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Infertile egg meal can replace fishmeal in broiler chicken diet

[a]*Akinola, O. S., [a] Akintola, K. A. and [b] Oluwatosin, O. O.
[a]Department of Animal Production and Health, [b]Department of Animal Nutrition, College of Animal Science and Livestock Production, University of Agriculture, Alabata Road, P.M.B. 2240, Abeokuta, Ogun State.
***Corresponding author:** bayomiola@gmail.com, +2348035700959

Abstract

Fishmeal, as animal protein source, is characterised by high cost, dwindling availability and adulteration by feed ingredient suppliers. In view of these, two hundred and ten (210) ten-day old broiler chicks were used, in 2 x 4 experimental layouts, to investigate the effect of replacing fishmeal with infertile egg meal of two forms (with or without shell) and at four graded levels (0, 30, 60 and 100%) on growth performance, haematology, serum biochemistry and carcass indices of broiler chicken. Crude protein (50.2%) and Ether extract (30.6%) were higher in infertile egg without shell (IEM) than in infertile egg with shell (IEMS) (41.36 and 23.4%). Egg forms (IEM or IEMS) did not affect (P>0.05) performance indices measured. Increasing levels of infertile egg meal reduced (P<0.05) body weight gain and final weight without affecting feed conversion ratio (FCR). The IEMS use led to reduction in feed cost (P<0.05) than in IEM. Levels of infertile egg meal reduced (P<0.05) feed cost per body weight gain with least cost at 100% replacement of fishmeal. The IEM elevated (P<0.05) serum total protein, urea and globulin but lowered serum creatinine. Increasing the levels of infertile egg meal lowered blood urea while increasing total protein and globulin. Inclusion of IEM at 100% improved Total protein, Albumin and Globulin. The cost of feed reduced (P<0.05) by 13.8% at 100% IEM and IEMS. It was concluded that infertile egg without shell can be used up to 100% in place of fishmeal in broiler chicken diets to reduce feeding cost and improve health without affecting the performance.

Keywords: Broiler chicken, Fishmeal, Infertile eggs meal, Performance, Carcass, Blood indices

Introduction

The significant increase in the global demand for livestock products will require increasing amounts of feed protein supplies and sources, which come with its attendant high cost. As a result, alternatives which will bring about lower feed price will need to be continually sourced and reviewed. There is therefore, strong justification for research and development investment into a number of very promising new protein feed sources (FAO, 2004). Feedstuff supplying appreciable and quality protein are limited when considering formulating ration for animals in the poultry and livestock industry. Protein feedstuffs from plant origin may not be solely used in feeding monogastric animals without supplementation with an animal protein source or with free amino acids. Fishmeal is the most readily available and high quality animal protein source use in formulating and compounding feed for monogastric animals in developing economies of the world. The superiority of fishmeal compared to other protein sources cannot be challenged; but its high cost results in the rise in prices of feed (Olaniyi and Salau, 2013); coupled with its dwindling availability and adulterations by feed ingredients suppliers (Adejinmi *et al.,* 2000). Regrettably, some fishmeal produced cannot easily be distinguished from other animal proteins (FAO, 2004). Also, many seas such as the North Sea are being seriously over-fished, leading to increasing international restrictions on their exploitation to try to conserve and regenerate fish stocks. In addition, there are still underlying concerns about the contamination of fish stocks by pollutants dumped in the oceans, leading to fishmeal contamination, for example by dioxin (FAO, 2004). Therefore, seeking alternatives to fishmeal in non-ruminant nutrition can be a means of solving these emerging challenges. Fish meal, which is the most common quality animal protein used in livestock feed could be replaced with animal by-products such as meat and bone meal (**Drewyor and Waldrop, 2000**), maggot meal (Awoniyi *et al.,* 2003; Adeniji, 2007), blood meal (Khawaja, 2007), poultry by-products and hatchery by-product meal (Swain *et al.,* 2011; Abiola *et al.,* 2012) to save on feed cost. Hatchery by-products consist of infertile eggs, dead-in-shells; weak and culled chicks' empty shells and male egg type chicks (Al-Harthi *et al.,* 2010; Glatz *et al.,* 2011). Reject infertile eggs, obtained after the candling process to detect infertile eggs, can give a good response in broiler as fishmeal, if processing and handling before and during drying are appropriately done. Since eggs contain ideal protein from which very healthy and vigorous chick are formed; therefore, its infertile form will no doubt be rich in high quality protein, minerals and vitamins to support of the fast growth of broiler chicken. Approximately 64% of the eggs set produce the chicks and the rests are available as waste. In India 567million eggs are set every year producing 17,406 tons of dried waste. Since fresh egg waste is wet and bulky, its transport is difficult; and disposal at the site is also a problem (Dhaliwal, 1995). Hatchery wastes is a good source of **crude protein**, fat and calcium with low phosphorous (Khan and Bhatti, 2002; Mehdipour *et al.,* 2009). While there is paucity of information on the use of reject infertile eggs and response of broilers to infertile egg meal as a replacement of fishmeal in the diet of broilers, most studies reported the use of hatchery waste meal and unhatched eggs in the diet of poultry and miro-livestock (Abiola, 1999; Abiola and Onunkwor, 2004; Mehdipour *et al.,* 2009; Agunbiade *et al.,* 2011; Abiola *et al.,* 2012; Odunsi *et al.,* 2013). Its use in poultry feed will reduce loss of foreign exchange, as a result of importation of fishmeal. It will also result in improvement in broiler production at reduced cost, leading to increased profit margin and reduced cost of poultry products. Proper utilization of reject infertile egg will solve part of the waste disposal challenges in the hatchery industry. This study therefore aimed at investigating performance and blood profile of broilers birds fed diets containing infertile eggs with or without shell.

