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Research Article

Performance and egg qualities of old-laying hens fed with diets containing selected phytogenic feed additives

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ABSTRACT

Performance and egg qualities of old-laying hens fed with diets containing ginger, turmeric and garlic were evaluated in a twelve (12) week feeding trial. A total of 135 laying birds of Isa-Brown strain which were sixty-four (64) weeks old were used for the trial and arranged in a completely randomized design. Five diets were formulated for the trial: Diet 1 (control), Diet 2 (3% inclusion level of turmeric), Diet 3 (3% inclusion level of ginger), Diet 4 (turmeric and garlic at 2.25% and 0.75%, respectively) and Diet 5 (ginger and garlic at 2.25% and 0.75%, respectively). Proximate compositions of the Phytogenic Feed Additives (PFAs) were determined with the moisture content ranging between 5.03-7.50%; ash (3.26-6.11%); ether extract (7.39-14.58%); fibre (10.28-13.79%); protein (3.07-7.23%) and Nitrogen Free Extract (58.88-61.54%). The performance indices, though not significantly (P>0.05) influenced by the test diets except for Hen Day Production (HDP)had the highest weight gained (0.16kg) recorded for birds fed on diet containing ginger. The highest (62.92 and62.04 %) HDP were observed in birds fed diets containing ginger and ginger + garlic; respectively. However, the lowest weight gained (0.04kg) was recorded in birds fed diet containing turmeric + garlic; this diet also recorded the lowest % HDP and FCR with values 57.50% and 2.37 respectively. The overall values for the qualities of eggs from laying hens fed the PFAs showed that only the Haugh Unit, yolk colour and albumen height were significantly (P<0.05) affected; with those on Turmeric + Garlic diets having the highest for these parameters. However, the fatty acid variables were not significantly (P>0.05) affected by the dietary treatments. It could be concluded that the inclusion of PFAs in the diets of laying hens especially at older age would help to sustain performance with improved quality.

Key words: Old-laying hens, turmeric, ginger, garlic, phytogenic feed additives

INTRODUCTION

Livestock production constitutes a very important component of the agricultural economy of developing countries, a contribution that goes beyond direct food productiontoinclude multi-purposeuses, such as skins, fibre, fertilizer andfuel,as wellas capital accumulation. Furthermore, livestock are closely linked to the social and cultural lives of several million resource-poor farmers for whom animal ownership ensures varying degrees of sustainablefarming and economic stability (Okoro, 2016). Nutrition is the most expensive factor in poultry production taking approximately 70% of production budgets (MmadubuikeandEkenyem, 2001). Therefore, a reduced cost of production while improving the feed efficiency wouldbe a feasible option.

Various feed additives are used in poultry to maximize net returns and carcass quality. In the past, growth-promoting antibiotics were used as feed additives; however, these wereassociated with residues in the meat and eggs by consumers, and have been banned orlimited in many countries (Diarra *et al.,* 2011). As a result, natural alternatives toantibiotics, such as herbs and medicinal plants, have attracted attention due to theirwide range of potential beneficial effects (Mahesh and Prabhakar 2018).Among growth promoters, the most commonly used are antibiotics (Okoro, 2016). However, their use is restricted due to possible development of drugresistance in bacteria, drug residue in carcass and also alteration of natural gut micro-flora (Botsoglou *et al*., 2002). Some green additives have been studied as alternatives in order to maximize the growth performance of poultry in the diets without antibiotics. Compared with synthetic antibiotics or inorganic chemicals, these plant-derived products have proved to be less toxic, residue free and are thought to be ideal feed additives in food animal production (Rajesh and Devvrat, 2018)

Ginger is a rhizome of the plant *Zingiber officinale* consumed as a delicacy, medicine or spice and medical treatment for certain ailments in traditional medicine (Okoro, 2016). Ginger a natural growth promoter can be a potential alternative to artificial growth promoters like antibiotics (Zhang *et al.,* 2009). Also, ginger root contains several compounds which have biological activities such as antioxidation, antimicrobial and pharmacological effects (Ali *et al.,* 2008). Ginger has been reported to enhance animal nutrient digestion and absorption because of the positive effect on gastric secretion and digestive enzyme activities (Platel and Srinivasan, 2000).

