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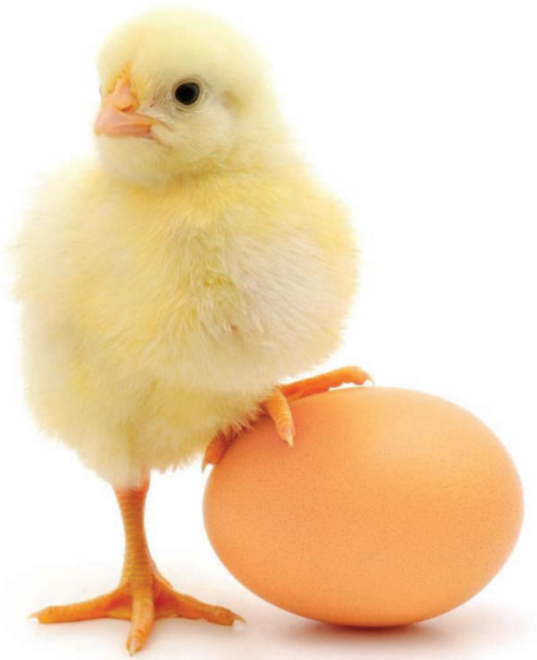

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Research Article
Growth Performance and Egg Quality Characteristics of Laying Hens Fed Fresh and Dry Ginger (*Zingiber officinale*)

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Abstract

Objective: This study was conducted to investigate the performance and egg quality characteristics of laying hens fed fresh and dry ginger. **Materials and Methods:** Ninety-six pullets at 16 weeks of age were allocated to three treatment groups with 4 replicates of 8 birds per replicate in a completely randomized design. Hens in treatments 1 and 2 received diets containing 0.00 and 0.50% dried ginger. In treatment 3, fresh ginger equivalent to diet 2 was administered through the drinking water. Quality of eggs laid were assessed at 8, 10 and 12 weeks of the laying periods. **Results:** Performance was not affected by either ginger treatment (p>0.05) and egg quality parameters were not affected until 10th weeks of the laying period. At 10th weeks of lay, egg shape index was significantly higher (p<0.05) in the ginger groups compared to the control group. At 12th week of the laying period, egg shape index was significantly higher (p<0.05) in the dry ginger group compared to control group. Yolk colour was higher (p<0.05) in the dry ginger group compared to fresh ginger group in the 12th week of the laying period. All shape indices higher than 72% were reported as standard for eggs. The effect of feeding ginger diets on egg shape is a matter of concern because round eggs may not fit in egg trays and thereby increasing egg breakage during transit. **Conclusion:** Dry ginger meal could be used in the diet of laying chickens to achieve darker and more attractive yolk colour.

Key words: Egg quality characteristics, ginger, growth performance, laying chickens, phytobiotics

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The sustainability and economic viability of a laying flock depend mainly on the number and quality of the eggs produced and sold. Egg quality is an important criterion in determining profitability in commercial egg production. The shell, albumen and yolk of eggs are used in measuring egg quality indices to determine eggs with better external and internal qualities[1]. High quality eggs with low fragility and perishability are not only beneficial to egg producers and consumers but also to the numerous industries that use eggs in product manufacture because the egg components can be separated without crossover contamination[2]. High economic returns would, therefore, be made by egg producers if egg productivity and quality are high. A variety of potential feed materials could be used in poultry feeding to improve production, reduce disease spread and enhance egg quality. Such materials which may be described as feed additives are probiotics[3], prebiotics[4], enzymes[5], organic acids[6] and phytogenics[7]. Phytogenics also called phytogenic feed additives (PFAs) or herbal plants have extensively been used in recent years as alternatives to antibiotics[8], due to antibiotic resistant micro-organisms are emerging due to antibiotic abuse in poultry production[9]. Increased use of phytogenic feed additives (PFAs) in poultry production is related to recent consumers' interest in improved food quality[10].