Materials and methods

The research was carried out at the poultry farm of Dynamic Initiative Farm Plot 5A Road 16 Owode Estate Abeokuta Road Ibadan, Oyo State (7 ˚ 22'59fiN, 3 ˚50'09fiE, 185 M above sea level). Located in the derived savannah vegetation zone of Southwestern Nigeria. The region's climate is Tropical and humid, with average of 1311 mm a^{-1} of rain falling during April to September. Daily temperatures average 21 ˚C in January (coolest month) and 34 ˚C in March, which is the hottest month.

Processing of test ingredient

The infertile eggs were collected from a hatchery in Ibadan. They were divided into two batches, processing of batch one involved the breaking, collection of content (albumen and yolk), whisking, oven drying in a local oven powered by charcoal and monitoring the temperature at 75 ºC until dried to form IEM. The second batch involved breaking, whisking with shell, oven drying at 75 ºC dried, to form IEMS. The IEM and IEMS were milled using 2 mm sieve and stored for subsequent use.

Experimental animal and management

Two hundred and twenty-five day-old Marshal broiler chickens sourced from a reputable commercial hatchery in Ibadan were brooded for ten days. Antibiotics and vitamin solutions were given; vaccines (against Gumboro and Lasota) were also administered. During the ten days brooding period birds received commercial broiler starter ration (Maize-soybean meal-based diet; CP=23%, ME=12.60 MJ/kg) *ad libitum*. After which, 210 chicks were allotted on weight equalization basis into 21 pens, each pen housed 10 chicks, with three pens allotted to each treatment; each pen represents a replicate.

Experimental diet and feeding

The IEM and IEMS replaced fishmeal of the control diet at 0, 30, 60 and 100%. Detail of inclusion levels of the two forms of infertile egg meals are as follows: Diet 1, control diet with fishmeal; Diet 2, IEM replaced 30% fishmeal; Diet 3, IEM replaced 60% fishmeal; Diet 4, IEM, replaced 100% fishmeal; Diet 5, IEMS replaced 30% fishmeal; Diet 6, IEMS replaced 60% fishmeal; Diet 7, IEMS replaced 100% fishmeal. Composition of each diet is as shown in Table 1. A straight diet, without partitioning into starter and finisher phase was used during the study. Metabolizable energy and crude protein contents of the feeds were balanced within the recommended range (NRC, 1994).