Garlic (*Allium sativum*) is commonly used as either a flavoring agent for food or as traditional therapeutic agent for the treatment of different diseases (Sallam *et al.* 2004). Animal studies have showed that garlic has hypolipidemic, hypotensive, hypoglycemic, hypo thrombotic, and hypo

atherogenic effects (Navidshad *et al.,* 2018). The flavonoid and organo-sulphur components of garlic and garlic derivatives have been shown to have therapeutic and antioxidant effects in laying birds (Navidshad *et al.,* 2018).

The active substances in turmeric (*Curcuma longa*) are curcuminoids aromatic turmerones (32.5%), alpha (15.6%) and beta turmerones (17.1%) and curlone (Rajesh and Devvrat, 2018).Curcuminoids have a wide spectrum of biological activities including antioxidant, antibacterial, antifungal, antiprotozoal, antiviral, anticoccidial and anti-inflammatory property. Turmeric as a supplement can modulate the lipid profile and cholesterol content (Rajesh and Devvrat, 2018).

Furthermore, recent studies showed that herbal enriched super eggs can be obtained from laying hens fed with diets supplemented with phytobiotics, herbs containing secondary metabolites such as garlic, onion, basil leaves, turmeric powder, citrus pulp, flaxseed (Damaziak *et al*., 2017; Mirbod *et al*., 2017; Ehr *et al*., 2017). It is therefore envisaged that performance and egg qualities will be improved in laying hens fed diets containing ginger, turmeric and garlic especially at older age. This thus formed the major thrust of this study.

MATERIALS AND METHODS

Experimental site

The field study was conducted at the Teaching and Research Farm of the Department of Animal Production and Health, The Federal University of Technology, Akure (FUTA), Ondo State, Nigeria.

Collection, processing of garlic, ginger and turmericand proximate composition analysis

Fresh Turmeric, garlic and ginger were purchased from the market and washed in water to remove the adhering dirt. The rinds were peeled off after which they were chopped into smaller pieces using kitchen knife. It was air-dried inside a house, milled and then packed in a big air tight polythene bag. However, the garlic was peeled and oven dried. The proximate composition (moisture, ash and fibre) were determined using AOAC (2000) methods. Crude protein content was determined using the micro-Kjedahl method as described by Agbede *et al.* (2009).

Determination of Free Fatty Acids(FFA)

Free Fatty Acids (FFA) was determined by weighing 1.00g of fat sample into a conical flask. 10ml of isopropyl alchohol was added. Thereafter, 3-5 drops of phenolphthalein indicator was added. The solution was titrated with 0.1% (0.025N) NaOH solution until yellow colour turns pink and persist for about 30 seconds.

Calculation

$$\text{FFA} = \frac{(V - B) \times N \times 28.21}{W}$$

Where:
V = volume of titrant
B = blank volume
N = normality
W = Weight of fat sample

Experimental layout and birds' management

Twelve (12) weeks feeding trial which was arranged in a Completely Randomized Design was conducted to determine the performance and egg qualities of birds fed with diets containing garlic, ginger and turmeric. One hundred and thirty-five (135) laying birds of Isa Brown strain which were sixty-four (64) weeks old were obtained from the Poultry section of the Teaching and Research Farm of the Department of Animal Production and Health, of the University. The formulation was done to meet the NRC (1994) requirements for laying hen.Five diets were formulated for the trial: Diet 1 (control), Diet 2 (3% inclusion level of Turmeric), Diet 3 (3% inclusion level of Ginger), Diet 4 (Turmeric and ginger at 2.25% and 0.75%, respectively) and Diet 5 (Ginger and garlic at 2.25% and 0.75%, respectively) as shown in Table 1. The response criteria included feed intake, feed conversion ratio and hen day production. Individual body weight of all hens was taken at the start of first phase and the end of the last phase, so as to determine the average body weight change. Egg production was recorded daily for each treatment and an average egg production rate (hen-day percentage) was calculated for every phase.

