phase. Feeding trial lasted for thirty days in the starter phase and feed intake records were taken daily during the period to obtain daily feed intake.

Feeding trial lasted for twenty-six (26) days in the finisher phase to get a total period of fifty-six (56) days. The final weights for the starter was taken as the initial weights of birds in the finisher phase. Weights of birds were again taken on day 35, and then weekly thereafter until they were 56 days of age, to obtain weekly weight gain and final weight of the finisher broilers. Feed and water were given *ad-libitum* and birds were managed on deep litter throughout the period. Conventional vaccination and medication procedures were observed. Experimental diets were fed and weights of left-over feed were accurately taken on daily basis in other to obtain feed intake.

Table 1: Ingredient and calculated nutrient composition of experimental broiler starter diets

	Ginger meal levels (%)			
Ingredients (%)	**0.0**	**0.5**	**1.0**	**1.5**
Maize	51.00	50.50	50.00	49.50
Ginger	0.00	0.50	1.00	1.50
Palm kernel cake	12.00	12.00	12.00	12.00
Soybean meal	22.00	22.00	22.00	22.00
Bone meal	3.00	3.00	3.00	3.00
Blood meal	3.00	3.00	3.00	3.00
Fish meal	5.00	5.00	5.00	5.00
Wheat offal	3.00	3.00	3.00	3.00
Vitamin/mineral premix*	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition				
Crude protein (%)	23.09	23.08	23.08	23.07
Calcium (%)	1.33	1.33	1.33	1.33
Phosphorus (%)	1.02	1.02	1.02	1.02
Crude fibre (%)	4.56	4.61	4.67	4.73
Metabolizable energy (Kcal/kg)	2872.73	2872.73	2871.53	2870.93

* Vit./Min. Premix, to provide per kg of feed: Vitamin A 8,500 IU; Vitamin D_3 1500 IU; Vitamin E 10,000 mg; Vitamin K_3 1500 mg; Vitamin B_1 1,600 mg; Vitamin B_2 4,000 mg; Niacin 20, 000 mg; Pantothenic acid 5,000 mg; Vitamin B_6 1,500 mg; Vitamin B_{12} 10.0 mg; Folic acid 500 mg; Biotin 750 mg; Choline chloride 175,000 mg; Cobalt 200 mg; Copper 3000 mg; Iodine 1,000 mg; Iron 20,000 mg; Manganese 40,000 mg; Selenium 200 mg; Zinc 30,000 mg; Antioxidant 1,250 mg at inclusion rate of 2.5 kg per ton of feed.

Table 2: Ingredient and calculated nutrient composition of the experimental broiler finisher diets

	Ginger meal levels (%)			
	T1	**T2**	**T3**	**T4**
Ingredients	**(0.0)**	**(0.5)**	**(1.0)**	**(1.5)**
Maize	55.50	55.00	54.50	54.00
Ginger meal	0.00	0.50	1.00	1.50
Palm kernel cake	10.00	10.00	10.00	10.00
Soy bean meal	17.00	17.00	17.00	17.00
Fish meal	5.00	5.00	5.00	5.00
Blood meal	2.00	2.00	2.00	2.00
Wheat offal	4.50	4.50	4.50	4.50
Bone meal	5.00	5.00	5.00	5.00
Vit./Min. Premix*	0.25	0.25	0.25	0.25
Common salt	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition				
Crude protein (%)	20.38	20.38	20.37	20.37
Calcium (%)	1.49	1.49	1.49	1.49
Phosphorus (%)	1.09	1.09	1.09	1.09
Crude fibre (%)	4.37	4.22	4.48	4.57
Metabolizable energy (Kcal/kg)	2899.62	2809.02	2898.42	2899.82

*Vit./Min. Premix, to provide per kg of feed: Vitamin A 8,500 IU; Vitamin D_3 1500 IU; Vitamin E 10,000 mg; Vitamin K_3 1500 mg; Vitamin B_1 1,600 mg; Vitamin B_2 4,000 mg; Niacin 20, 000 mg; Pantothenic acid 5,000 mg; Vitamin B_6 1,500 mg; Vitamin B_{12} 10.0 mg; Folic acid 500 mg; Biotin 750 mg; Choline chloride 175,000 mg; Cobalt 200 mg; Copper 3000 mg; Iodine 1,000 mg; Iron 20,000 mg; Manganese 40,000 mg; Selenium 200 mg; Zinc 30,000 mg; Antioxidant 1,250 mg at inclusion rate of 2.5 kg per ton of feed.

Data collection
Data obtained were used to compute daily weight gain, daily feed intake and feed conversion ratio. Total weight gain of birds were calculated as the difference between final weight and initial weight. This was divided by the number of days to obtain the daily weight gain. Daily feed intake was determined as the difference between quantity of feed fed and that left-over the next morning. Feed conversion ratio was determined as average daily feed intake divided by average daily weight gain. Economy of production was estimated as cost of feed consumed divided by total weight gain per bird.