Herbal plants are preferred as feed additives not only because they are efficacious, reduce feed cost, possess detoxifying effects in feeds leading to minimum health hazards but they are environmentally friendly[11]. Herbal plants such as ginger, have beneficial effects on the digestive system as they increase digestive enzyme production and enhance liver function for efficient feed utilization[12]. Ginger is a phytogenic feed additive which has been found to enhance nutrient digestion and absorption because of its positive effects on gastric secretion, enterokinesia and digestive enzyme activities[13]. Ginger is the rhizome of *Zingiber officinale*, consumed as a delicacy, medicine or spice. It has been reported to enhance animal performance, feed conversion ratio, meat safety and meat quality[14,15]. Ginger root powder added at the level of 1% in the diet of laying hens increased egg production and feed intake and decreased feed conversion ratio[16].

Ginger does not only enhance animal performance but also impart antioxidant properties to food products attributable to the numerous components of its essential oil[17-19]. Dietary essential oils of ginger did not affect feed intake, egg index, yolk index and Haugh unit ($p>0.05$) in laying hens but improved eggshell quality traits (eggshell weight and thickness)[20]. Various researchers have reported the antimicrobial, immunomodulatory, anti-oxidative and growth promoting effects of ginger in animals[19,21-23]. Enhanced feed intake by animals fed ginger diets has been attributed to the enhanced flavour and odour of the diets by ginger essential oils[21]. Laying hens fed ginger at 0, 5, 10, 15 and 20 g kg^{-1} levels had similar laying rate and average egg weight with significantly increased egg mass in supplemented groups[24]. Ginger supplementation in poultry diets has largely been in dry milled forms. Over 50 bioactive compounds have been identified in ginger[25] and the most potent ones responsible for its pharmacological effects and pungency are gingerol, shagaol, zingerone[26,27]. Most of these compounds are volatile and their significant proportion is lost or chemically altered during the drying process depending on the technology used and ambient conditions. An *et al.*[27] reported that while gingerol levels increased, shagaol contents tended to increase with drying. Ding *et al.*[25] found that most bioactive compounds in ginger decreased with drying irrespective of methods used while An *et al.*[27] reported that air dried ginger gave the lowest free radical scavenging ability (a measure of antioxidation capacity). It is therefore obvious that fresh or dried ginger will produce varying physiological effect on poultry particularly laying hens whole physiological functions are largely dependent on interplay of several antioxidants and hormones. This study was therefore conducted to determine the effects of fresh and dry ginger on performance of laying hens and quality characteristics of the eggs.

MATERIALS AND METHODS

Source and processing of ginger: The fresh ginger used in this study was procured from a local market in Owerri. Ginger rhizomes were washed and sliced into tiny pieces of about 5 mm thickness to increase the surface area for rapid sun-drying. The sliced pieces were spread on black polythene mats and sun-dried to constant weight, which was achieved within 5-7 days. The sun dried ginger was milled using a hammer mill fitted with a 0.01 mm sieve and stored in air-tight plastic containers at room temperature. Fresh rhizomes were reserved for the daily oral aqueous administration. For this, ginger rhizomes were weighed daily during the experiment using a sensitive digital scale (SF-400, China), washed and sliced into small pieces and then ground using a grinding machine (Molino Tolva Alta, model 121, Landers, Medellin, Colombia). The ground ginger paste was mixed with three

Table 1: Ingredient and calculated nutrient composition of experimental layers diets

Ingredients	0% ginger	0.5% dry ginger	0.5% fresh ginger
Maize	49.50	49.00	49.50
Ginger	0.00	0.50	0.00
Soybean meal	14.00	14.00	14.00
Palm kernel cake	7.00	7.00	7.00
Wheat offal	14.50	14.50	14.50
Fish meal	2.00	2.00	2.00
Blood meal	2.00	2.00	2.00
Bone meal	6.00	6.00	6.00
Limestone	4.00	4.00	4.00
Vitamin and mineral premix	0.25	0.25	0.25
Lysine	0.25	0.25	0.25
Methionine	0.25	0.25	0.25
Common salt	0.25	0.25	0.25
Total	100.00	100.00	100.00
Calculated nutrient composition			
Crude protein	17.55	17.54	17.55
Crude fibre	4.52	4.58	4.52
Calcium	3.82	3.82	3.82
Phosphorus	1.51	1.51	1.51
Metabolizable energy (kcal kg^{-1})	2527.22	2526.62	2527.22