Table 1: Ingredients (g/kg) and nutrient composition of experimental diet

Ingredients	IEM				IEMS			
	0%	30%	60%	100%	0%	30%	60%	100%
Maize	590	590	590	590	590	600	600	600
Fishmeal 72%	50	35	20		50	35	20	-
Egg meal	-	15	30	50	-	-	-	-
Egg meal (shell)	-	-	-	-	-	15	30	50
Wheat bran	20	20	15	10	20	20	10	10
Limestone	10	10	10	10	10	10	10	10
Bone meal	30	30	30	30	30	20	20	10
Soya meal	290	290	295	300	290	290	300	310
Lysine	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
*Vitamin and mineral Premix	3	3	3	3	3	3	3	3
Common Salt	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Methionine	2	2	2	2	2	2	2	2
Total	1000	1000	1000	1000	1000	1000	1000	1000
Calculated chemical composition (%)								
ME (MJ/kg)	12.20	12.18	12.17	12.19	12.20	12.28	12.24	12.26
Crude protein	21.78	21.47	21.30	21.31	21.78	21.41	21.29	21.11
Ether extract	3.80	4.11	4.42	4.82	3.80	4.05	4.25	4.55
Crude fiber	2.85	2.86	2.85	2.81	2.85	2.91	2.92	3.03
Calcium	1.30	1.30	1.24	1.21	1.30	1.07	1.10	0.88
Phosphorus	0.60	0.60	0.61	0.61	0.60	0.47	0.46	0.33
Lysine	1.78	1.74	1.71	1.68	1.78	1.72	1.67	1.61
Methionine	0.58	0.58	0.57	0.56	0.58	0.57	0.55	0.54

*Premix contained the following (Univit. 15 Roche) in per kg of diet: 1500I.U.,Vit. A; 1500I.U.,Vit. D; 3000I.U.,Vit. E; 3.0g, Vit.K; 2.5g, Vit.B_2; 0.3g, Vit.B_6; 8.0mg, Vit. B_{12}; 8.0g, Nicotinicacid; 3.0g, Ca -Pantothenate; 5.0mg, Fe; 10.0g, Al; 0.2g, Cu; 3.5mg, Zn; 0.15mg, I; 0.02g, Co; 0.01g Se.

IEM – Infertile Egg Meal; IEMS – Infertile Egg meal with Shell

Parameters measured

Chemical composition of test ingredients and experimental diets

Dry matter of test ingredients and feed samples were determined at 105°C overnight, Ash content by incinerating at 550°C for 5.5 h in a Muffle furnace. The crude protein (CP), crude fibre (CF), ether extract (EE) content of the test ingredients and feeds were determined according to methods described by AOAC (2005). The metabolizable energy (ME) of IEM, IEMS and experimental diets were derived using the formulae developed by Pauzenga, (1985):

ME = 37 x %Crude Protein + 81.8 x %Fat + 35.50 x %NFE ….…Equation 1

Growth performance

Initial body weight before the commencement of the study were taken, after which body weight and feed intake were measured at weekly intervals, on pen basis (pen=3 per treatment). Feed intake was determined by subtracting left-over feed from feed given to birds in each replicate on daily basis. Body weight gain was calculated as difference between final and initial body weight. The feed conversion ratio was calculated as feed intake per unit body weight gain for the study duration. The cost of individual ingredient during the study was used to calculate cost of feed and subsequently the cost per kilogram body weight gained of broilers. Mortality was expressed in fraction of number dead to initial number of birds at commencement of the study, in replicates and treatments.

Carcass characteristics determination

At the end of the study, two birds from each replicate (n=6 per treatment), whose weights were representative of average weight of birds contained in each replicate were selected, sacrificed and eviscerated, according to standard procedures (Jensen, 1984) to dissect the cut-up parts such as head, neck, shank, thigh, drumstick, back and breast, and weighed. The internal organs, such as liver, gizzard, kidney and heart were removed and weighed using a top-loading scale. The values obtained were expressed as percentage of live weight.

Blood sample collection

At day 56, 2.5 mL of blood samples were collected from two birds in each replicate (n=6 per treatment), by jugular vein puncture into tubes containing ethylenediamine-tetra-acetate (EDTA) for haematological parameters. While another 2.5 mL of blood samples from the same birds were collected into plain tubes for the determination of blood serum parameters. The blood samples were contained in well labeled sample bottles and the followings were determined for haematological parameters: packed cell volume (PCV), haemoglobin concentration (Hb) and red blood cell (Rbc); and for serum biochemistry: Total protein, albumin, globulin, uric acid, creatinine, and calcium (mg/dL). Fixed in a capillary tube, the blood was centrifuged at a revolution of 12,000 per minute for five minutes in a Hawksley micro haematocrit centrifuge. The PCV value was obtained using micro haematocrit reader and expressed in percentage. The Hb was determined spectophotometrically according to the method of ICSH, 1967. RBC was carried out by use of the haemocytometer. Total protein, urea concentration, creatinine, albumin was determined spectrophotometrically by Randox kit. Globulin was obtained by subtracting albumin values from total serum protein. Calcium was determined spectrophotometrically using Randox kit.