Determination of carcass parameters
At the end of the feeding trial, twelve (12) birds were selected (weight range 2300 – 2500 g), one from each replicate, tagged and kept in a separate pen, for determination of carcass characteristics. They were starved for twelve hours (over-night) so that the gut contents can be evacuated. In the following morning the birds were reweighed to get the fasted weight. They were then slaughtered by severing the jugular veins and then left to bleed thoroughly. Thereafter, the carcasses were sub-scalded by immersing them in hot water (60 ^{0}C) for 30 seconds according to Oluyemi and Roberts (2000), in order to loosen the feathers. They were then de-feathered, washed, dissected and eviscerated. This was followed by cutting them into different carcass parts and their weights recorded. Weights of internal organs such as liver + gall bladder, heart, full gizzard, empty gizzard and abdominal fat were also recorded.

Statistical analysis
All data generated were subjected to analysis of variance (ANOVA) for the completely randomized design. Statistical differences in treatment means were determined using Duncan's New Multiple Range Test (DNMRT) as outlined by Obi (1990).

RESULTS
Performance of the starter broilers fed different levels of ginger meal is presented in Table 3. There were no significant differences ($P > 0.05$) in final live-weight and weight gain of broilers at the starter phase. Numerically higher values were, however, observed in treated groups compared to control group. Average daily feed intake was significantly ($P < 0.05$) affected with ginger diet groups having higher values. Feed conversion ratio was not affected ($P > 0.05$) by ginger inclusion in the diet. Feed cost per kilogram weight gain was also not affected ($P > 0.05$) by treatment diets.

Table 3: Performance of starter broilers fed different levels of ginger meal

Parameters	Ginger meal levels (%)				
	(0.0)	(0.5)	(1.0)	(1.5)	SEM
Av. Initial live-weight (g)	35.44	35.54	36.96	33.57	1.62
Av. Final live-weight (g)	659.81	762.96	787.72	753.89	41.58
Av. Total weight gain (g)	624.38	727.42	750.76	720.32	41.79
Av. Daily weight gain (g)	20.80	24.25	25.03	24.01	1.09
Av. Total feed intake (g)	1,189.80	1,361.10	1,463.70	1,403.10	-
Av. Daily feed intake (g)	39.66^b	45.37^a	48.79^a	46.77^a	0.16
Feed conversion ratio	1.91	1.87	1.95	1.95	-
Feed cost (₦)/kg weight gain	322.42	364.63	429.99	479.63	23.58

$^{a, b}$ Means on the same row having different superscripts are significantly affected ($P < 0.05$).
SEM = Standard Error of Means
Av. = Average

The performance of the finisher broilers fed different levels of ginger meal is presented in Table 4. There were no significant differences ($P > 0.05$) in the performance parameters measured; final live-weight, weight gain, feed intake and feed conversion ratio, though slight increases in final live- weight and feed intake were observed in the ginger groups. This suggests that finisher broiler chickens were not affected by dietary inclusion levels of ginger meal at levels of 0.0 % to 1.5 %.
Economic data for finisher broilers fed different levels of ginger meal is presented in Table 5. The economic data shows that finisher broilers fed different levels of ginger meal had significantly higher ($P < 0.05$) feed cost per kilogram weight gain at the 1.5 % level while groups fed 0.0, 0.5 and 1.0 % ginger levels were similar ($P > 0.05$).

Table 4: Performance of finisher broilers on different levels of ginger meal

Parameters	Ginger meal levels (%)				
	T1 (0.0)	T2 (0.5)	T3 (1.0)	T4 (1.5)	SEM
Av. Initial live-weight (g)	659.81	762.96	787.73	753.89	41.58
Av. Final live-weight (g)	2213.75	2366.19	2333.80	2359.03	84.84
Av. Total weight gain (g)	1553.94	1603.23	1546.07	1605.14	108.50
Av. Daily weight gain (g)	59.77	61.66	59.46	61.74	3.99
Av. Daily feed intake (g)	132.63	138.73	132.68	144.08	4.84
Feed conversion ratio	2.22	2.25	2.23	2.33	0.20

Differences were not statistically significant (P > 0.05) in all the parameters.
SEM = Standard Error of Means
Av. = Average

Table 5: Economic data for finisher broilers fed different levels of ginger meal

Parameters	Ginger meal levels (%)				
	T1 (0.0)	T2 (0.5)	T3 (1.0)	T4 (1.5)	SEM
Cost/ kg of feed (N)	165.50	183.18	216.86	242.53	-
Total feed intake (g)/bird	3448.38	3606.98	3449.68	3746.08	-
Cost of feed consumed/bird (N)	570.71	660.73	748.10	908.54	-
Cost of feed (₦)/kg weight gain	382.85^{b}	412.49^{b}	484.86^{ab}	566.08^{a}	17.56

$^{a, ab, b}$ Means within a row having different superscripts are significantly different (P < 0.05).
SEM = Standard Error of Means

Result of carcass characteristics of broilers fed varying levels of ginger meal is presented in Table 6. Percentage neck weights and abdominal fat were significantly reduced (P < 0.05) in the 1.5 % ginger group with the control, 0.5 % and 1.0 % groups having similar and higher values but all other carcass parameters measured were similar (P > 0.05) across dietary treatments. There were numerical increases in the dressing percentage and plucked weight percentage in the ginger groups compared to the control group.