*Agrited®: Formulated to provide per kg feed, Vitamin A: 10,000,000 IU, Vitamin D_3: 2,000,000 IU, Vitamin E: 12,000 IU, Vitamin K_3: 2000 g, Thiamin (B_I): 1.5g, Riboflavin (B_2): 5 g, Pyridoxine (B_6): 1.5 g, Vitamin B_{12}: 10 mg, Biotin: 20 mg, Niacin: 15 g, Pantothenic acid: 5 g, Folic acid: 0.5 g, Manganese: 75 g, Zinc: 50 g, Iron: 25 g, Copper: 5 g, Iodine: 1 g, Selenium: 100 mg, Cobalt: 300 mg, Antioxidant: 125 g, Choline chloride: 150 g

litres of fresh water, passed through a cheese cloth and the filtrate was recovered. The filtrate was divided equally into three and each was served every morning to one of the four replicates fed the third diet.

Diet formulation: Three experimental diets were formulated as shown in Table 1. The first diet (the control)and the third diet did not contain ginger, while the second diet contained 0.5% sundried ginger. However, birds served the third diet were given the aqueous fresh ginger through the drinking water as described above. From the estimate of the feed intake of the layers, the quantity of dried ginger that would be eaten per day and the corresponding fresh weight were calculated. This quantity of fresh ginger was ground and given through the drinking water. Hence birds fed the second and third diets received the same quantity of ginger, howbeit, the second group was given sundried ginger applied through the feed and the third group received fresh ginger applied through the drinking water. The experimental layer diets were formulated to provide 17.54% crude protein and 2527.22 kcal kg^{-1} metabolizable energy.

Management of layers: Ninety-six pullets of Isa-brown strain at sixteen weeks of age were procured from a poultry dealer. The birds were acclimatized for two weeks before commencement of the experiment at eighteen weeks of age. The pullets were divided into the three-diet group of 32 birds each and thereafter subdivided into four replicates with eight birds per replicate in a completely randomized design. Each replicate were housed in a pen measuring 1.2 m×1.2 min deep litter system. Feed and water were provided *ad libitum*. Aqueous fresh ginger was prepared every morning for the group receiving 0.5% fresh ginger.

Data collection

Performance parameters: The birds were weighed at the beginning (point of lay) and at the end of the experiment to determine the live weight change during the experiment. Feed intake was obtained daily as the difference between the feed offered and the left-over feed remaining the next morning. Daily egg production was recorded and used to calculate hen-day egg production. Average egg weights were obtained by dividing the total weight of eggs by the total number produced. Feed conversion ratio was calculated by dividing the daily feed intake by the average daily egg weight. Cost of feed was estimated at prevailing market price of feed ingredients and cost of feed consumed per bird was calculated and used to determine the cost of feed required to produce a dozen eggs.

Egg quality analysis: Egg quality assessment was carried out on fresh eggs at weeks 8, 10 and 12 of the laying periods. Parameters examined include the exterior and interior egg quality characteristics, such as egg weight, shell weight and thickness, albumen and yolk weights, egg index, yolk index, albumen index, albumen: Yolk ratio, yolk colour and Haugh unit. At each stage of the analysis, two eggs per replicate were used, that is, a total of 24 eggs. The egg, shell and yolk weights were determined by weighing with digital scale (SF-400, China). The intact egg was first weighed. The lengths of the oblong and horizontal circumferences of the egg were measured by winding a string round the eggs and then tracing on a ruler to determine the lengths. The egg was then broken and the contents poured unto a flat tray. The weight of the eggshells was then weighed. The height of the thick albumen and that of the yolk were measured using a spherometer. The longest and shortest diameters each of the yolk and albumen were measured using a Vernier calliper while the yolk was still within the albumen. The yolk was then scooped out with a spoon and weighed. The albumen weight was calculated by subtracting shell and yolk weights from the weight of the intact egg. Percentages of shell, albumen and yolk weights based on egg weight were calculated. Egg shell thickness (mm) was measured using a micrometer screw gauge. Yolk colour was determined by matching with a Hoffman-La Roche yolk colour fan on a scale of 1-15. Any colour chip that best matches with the yolk colour was taken as the yolk colour.