Statistical analysis

Data from growth performance, carcass characteristics and blood were subjected to one way analysis of variance in a 2 (IEM and IEMS) by 4 (0, 30, 60 and 100%) factorial arrangement, using general linear model (GLM) procedure of Minitab 17.0 (Minitab statistical software, 2016). The model is $Y_{ijk}=\mu+T_i+L_j+TL_{ij}+e_{ijk}$, where Y_{ij} is the observed response; μ is the overall mean; T_i the effect of egg form i and L_j is the effect of level of infertile egg j; TL_{ij} is the interaction between T, egg form and L, level of infertile egg; and e_{ijk} the residual error. Significant means were separated using Tukey–Kramer post hoc test for multiple mean comparisons in Mintab 17.0 statistical software.

Results

Analysis of test ingredients and experimental diet.

Chemical composition of IEM and IEMS (Table 2) showed that IEMS had higher ash content compared to IEM. Crude protein, energy and ether extract were higher in IEMS compared to value recorded in IEM. Crude fibre was higher in IEMS. Chemical composition of the experimental diet (Table 3) revealed that the diets were isocaloric and isonitrogenous, Additionally, the mineral content was the same for all the diets. However, diets with IEM had increased ether extract content as the levels of IEM increased in diets.

Growth Performance and cost benefit

The main effect of infertile egg forms and the levels of use on the growth performance of broiler birds are presented in Table 4. Egg form did not affect (P>0.05) the performance indices, except cost of feed consumed, which was higher in broilers fed IEM. At 60% and above, there was reduced final body weight significantly (P<0.05). But significant reduction in body weight gain occurred, only at 100% level of fishmeal replacement. However, FCR was not affected (P>0.05) by levels of infertile eggs used. Feed cost/body gain was significantly (P<0.05) reduced at 100% infertile eggs meal replacement of fishmeal. The interaction of the egg forms and levels used to replace fishmeal did not significantly (P>0.05) affect the growth and cost parameters considered (Table 5). Diet containing IEMS at 100% replacement level of fishmeal appeared to be the cheapest to produce a kilogram of meat.

Table 2: Chemical composition of infertile Egg meal without and with shell

Component	IEM	IEMS
Crude protein (%)	50.36	41.36
Crude fiber (%)	1.60	3.76
Crude fat (%)	30.59	23.68
Ash (%)	5.56	22.08
Nitrogen free extract (%)	11.89	9.12
Dry matter (%)	91.80	92.75
*Calcium (%)	0.1	6.0
ME (MJ/kg)	20.1	15.9

IEM – Infertile Egg Meal; IEMS – Infertile Egg Meal with Shell
*Source: Buckler and Martins, 1920

Table 3: Chemical composition of Experimental diets

Parameters	IEM				IEMS			
	0%	30%	60%	100%	0%	30%	60%	100%
Dry matter	93.06	93.85	93.06	93.69	93.06	93.86	93.41	93.72
Crude protein	22.57	22.34	22.39	22.18	22.57	22.34	22.06	21.96
Crude fibre	3.22	3.37	3.46	3.59	3.22	3.64	3.71	3.92
Ether extract	4.26	4.38	5.46	5.57	4.26	4.12	4.36	4.52
Ash	6.35	5.94	5.87	5.64	6.35	6.29	6.45	6.72
NFE	56.66	57.82	55.88	56.71	56.66	57.47	56.83	56.6
ME (MJ/kg)	13.4	13.6	13.6	13.8	13.4	13.4	13.4	13.4

IEM – Infertile Egg Meal; IEMS – Infertile Egg Meal with Shell
NFE, Nitrogen free extract; ME, Metabolizable energy

Table 4: Main effect of egg forms and levels on the growth performance and cost benefit of broiler