Egg quality evaluation

The trial was carried out in three (3) phases of four (4) weeks per phase.Three days to the end of each phase, eggs were collected and analyzed for both external and internal qualities. Egg quality parameters assessed included egg weight, egg length and breadth, albumen height, albumen weight, albumen length, albumen breadth, yolk weight, yolk length, yolk breadth, yolk height, yolk colour and Haugh unit.

Table 1: Gross composition of diets fed at laying phase

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Maize	59.5	59.5	59.5	59.5	59.5
GNC	14	14	14	14	14
Soybean meal	8	8	8	8	8
Wheat offal	6	6	6	6	6
DCP	2	2	2	2	2
C/stone	7	7	7	7	7
Premix	0.3	0.3	0.3	0.3	0.3
Tumeric	0	3	0	0	0
Tumeric+Garlic	0	0	0	3 (2.5+0.5)	0
Ginger+Garlic	0	0	0	0	3 (2.5+0.5)
Ginger	0	0	3	0	0
Methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Salt	0.3	0.3	0.3	0.3	0.3
Vegetable oil	2.3	2.3	2.3	2.3	2.3

External egg qualities

The egg weight was measured using a sensitive scale, while the egg length and breadthwere measured for each egg using Vernier caliper. The breadth was measured as the distance between two ends of each egg at the widest cross-sectional region using the Vernier caliper. The length was measured as the distance between the broad and narrow ends of the eggs.

Internal egg qualities

The following measurements were determined:

Albumen height

The eggs were gently broken and the maximum albumen height were measured with tripod spherometer.

Albumen weight

This is the difference between the egg weight and the sum of weight of yolk and dry egg shell expressed as a percentage of the whole egg.

Yolk weight

This was measured using the sensitive scale.

HaughUnit (HU)

This was calculated using the values obtained for the egg weight and the albumen height as expressed by Haugh (1937) in the formula shown below:

$$HU == 100\log (H+7.5-1.7W^{0.37})$$

Where, H =Albumen height in mm
W = egg weight in gram

Statistical analysis

All data were subjected to one-way Analysis of Variance (ANOVA) using SPSS version 23.0 (SPSS Software products, Marketing Department, SPSS Inc Chicago, IL, USA). Where there were significant differences, Duncan Multiple Range Test (DMRT) of the same package was used to compare the mean values.

RESULTS

Proximate composition

Table 2 shows the proximate composition of the Phytogenic Feed Additives (PFA) used in this experiment. Highest value (7.50 %) of moisture content was recorded inTurmeric + Garlic which was significantly (P<0.05) different from the other valueswhile the lowest value of 5.03% was observed in Turmeric. Similar trend was observed for ash content as Turmeric + Garlic had the highest value of 6.11% and lowest value of 3.26% was seen in Turmeric. However, the highest percentage fat was recorded in Turmeric (14.98%) while the lowest value (7.39%) was seen in Turmeric + Garlic. The percentage crude fibre content was significantly (P<0.05) highest in Turmeric + Garlic (13.79%)compared to 10.28% seen in Ginger. Also, the percentage crude protein (CP) was significantly(P<0.05) highest (7.23%) in Ginger while Garlic +Ginger had the lowest value of 3.07% CP. Ether extract was observed to be significantly (P<0.05) highest (61.54%) in Turmeric but not significantly different from the value (60.89%) obtained in Garlic +Gingerand the lowest value (58.88%) was seen in Turmeric +Garlic.