Table 6: Effect of dietary inclusion levels of ginger meal on the carcass characteristics and organ weights of finisher broilers

Parameters	Ginger meal levels (%)				
	T1 (0.0)	T2 (0.5)	T3 (1.0)	T4 (1.5)	P-VALUE
Live weight (g)	2216.67	2233.33	2250.00	2255.10	-
Plucked weight (% of LW)	82.38	88.80	89.01	88.51	0.41
Dressed weight (% of LW)	60.51	68.95	65.94	64.89	0.43
Cut-up parts and organ weights (% of LW)					
Head	2.24	2.37	2.01	2.13	0.21
Neck	4.60^{a}	4.02^{ab}	4.10^{ab}	3.85^{b}	0.13
Heart	0.54	0.45	0.54	0.53	0.65
Shanks	4.23	3.84	3.43	3.83	0.24
Legs	26.04	26.12	25.34	26.71	0.66
Thighs	10.41	11.27	11.64	11.51	0.31
Drumsticks	10.39	10.93	9.93	10.82	0.24
Wings	8.32	8.47	8.44	8.29	0.92
Liver + gall bladder	2.19	2.24	2.01	2.18	0.60
Full gizzard	3.01	2.86	2.89	2.87	0.96
Empty gizzard	2.27	2.06	2.11	2.05	0.76
Abdominal fat	1.00^{ab}	1.24^{a}	1.10^{a}	0.41^{b}	0.074
Breast muscle	20.17	22.17	22.81	21.01	0.55

$^{a, ab, b}$ Means in the same row bearing different superscripts are significantly different (P < 0.05)
P-Value = Level of Significance.

DISCUSSION

Performance parameters in this study showed that at the starter phase average feed intake was significant with ginger groups having higher values than the control group, but all other parameters measured were similar. At the finisher phase, however, all the

performance parameters were similar and feed intake of ginger groups was numerically higher, with no definite trend followed. Agu *et al* (2017) reported no significant influence of ginger meal in performance of broiler chickens fed ginger diets for a period of eight weeks. Our result in the finisher broilers is in agreement with Zhang *et al*. (2009) who had reported that feed intake was similar in broilers fed ginger and the control group although numerically higher values were observed in the ginger groups. Dooley *et al*. (2009) also reported similar feed intake in broilers fed ginger extract for a period of six weeks compared to the control group without ginger while Arkan *et al*. (2012) and Herawati (2010) reported that feed intake of broilers fed ginger extract was significantly depressed.

Percentage neck weights and abdominal fat were significantly reduced in broilers fed 1.5 % ginger (3.85 % and 0.41 %) but the control, 0.5 % and 1.0 % groups had higher and similar values (4.60 % and 1.00 %), (4.02 % and 1.24 %) and (4.10 % and 1.10 %) respectively. Our result is contrary to Zhang *et al*. (2009) that carcass weight, dressing percentages and carcass quality were superior in broilers fed diets containing ginger compared to control group. Eltazi (2014) noted that except broilers fed 2.0 % ginger powder, all carcass components measured were significantly improved when ginger powder was added at levels of 0.0 %, 0.5 %, 1.0 % and 1.5 % as feed additive in the diet of broilers for a period of six weeks.

Barazesh *et al*. (2013) reported that broiler chickens fed 1.5 % ginger powder had their thigh percentage significantly increased but significantly reduced abdominal fat and all other carcass parameters measured were not affected when the broilers were fed diets supplemented with ginger for a period of six weeks. Valiollahi *et al*. (2014) also noted that abdominal fat of broiler chickens was significantly reduced by addition of ginger and its essential oils in the ration. Zhao *et al*. (2011) reported similar values in laying rate and average egg weight when laying hens were fed ginger at rates of 0, 5, 10, 15 and 20 g/kg but significant increases were observed in the egg mass in supplemented groups.

CONCLUSION AND RECOMMENDATION

Broiler chicks fed ginger diets had significantly higher feed intake and numerically higher weight gain compared to the group fed control diet without ginger. At the finisher level, however, there was no significant influence of ginger meal on the performance parameters but broilers fed ginger diet at 1.5 % level had significantly increased feed cost per kilogram weight gain. Finisher broilers fed 1.5 % ginger meal had significantly reduced percentage neck weight and abdominal fat. It is concluded and recommended that broiler chickens could be fed 0.5 % ginger meal level in their diet to increase weight gain at reduced feed cost but up to 1.5 % level to achieve a reduced fat content in the meat.

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