Parameters	Egg form		P	Levels				SEM	P
	IEM	IEMS	value	0%	30%	60%	100%		value
Initial body weight (g)	261.25	261.25	1.000	261.67	261.67	260.83	260.83	0.620	0.946
Final body weight (g)	2489.17	2457.18	0.430	2591.67[a]	2485.19[ab]	2420.00[b]	2395.83[b]	23.20	0.013
Weight gain/day (g)	45.34	44.57	0.361	47.55[a]	44.35[ab]	44.33[ab]	43.59[b]	0.480	0.017
Feed intake/day (g)	118.46	117.92	0.333	119.32	118.29	117.94	117.21	0.291	0.072
Feed Conversion ratio	2.60	2.66	0.220	2.51	2.66	2.66	2.69	0.026	0.054
Cost of feed(₦)/day	12.55[a]	12.34[b]	0.003	13.32[a]	12.74[b]	12.23[c]	11.47[d]	0.158	0.000
Feed cost(₦)/weight gain	275.44	278.20	0.588	280.60[ab]	287.04[a]	276.23[ab]	263.38[b]	2.800	0.031
Dead/Alive	1/120	1/120	-	0/60	2/60	0/60	0/60	-	-

[a,b,c]Means on the same row with different superscripts are significantly different

IEM – Infertile Egg Meal; IEMS – Infertile Egg Meal with Shell

Table 5: Interactive effect of egg forms and levels on the growth performance and cost benefit of Broiler

Parameters	IEM				IEMS				SEM	P value
	0	30	60	100	0	30	60	100		
Initial weight (g)	261.67	260.00	261.67	261.67	261.67	261.33	260.00	260.00	0.620	0.551
Final weight (g)	2591.67	2500.00	2448.33	2416.67	2591.67	2470.37	2391.67	2387.50	23.20	0.963
Weight gain g/day	47.55	44.69	45.15	43.98	47.55	44.01	43.50	43.20	0.418	0.916
Feed intake g/day	119.32	118.93	118.43	117.18	119.32	117.65	117.45	117.25	0.291	0.770
Feed conversion ratio	2.51	2.61	2.63	2.67	2.51	2.71	2.70	2.72	0.026	0.086
Feed Cost (₦)/day	13.32	12.82	12.37	11.69	13.32	12.68	12.10	11.25	0.158	0.077
Feed Cost (₦)/weight gain	280.60	280.97	274.24	265.93	280.60	293.12	278.22	260.84	2.800	0.701
Dead/Alive	0/30	1/30	0/30	0/30	0/30	1/30	0/30	0/30	-	-

[a,b,c]Means on the same row with different superscripts are significantly different
IEM – infertile egg meal; IEMS – infertile egg meal with shell

Blood Parameters

Hematological and Serum biochemistry parameters of broilers fed two egg forms and at four levels of inclusion are shown in Table 6. Egg forms and level of used did not affect ($P>0.05$) PCV, RBC and haemoglobin measured. Total protein, Uric acid, Globulin were higher ($P<0.05$) in broilers fed IEM diet, while Creatinine was higher ($P<0.05$) in broilers fed IEMS diets. Total protein and Globulin were highest ($P<0.05$) in birds fed diet with 100% infertile eggs replacing fishmeal. Uric acid was lower ($P<0.05$) in birds fed diets with 30% to100% levels infertile eggs meal. Blood calcium was highest in broilers fed with diet containing 60% infertile eggs. The interactive effect of egg forms and the levels of used on the heamatology and serum biochemistry measured are shown in Table 7. The interaction of egg forms and levels of use had no significant effect ($P>0.05$) on the indices measured for haematological parameters. Significantly ($P<0.05$) highest total protein, albumin and globulin were recorded in birds on 100% IEM diet. There was no significant ($P>0.05$) interaction between egg forms and levels of use for serum urea, creatinine and calcium.