Performance indices

The performance indices (Table 3) were not significantly (P>0.05) influenced by the experimental diets with the exemption of Hen Day Production (HDP). The highest (62.92 an62.04%) HDP was observed in birds fed diets containing ginger and ginger + garlic; respectively while the lowest HDP (57.50%) was recorded for birds fed diet containing turmeric + garlic.

Egg quality analyses for first laying phase

Table 4 shows the egg quality analyses for the first phase of egg laid by the experimental birds. Only the albumen height, haugh unit and yolk colour were significantly influenced (P<0.05) by the inclusion levels of garlic, ginger and turmeric. The albumen height was highest (1.08cm) in eggs of the birds fed the control diet but not significantly (P>0.05) different from the value (0.96cm) for those on Garlic +Gingerwhile the lowest values (0.86cm and 0.84cm) were observed in birds fed diets containing Ginger and Turmeric + Garlic, respectively. The same trend was observed in the Haugh unit. However, the yolk colour was significantly highest (13.67) in eggs from the birds fed diet containing Turmeric +Garlic while the lowest value (7.22) was seen in the control diet..

Egg quality analyses for second laying phase

Table 5 reveals the egg quality analyses for the second phase of egg laid by the experimental birds. Only the albumen weight and albumen breadth were significantly (P<0.05) influenced by the varying levels of garlic, ginger and turmeric. The albumen weight had the highest value (40.65g) in birds fed the control diet though not significantly (P>0.05) different from the values 40.24g and 39.03g for diets containing Turmeric and Garlic + Ginger, respectively. Also, the albumen breadth had the highest value (7.63cm) in birds fed the diet containing Turmeric but not significantly (P>0.05) different from values 7.40cm and 7.32cm of the control diet and diet containing Garlic + Ginger, respectively.Thiswas lowest (7.00cm) at diet containing Ginger which was not significantly (P>0.05) different from 7.06cm of diet containing Turmeric + Garlic.

Egg quality analyses for third laying phase

Table 6 shows the egg quality analyses for the third phase of egg laid. It was observed that none of the parameters measured

Table 2: Proximate composition

Nutrients (%)	Turmeric	Ginger	Turmeric +Garlic	Garlic +Ginger	±SEM	P value
Moisture	5.03[d]	7.08[b]	7.50[a]	5.89[c]	0.01	0.001
Ash	3.26[d]	5.69[b]	6.11[a]	4.16[c]	0.01	0.001
EE	14.98[a]	9.61[c]	7.39[d]	12.51[b]	0.06	0.001
Fibre	11.52[c]	10.28[d]	13.79[a]	13.49[b]	0.03	0.001
Protein	3.67[c]	7.23[a]	6.33[b]	3.07[d]	0.07	0.001
NFE	61.54[a]	60.07[b]	58.88[c]	60.89[a]	0.12	0.001

[a,b,c] – Means on the same row having different superscripts are significantly (P< 0.001) different. EE = Ether Extract, NFE = Nitrogen Free Extract.

Table 3: Performance indices

Performance indices	Control	Turmeric	Ginger	Turmeric + Garlic	Garlic +Ginger	SEM	P-value
Initial Weight (kg)	1.84	1.97	1.77	1.87	1.81	0.02	0.09
Final Weight (kg)	1.99	2.02	1.93	1.92	1.95	0.02	0.59
Weight Gained (kg)	0.15	0.05	0.16	0.04	0.14	0.02	0.10
FI/Bird/Day (g)	112.53	113.07	112.66	113.35	112.59	0.12	0.22
% HDP	58.25[b]	58.47[b]	62.92[a]	57.50[b]	62.04[a]	0.98	0.04
FCR	2.34	2.33	2.15	2.37	2.18	0.04	0.35

[a,b,c] – Means on the same row having different superscripts are significantly (P< 0.05) different
FI= feed intake, %HDP= percentage Hen Day Production, FCR= feed conversion ratio.