The internal egg quality parameters were calculated using the following formulas:

$$\text{Egg shape index} = \frac{\text{Horizontal circumference of egg}}{\text{Oblong circumference of egg}}$$

$$\text{Yolk index} = \frac{\text{Yolk height}}{\text{Yolk diameter}}$$

$$\text{Albumen index} = \frac{\text{Albumen height}}{\text{Albumen diameter}}$$

$$\text{Albumen: yolk ratio} = \frac{\text{Albumen weight}}{\text{Yolk weight}}$$

$$\text{Haugh unit (HU)} = 100\log\left[H - \frac{\sqrt{G(30W^{0.37} - 100)}}{100} + 1.9\right]$$

Where:

H = Observed albumen height in millimetres
G = Gravitational constant (32.2)
W = Weight of egg (g)

The results obtained were analysed in a completely randomized design (CRD) and significantly different means were separated using LSD following the methods described by Snedecor[28].

RESULTS AND DISCUSSION

Performance of laying chickens fed ginger diets and the economics of production is presented in Table 2 while the egg quality parameters determined at weeks 8, 10 and 12 of the laying periods is presented in Tables 3-5, respectively. The results indicated that ginger supplementation had no effect ($p>0.05$) on the performance parameters evaluated (live-weight ,feed intake, egg weight, feed conversion ratio and hen-day egg production). Hen-day egg production was numerically higher in the fresh ginger group, followed by dry ginger and then control group. Cost per kilogram feed and feed cost per dozen eggs were numerically higher in the dry ginger, followed by fresh ginger and then control groups.

All the egg quality parameters were similar ($p>0.05$) at week 8 of the laying period (Table 3). At week 10, egg shape index was significantly ($p<0.05$) higher in birds fed ginger diets compared to the control group (Table 4). The highest value was recorded in eggs of chickens fed dry ginger followed by those fed fresh ginger and then 0.0% ginger group but all other parameters were similar ($p>0.05$). At week 12 (Table 5), egg shape index was significantly higher in dry ginger group compared to the control and yolk colour was

Table 2: Performance of laying chickens fed ginger diets and the economics of production

Parameters	0% ginger	0.5% dry ginger	0.5% fresh ginger	SEM
Av. initial live weight (g)	1695.00	1658.50	1754.25	41.93
Av. final live weight (g)	1681.50	1736.00	1716.30	33.76
Av. daily feed intake (g)	113.79	112.83	114.99	1.79
Av. egg weight (g)	61.77	59.91	61.36	0.74
Feed conversion ratio	1.84	1.89	1.88	0.37
Hen-day egg production (%)	57.24	57.44	63.66	3.95
Cost (₦) kg^{-1} feed	134.30	160.15	157.05	-
Feed cost (₦) $dozen^{-1}$ eggs	325.26	385.94	341.34	15.68

Means in the same row without superscripts are statistically similar ($p>0.05$), Av: Average

Table 3: Quality characteristics of eggs collected at 8 weeks in lay from hens fed ginger diets

Parameters	0% ginger	0.5% dry ginger	0.5% fresh ginger	SEM
Egg weight (g)	62.50	63.25	62.25	1.57
Shell weight (g)	8.00	9.00	8.00	0.74
Shell weight (%)	12.84	14.19	12.86	1.16
Yolk weight (g)	14.00	14.25	14.25	0.46
Yolk weight (%)	22.49	22.55	22.89	0.88
Albumen weight (g)	40.50	40.00	40.00	1.54
Albumen weight (%)	64.67	63.26	64.25	1.28
Egg shape index	0.90	0.86	0.89	1.26
Yolk index	0.54	0.56	0.54	0.02
Albumen index	0.17	0.16	0.19	0.01
Albumen: Yolk ratio	3.23	2.72	2.80	0.15
Yolk colour	1.00	1.25	1.00	0.14
Shell thickness (mm)	0.45	0.47	0.42	0.02
Haugh unit	70.00	71.65	72.05	2.32

Means in a row without superscripts are similar (p>0.05)

Table 4: Quality characteristics of eggs collected at 10 weeks in lay from hens fed ginger diets