Table 6: Main effect of gg forms and levels on blood parameters of broiler chickens

	Egg Form		P	Levels				SEM	P
	IEM	IEMS	value	0	30	60	100		value
Haematology									
PCV (%)	33.67	31.50	0.123	34.67	31.33	32.33	32.00	0.768	0.346
RBC ($x10^{12}/l$)	1.86	1.74	0.39	1.80	1.62	1.90	1.83	0.0634	0.429
Hb (g/dl)	9.10	8.53	0.304	10.07	8.38	8.27	8.55	0.298	0.098
Serum biochemistry									
Total protein (g/dl)	4.89^{a}	4.092^{b}	0.004	4.27^{b}	4.10^{b}	4.37^{ab}	5.23^{a}	0.282	0.016
Uric acid (g/dl)	3.06^{a}	2.44^{b}	0.013	3.53^{a}	2.42^{b}	2.63^{b}	2.42^{b}	0.163	0.007
Albumin (g/dl)	2.74	2.51	0.335	2.30	2.28	2.88	3.03	0.185	0.076
Globulin (g/dl)	2.15^{a}	1.58^{b}	0.002	1.97^{ab}	1.82^{ab}	1.48^{b}	2.20^{a}	0.145	0.026
Creatinine (mg/dl)	0.58^{b}	0.84^{a}	0.049	0.70	0.63	0.65	0.85	0.0673	0.611
Calcium (mg/dl)	12.08	12.59	0.506	13.07^{ab}	10.78^{b}	14.22^{a}	11.27^{ab}	0.440	0.019

^{a,b,c}Means on the same row with different superscripts are significantly different
IEM – infertile egg meal; IEMS – infertile egg meal with shell
PCV, Packed cell volume; RBC, Red blood corpuscle; HB, Haemoglobin

Table 7: The interactive effect of egg form and levels on blood parameters of broiler chickens

	IEM				IEMS					
	0	30	60	100	0	30	60	100	SEM	P
Haematology										
PCV %	34.67	30.67	36.67	32.67	34.67	32.00	28.00	31.33	0.768	0.072
Rbc ($x10^{12}/l$)	1.80	1.60	2.10	1.93	1.80	1.63	1.70	1.83	0.0634	0.648
Hb (g/dl)	10.07	8.10	9.43	8.80	10.066	8.67	7.10	8.30	0.298	0.283
Serum biochemistry										
Total protein (g/dl)	4.27^{bc}	4.27^{bc}	3.57^{bc}	7.47^{a}	4.27^{bc}	3.93^{bc}	5.17^{bc}	3.00^{c}	0.282	0.000
Albumin (g/dl)	2.30^{bc}	2.13^{bc}	2.30^{bc}	4.23^{a}	2.30^{bc}	2.43^{bc}	3.47^{ab}	1.83^{c}	0.185	0.000
Globulin (g/dl)	1.97^{b}	2.13^{b}	1.27^{b}	3.23^{a}	1.97^{b}	1.50^{b}	1.70^{b}	1.17^{b}	0.142	0.000
Uric acid (g/dl)	3.53	2.67	3.50	2.53	3.53	2.17	1.77	2.30	0.163	0.057
Creatinine (mg/dl)	0.70	0.33	0.43	0.83	0.70	0.93	0.87	0.87	0.0673	0.276
Calcium (mg/dl)	13.07	10.57	14.37	10.30	13.07	11.00	14.07	12.23	0.440	0.737

^{a,b,c}Means on the same row with different superscripts are significantly different
IEM – infertile egg meal; IEMS – infertile egg meal with shell
PCV, Packed cell volume; RBC, Red blood corpuscle; HB, Haemoglobin

Carcass Characteristics

Egg forms and levels of use did not significantly (P>0.05) affect the measured indices (Table 8). Also, the interaction of egg forms and level of use had no effect (P>0.05) the carcass attribute and internal organ weights of broiler chicken (Table 9).

Table 8: Main effect of egg forms and levels on the carcass characteristics of Broiler

	Egg Form			Levels				SEM	P value
	IEM	IEMS	P	0	30	60	100		
Live weight (kg)	2.49	2.46	0.391	2.58[a]	2.48[ab]	2.42[b]	2.42[b]	0.0210	0.020
Eviscerated weight (%)	81.11	79.26	0.251	81.29	82.41	78.10	78.93	0.834	0.206
Cut Parts (%)									
Shanks	4.84	4.56	0.098	4.80	4.67	4.88	4.45	0.0838	0.293
Breast	20.76	20.18	0.561	21.22	20.55	20.57	19.56	0.486	0.683
Neck	4.30	4.28	0.886	4.21	4.38	4.13	4.44	0.0874	0.564
Wings	8.33	8.26	0.767	8.37	8.36	8.26	8.18	0.104	0.919
Thighs	20.53	20.28	0.708	20.32	20.85	20.40	19.98	0.291	0.803
Back	15.77	15.77	0.996	15.54	16.28	15.76	15.52	0.328	0.853
Internal organs (%)	12.21	12.04	0.635	12.75	11.56	11.93	11.86	0.184	0.251