Table 4: Egg quality analyses for first laying phase

Quality Parameters	Control	Turmeric	Ginger	Turmeric +Garlic	Garlic +Ginger	±SEM	P value
Egg weight (g)	63.56	63.18	62.91	59.78	64.73	0.74	0.31
Egg length(cm)	5.72	5.67	5.64	5.57	5.72	0.04	0.61
Egg breadth (cm)	4.38	4.40	4.37	4.34	4.44	0.02	0.59
Yolk weight (g)	14.99	15.49	15.17	15.61	15.48	0.23	0.91
Yolk length (cm)	3.96	3.93	4.00	4.04	4.10	0.03	0.27
Yolk breadth (cm)	4.14	4.13	4.19	4.18	4.32	0.02	0.13
Yolk height (cm)	1.72	1.79	1.77	1.77	1.74	0.03	0.96
Albumen weight (g)	40.82	39.43	36.78	37.20	41.00	0.66	0.14
Albumen length (cm)	8.03	8.47	8.64	8.04	8.50	0.10	0.19
Albumen breadth (cm)	6.52	6.73	7.03	6.61	6.83	0.09	0.46
Albumen height (cm)	1.08[a]	0.89[b]	0.86[b]	0.84[b]	0.96[ab]	0.02	0.01
Haugh unit	101.28[a]	92.60[b]	90.59[b]	90.70[b]	95.56[ab]	1.09	0.02
Yolk colour	7.22[c]	12.78[b]	11.67[b]	13.67[a]	11.78[b]	0.12	0.01

[a,b,c] – Means on the same row having different superscripts are significantly (P< 0.05) different.

Table 5: Egg quality analyses for second laying phase

Quality Parameters	Control	Turmeric	Ginger	Turmeric +Garlic	Garlic +Ginger	±SEM	P value
Egg weight (g)	64.99	62.92	60.90	61.95	63.21	0.52	0.16
Egg length(cm)	5.81	5.73	5.63	5.66	5.71	0.03	0.33
Egg breadth (cm)	4.39	4.37	4.36	4.36	4.46	0.02	0.55
Yolk weight (g)	16.01	15.79	14.78	15.74	15.92	0.19	0.28
Yolk length (cm)	4.16	4.22	4.14	4.17	4.23	0.02	0.51
Yolk breadth (cm)	3.94	4.01	3.87	3.89	3.96	0.02	0.25
Yolk height (cm)	1.51	1.61	1.48	1.53	1.53	0.02	0.55
Albumen weight (g)	40.65[a]	40.24[ab]	37.54[bc]	37.11[c]	39.03[abc]	0.45	0.05
Albumen length (cm)	9.17	9.27	8.99	9.04	9.26	0.09	0.84
Albumen breadth (cm)	7.40[ab]	7.63[a]	7.00[b]	7.06[b]	7.32[ab]	0.07	0.03
Albumen height (cm)	0.59	0.51	0.51	0.53	0.54	0.01	0.20
Haugh unit	72.03	66.03	66.33	69.11	68.56	1.20	0.52
Yolk colour	8.89	9.22	9.33	9.61	9.28	0.09	0.15

[a,b,c] – Means on the same row having different superscripts are significantly (P< 0.05) different.

was significantly influenced by the dietary treatments except the Albumen height. Those eggs from birds fed Turmeric + Garlic had significant (P<0.05) highest value (0.46cm) compared to others though not significantly (P>0.05)different from those on Garlic + Ginger (0.40cm).

Fatty acids

Table 7 shows the free fatty acid (FFA) compositions of the eggs of birds fed with diets containing phytogenic feed additives. All the FFA were not significantly (P>0.05) influenced by the phytogenic feedadditives excluding 4,7,10,13,16,19-docosahexaenoic acid. The highest value (14.62) for this FFA was seen in those on Turmeric which was not significantly (P>0.05) different from other values excluding 13.34 from those on ginger which was the lowest value.