Parameters	0% ginger	0.5% dry ginger	0.5% fresh ginger	SEM
Egg weight (g)	60.50	62.50	62.75	1.40
Shell weight (g)	7.75	7.75	7.75	0.48
Shell weight (%)	12.87	12.38	12.35	0.78
Yolk weight (g)	14.00	14.75	14.75	0.46
Yolk weight (%)	23.12	23.62	23.51	0.51
Albumen weight (g)	38.75	40.00	40.25	1.07
Albumen weight (%)	64.01	64.01	64.15	0.70
Egg shape index	0.83^{b}	0.89^{a}	0.88^{a}	0.01
Yolk index	0.50	0.54	0.48	0.02
Albumen index	0.18	0.17	0.16	0.01
Albumen: Yolk ratio	3.07	2.90	2.96	0.19
Yolk colour	1.25	1.75	1.50	0.26
Shell thickness (μm)	0.45	0.38	0.36	0.02
Haugh unit	72.05	71.90	71.88	2.51

Means in a row with different superscripts are significantly different (p<0.05)

Table 5: Quality characteristics of eggs collected at 12 weeks in lay from hens fed ginger diets

Parameters	0% ginger	0.5% dry ginger	0.5% fresh ginger	SEM
Egg weight (g)	60.00	61.00	61.25	0.72
Shell weight (g)	7.75	7.75	7.75	0.48
Shell weight (%)	12.95	12.72	12.64	0.83
Yolk weight (g)	14.25	14.00	14.50	0.62
Yolk weight (%)	23.75	22.95	23.72	1.09
Albumen weight (g)	38.00	39.25	39.00	0.92
Albumen weight (%)	63.30	64.34	63.90	0.94
Egg shape index	0.86^{b}	0.89^{a}	0.88^{ab}	0.01
Yolk index	0.53	0.52	0.51	0.02
Albumen index	0.17	0.17	0.18	0.01
Albumen: Yolk ratio	3.02	2.89	3.20	0.29
Yolk colour	1.50^{ab}	2.00^{a}	1.00^{b}	0.16
Shell thickness (mm)	0.37	0.39	0.36	0.02
Haugh unit	76.33	69.56	73.40	3.02
Egg cholesterol	165.25	152.50	150.25	9.46

Means in a row with different superscripts are significantly different (p<0.05)

also significantly higher (p<0.05) in dry ginger group compared to the fresh ginger group. Egg cholesterol content was not affected by ginger treatment.

Age, genotype of hen, nutrition, oviposition time and rearing system are some of the factors that affect egg quality characteristics[29]. Akbarian *et al.*[30] reported that egg weight, feed intake and feed conversion ratio were similar (p>0.05), egg production was higher and egg cholesterol content reduced (p<0.05) in hens fed diets containing 0.5 or 0.75% ginger root compared to the control group fed a diet without ginger. Duman *et al.*[31] and Narushin and Romanov[32] classified shape index (SI) as: Sharp eggs (SI<72), Normal (Standard) eggs (SI = 72-76) oval shape eggs, Round eggs (SI>76). Based on this classification, eggs laid in this study which ranged from 0.83 to 0.89 are round. The high shape indices observed in this study could also have resulted from the genetic make-up of the birds. Round eggs cannot be graded as AA (nearly perfect) or A (slightly less than AA). Eggs with round shape and unusually long eggs are poor in appearance and do not sit well in egg trays. Such eggs are more liable to be broken during transport than normal shape eggs, which in turn will increase economic losses for the farmer and merchants.

The darker colour of yolks from the dry ginger group could be due to the presence of carotenoids in the dried ginger. Dietary inclusion of the sundried ginger has led to better absorption of these pigments than fresh ginger in drinking water. An oily environment promotes the absorption of fat soluble substances like carotenoids. The yellow colour of ginger indicates its xanthophyll content. The higher yolk colour of eggs from the dry ginger group could also be due to the higher shape index observed in eggs from this group. Alipanah *et al.*[33] reported a non-significant negative correlation between yolk colour and egg shape index. However, Duman *et al.*[31] observed no correlation between egg shape index and yolk colour. Based on yolk colour, eggs from the dry ginger group would be preferred because most people generally prefer eggs with darker yolk colour[34].

CONCLUSION

Laying chickens could be fed sundried ginger at 0.5% levels in their diet without incurring adverse effect on performance but egg shape index should be monitored from 12 weeks in lay to avoid producing round eggs that cannot sit well in crates and are liable to breakage on transit. Providing fresh ginger in drinking water did not improve performance as compared to the dietary sundried ginger treatment which was easier to administer. Dry ginger meal may be used in the diet of laying chicken to achieve darker and more attractive yolk coloured.

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