[a,b,c]Means on the same row with different superscripts are significantly different
IEM – infertile egg meal; IEMS – infertile egg meal with shell

Table 9: Interactive effect of infertile egg reject meal on carcass characteristic of broiler at different level

	IEM				IEMS				SEM	P Value
	0	30	60	100	0	30	60	100		
Live weight(kg)	2.58	2.49	2.45	2.45	2.58	2.46	2.39	2.39	0.210	0.948
Eviscerated weight (%)	81.11	86.42	77.14	79.59	81.29	78.40	79.06	78.28	0.834	0.154
Cut Parts (%)										
Shanks	4.802	4.867	5.030	4.667	4.802	4.487	4.737	4.226	0.838	0.785
Breast	21.22	20.31	20.00	21.50	21.22	20.79	21.15	17.57	0.480	0.271
Neck	4.21	4.63	4.22	4.15	4.21	4.13	4.03	4.73	0.0874	0.189
Wings	8.37	8.42	8.23	8.29	8.37	8.31	9.29	8.08	0.104	0.974
Thighs	20.32	20.69	20.50	20.49	20.32	20.99	20.28	19.48	0.291	0.890
Back	15.54	15.89	15.50	16.16	15.54	16.66	16.02	14.82	0.328	0.725
Internal orgnas	12.75	11.95	11.48	12.67	12.75	11.98	12.39	11.06	0.184	0.100

IEM – infertile egg meal; IEMS – infertile egg meal with egg shell

Discussion

The lower crude protein recorded for IEMS may be due to it higher content of egg shells; which is evident in its higher ash content. This observation is in line with the report of Abiola, *et al.* (2012), who obtained reduced crude protein content due to increased calcium content in hatchery waste with shell. Abiola, *et al.* (2012) reported 42.26% CP and 23.68% fat for un-hatched incubator eggs, which are close to the value of IEMS obtained in this study. IEMS also had reduced fat and energy contents, when compared to IEM. The result from the chemical composition of the different diets corroborated that which was obtained from the test ingredients. High fat content of the IEM increased the fat content of the IEM diets. However, this did not affect the energy level of the diets, as diets energy level was balanced during formulation. The high ash content of the IEMS, which was majorly due to its calcium content, was also balanced during feed formulation. Apparently, as observed in this current study, the forms of infertile used had no effect on the feed efficiency of broilers. This might be due to the fact that the high calcium content of IEMS had been considered during the feed formulation; therefore, preventing imbalance in the calcium level of the diets. As a result, problems of nutrient uptake and utilization were prevented. Cost of feed intake was however higher in broiler fed IEM diet than those on IEMS diet. Our results showed that at 60% and above of the combined use of the two forms of infertile egg meal, decrease in final body weight of the broiler chicken occurred. However, decrease in body weight gain did not occur until at 100% levels of use. Abiola, *et al.* (2012) used un-hatched incubator eggs up 30% replacement of fishmeal in broiler diet and reported similar decreasing trend of body weight gain by broiler with increasing levels of inclusion. Whereas in another study (Abiola *et al.,* 1999) where un-hatched incubator eggs without shell replaced soybean meal in cockerel diet, performance of birds was significantly improved up to 15% level of use. Feed cost and feed cost per weight gain decreased with increasing level of IEM or IEMS in broiler diet. Individual use of IEMS or IEM at any level of use had no influence on response of broiler. The level of infertile eggs inclusion did not significantly influence the feed intake of broilers. This is an indication that the birds were on the same plane of nutrition, as regard calcium and other nutrients, otherwise feed intake might be impeded, as excess dietary calcium can reduce feed intake (Vicenzi, 1996). Furthermore, the efficiency of feed conversion by birds was not affected by infertile egg meal at any level of its use. Growth and FCR were reported to improve in broiler, quail and Vanaraja chicks when hatchery waste totally replaced fishmeal (Agunbiade *et al.,* 2011; Swain *et al.,* 2011; Odunsi *et al.,* 2013). Increased use of infertile eggs in broiler diet decreased feed cost and cost of producing a kilogram of broiler chicken meat, thereby increasing profit, as reported by Swain *et al.,* 2011, that used hatchery waste in Vanaraja chicks. The use of infertile egg meal was expected to improve broiler performance beyond that of hatchery waste meal and un-hatched incubator eggs. This might be caused by the high fat content of infertile eggs. Abiola, *et al.* (2012) reported a value of 180.50 g/kg of fat in un-hatched eggs, while this study reported 236.80 g/kg in IEMS and 305.90 g/kg in IEM. Also, while Agunbiade, *et al.* (2011) reported improve performance of broiler chicken with hatchery waste; the author did not indicate the type of fishmeal the hatchery waste replaced. Local fishmeal is low in nutritive value compare to imported 72% CP fishmeal used in this study. Additionally, difference in the report of this study to that of Odunsi, *et al.* (2013) and Swain, *et al.* (2011), might be due to differences in response of species. The cost of feed reduced significantly by 13.8% at 100% replacement of fishmeal with IEM or IEMS. Feed cost per kg weight gain reduced significantly by 8.2% at 100% replacement of fishmeal. The IEMS or IEM and their levels of use had no effect on the haematological parameters of broiler. This indicates no negative effect on broiler chicken health in replacing fishmeal with IEM or IEMS. The finding is similar to the report of Abiola, (2012) and Agunbiade, *et al.* (2011), whose levels of inclusion of hatchery waste meal in broiler diets had no significant effect on the haematological indices measured. Ishikawa, *et al.* (2007) indicated that yolk protein reduces the absorption of iron, as a result affecting the formation of haemoglobin in the blood. However, the use of infertile eggs at 30% to100% levels in this study did not significantly affect the formation of haemoglobin. Indication that iron absorption was not to a large extent impeded. The serum biochemistry of broilers chicken fed 100% IEM showed significantly higher total protein, Albumin and globulin than birds fed IEMS diets. This agrees with the report of Robert, *et al.* (2003), that birds exhibited high level of