DISCUSSION

The moisture content of the Phytogenic Feed Additives (PFAs) used in this study ranged between 5.03 – 7.08%, these values were lower than the 8.92% moisture reported by Ikpeama *et al.* (2014) when chemical composition of turmeric was evaluated. The crude protein(CP) of the PFAs was highest at ginger, with the CP content of 7.23%. However, this value was lower than 8.83% CP reported by Ugwoke and Nzekwe (2010) when chemical analysis of ginger was carried out but higher than 5.28% CP reported by Adanlawo and Dairo (2007).Also, the values in this experiment supersedes 1.83% CP reported by Ahaotu and Lawal (2019) during the determination of proximate composition of turmeric. However, the ash and fibre contents in this study were highest at Turmeric + Garlic which showed that the mixture of these PFAs had higher mineral compositions for optimal performance of the birds. The ether extract was highest (14.98%) at turmeric which signified high fat content in turmeric. This negates the values reported by Ahaotu and Lawal (2019) and Ikpeama *et al.* (2014) with values of 0.80% and 6.85% respectively. However, this corroborated the report of Ahamefula *et al.* (2014) that turmeric contains beta - carotene as well as polyphenol coupled with fatty acid and essential oil.

The performance indices were not statistically influenced by the diets in the course of the experiment. However, the best

Table 6: Egg quality analyses for third laying phase

Quality Parameters	Control	Turmeric	Ginger	Turmeric +Garlic	Garlic +Ginger	±SEM	P value
egg weight (g)	58.11	60.22	58.93	60.89	59.46	0.66	0.71
egg length(cm)	5.63	5.64	5.59	5.71	5.56	0.03	0.64
egg breadth (cm)	4.21	4.32	4.28	4.40	4.32	0.02	0.08
yolk weight (g)	13.68	15.08	15.27	15.01	15.29	0.23	0.16
yolk length (cm)	4.18	4.06	4.08	4.18	4.07	0.03	0.62
yolk breadth (cm)	3.90	3.89	3.84	3.84	3.88	0.03	0.97
yolk height (cm)	1.37	1.42	1.39	1.47	1.42	0.02	0.61
Albumen weight (g)	35.26	36.92	34.93	37.26	35.70	0.53	0.56
Albumen length (cm)	9.12	9.66	9.43	9.39	9.02	0.10	0.31
Albumen breadth (cm)	7.09	6.93	7.07	7.13	7.40	0.10	0.69
Albumen height (cm)	0.34^{b}	0.32^{b}	0.33^{b}	0.46^{a}	0.40^{ab}	0.02	0.05
Haugh unit	53.81	49.22	49.39	61.52	57.89	1.57	0.07

^{a,b,c} – Means on the same row having different superscripts are significantly (P< 0.05) different.

Table 7: Fatty acid analyses

Name of the fatty acid	Control	Turmeric	Ginger	Turmeric + Garlic	Garlic +Ginger	±SEM	P value
Methyl tetradecanoate	17.87	17.88	17.81	17.88	17.84	0.02	0.08
Pentadecanoic acid	9.15	9.15	9.13	9.14	9.13	0.01	0.65
9 - Hexadecenoic acid	24.89	23.30	16.27	22.95	21.80	2.23	0.14
Hexadecanoic acid	43.22	42.19	34.77	41.85	40.67	2.13	0.11
Heptadecanoic acid	9.65	9.64	9.58	9.61	9.61	0.02	0.31
Gamma.-linolenic acid	15.36	15.07	12.46	15.31	14.59	0.93	0.22
9,12-Octadecadienoic acid	15.03	14.31	12.10	14.49	14.13	0.69	0.10
Methyl stearate	24.59	23.92	22.29	23.94	24.08	1.15	0.68
5,8,11,14-eicosatetraenoic acid	16.63	16.44	13.50	16.32	15.68	1.06	0.29
5,8,11,14,17- eicosapentaenoic acid	13.38	13.28	11.82	13.23	12.91	0.53	0.29
8,11,14-eicosatrienoic	13.00	12.91	11.54	12.84	12.57	0.49	0.29
Cis-11-Eicosenoic acid	10.24	10.22	9.96	10.21	10.17	0.09	0.27
4,7,10,13,16,19- docosahexaenoic acid	14.54^{a}	14.62^{a}	13.34^{b}	14.50^{a}	14.33^{a}	0.21	0.01