Albumin, Total protein and Globulin with increase of hatchery waste meal inclusion in their diet. Babatunde and Oluyemi, (2000), indicated that adequate utilization of protein in the diets resulted in increased serum globulin. This suggests that the birds fed with diet containing 100% IEM utilized the protein better than birds on IEMS and the control diets. The decrease in the value of uric acid as the inclusion level of infertile egg meal increased in diets revealed that the amino profile of diets used were more balanced; agreeing with report of Agunbiade, (2011), who opined that amino imbalance would result in increase of blood uric acid in birds. Type of egg form and their levels of inclusion did not affect any of the carcass parameters measured. This is similar to the findings of Abiola, *et al.* (2012), that reported no significant effect of hatchery waste on carcass characteristics of cockerels when fed with diet containing hatchery waste meal in replacement of fish at 30% level. Infertile eggs might be said to be superior to the conventional hatchery waste, as infertile eggs contain whole intact eggs with or without shell; therefore, retaining more nutrients than hatchery waste, to support good carcass characteristics at 100% use in replace of fishmeal. However, Deshmukh and Patterson (1997), reported that fermented and extruded hatchery waste meal inclusion in broiler chicken diets resulted in better carcass characteristics, when used at relatively lower level. Lactic acid bacteria, normally found in fermented feed (Jensen and Mikkelsen, 1998) materials are capable of IP6 degradation (Reale *et al.,* 2004) and higher availability of phosphorus in cereal based diets. Fermented products produce better response when used in the diets of animals (Scholten *et al.,* 1999; Badau *et al.,* 2005; Akinola *et al.,* 2015). Therefore, the report by Deshmukh and Patterson (1997), cannot be attributed to the effect of hatchery waste alone.

Conclusion

From this study, replacing infertile egg meal with or without shell did not have adverse effect on the feed utilization by broiler chicken, as feed conversion ratio was not affected and feed cost was significantly reduced at 100% use of infertile egg meal. Also, carcass indices were not affected with the use of infertile egg meal with or without shell. Additionally, haematological indices were not affected by the use and levels of infertile egg meal. Birds on infertile egg without eggs appear to be on better nutrition plane and good health than birds on infertile egg without eggs with shell and the control diet, as birds on infertile egg without eggs had significantly higher total protein, albumin and globulin and lower uric acid level.

Confiict of interest statement

There is absolutely no conflict of interest with any individual or organization regarding the materials discussed in the manuscript.

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