^{a,b,c} – Means on the same row having different superscripts are significantly (P< 0.05) different.

feed conversion ratio (FCR) was seen in birds fed with diet containing ginger which was marginally different from the FCR of birds fed with diet containing turmeric. This implies that birds fed diet containing ginger had the best percentage hen day production. Since the performance indices were not influenced by the diets, it could be said that synergy of different factors is responsible for the performance indices of laying birds(Tumova and Gous, 2012).

Eggs laid were analysed for three phases in this study. Phase I showed that some of the egg parameters were influenced by the PFAs. The highest values for albumen height and Haugh unit were seen in the control diet. However, among the test diets, diet containing turmeric had the highest values for these egg parameters. As albumen quality is an important indicator of egg freshness, it can be said that turmeric had refreshing properties on the albumen over other PFAs used in this experiment. This automatically affected the Haugh unit as it was determined by the albumen height and egg weight. Also, diets containing turmeric had superior values for yolk colour over other diets. This can be due to richness of turmeric in carotene pigment which reflected in the colouration of the egg yolk (Ahamefula *et al*., 2014).

Second phase showed that only the albumen weight and breadth were influenced by the diets. However, the values from diet containing turmeric only, had superior values over other test diets containing PFAs which is also attributed to the refreshing property of turmeric on the albumen and also, the ability of the birds to efficiently metabolize and utilize the nutritive qualities of turmeric. The significance of the diets on some of the albumen parameters can also be related to oviposition time, as reported by Tůmová and Gous (2012) that yolk percentage is slightly lower ineggs laid in the afternoonbut they containsignificantly more albumen.

The third egg laying phase showed that only the albumen height was influenced by the diets. Diet containing turmeric + garlic had the highest value for albumen height which could be due to the oviposition time. The little significance on the egg parameters could also be associated with the birds' age. Tumova and Gous (2012) reported that external and internal quality of eggs depend on genotype and environmental factors such as housing system, oviposition time, age, ambient temperature and nutrition, as well as their interactions.

Fatty acids were analyzed in the eggs laid by birds fed with diets containing Phytogenic Feed Additives (PFA). Several fatty acids were seen in the eggs analyzed which corroborated the reports ofCherian and Quezada (2016). In this study 4,7,10,13,16,19-docosahexaenoic acid was the only fatty acid influenced by the diets, and its value was highest in diet containing turmeric while diet containing ginger had the lowest value of all the test diets. According to study by Cherian and Quezada (2016), the test ingredients did not influence the fatty acid compositions of the eggs analyzed. This could be due to the genetic conformation of the birds aiding the natural production of different fatty acids.

CONCLUSION

It can be deduced from this study that the Phytogenic Feed Additives (PFAs) had marginal influence on the external and internal qualities of eggs collected from Isa-Brown laying birds. Across the phases, the recorded value for egg weight was largest at diet containing Garlic + Ginger. Also, the highest % Hen Day Production (HDP) and the best Feed Conversion Ratio (FCR) were seen in both diets containing Ginger and Garlic + Ginger. Birds also recorded better performance in weight gained in these diets. Hence, diets containing Ginger and Garlic + Ginger are adoptable by farmers for good egg sizes and better output in % HDP while the FCR is also with reasonable output, while diets containing Turmeric and Turmeric + Garlic are recommendable for quality yolk colouration.

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