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Full Length Research Paper

Particulating broiler finisher feeds into forms and diameters for nutritional and economic benefits (part 2)

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A study was conducted to examine the nutritional and economic effects of using pellet diets at various pellet diameters of 2, 4 and 6 mm pellet for broiler finisher birds in an experiment using Arbor Acre broilers chickens. Two hundred and forty Arbor Acre birds at the finisher phase (28-56 days) of broiler production were used in a 2 x 4 factorial experiment using completely randomized design. Diets in this study had same quantities of ingredients with identical nutrients composition. The study was conducted under similar environmental conditions and management practices. Data on growth performance, nitrogen utilization, carcass and visceral organs characteristics, haematology and serum biochemistry were collected and evaluated. Economic analyses were carried out. Birds on 4 mm pellet diameter diet had the highest body weight gain of 59.11±0.54 g/bird/day and the lowest feed conversion ratio (FCR) of 2.11±0.03. Measured carcass and visceral organs were higher ($P<0.05$) for birds on the pellet diets. Most heamatogical parameters were higher for birds on the pellet diets. Birds on balanced 4 mm pellet diets had better feed intake, increased growth rate and better feed efficiency when fed with broiler finisher birds. The 4 mm pellet diets also enhanced most carcass and organs characteristics. Heamatological and blood biochemistry indices of experimental birds on 4 mm pellet diets were not adversely affected and were better in some cases than values obtained from existing literature. There was an overall better net return per bird for birds on 4 mm pellet diameter diets in broiler finisher diets.

Key words: Nutritional benefit, cost and benefit analyses, feed pelleting.

INTRODUCTION

Grinding and pelleting have been identified to have greatest influence on feed quality of all feed processing operations (Lahaye et al., 2004). The feed processing operations can affect, either positively or negatively, the feed quality and subsequent bird performance (Ravindran and Amerah, 2008).

Broilers are known to make better gains on pelleted feed than a mash ration. However, Hoffman (1963), posited that valuing benefit and costs of pellet and mash feed is important because conserving and investing in analyzing the costs and benefits of each feed form showed that mash was the cheapest method of feeding compounded rations when considered in terms of price per tonne.

Offering feed to poultry in pellet form enhances the economics of production by improving feed efficiency and growth performance in broilers (Behnke and Beyer, 2002). The improvement in feed efficiency and ultimately

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the growth performance can be attributed to the decreased feed wastage, higher bulk and nutrient density, zero selective feeding, decreased time and energy spent for eating, decreased ingredient segregation, destruction of feed-borne pathogens, thermal modification of starch and protein, improved palatability and inactivation of enzyme inhibitors (Behnke, 1994; Jensen, 2000; Peisker, 2006).

The present study was undertaken to determine the nutritional advantages with reference to the cost and benefit analyses of pelleting feeds for broiler finisher production.

MATERIALS AND METHODS

Experimental site

The two studies were carried out at the Poultry Research Unit of the Teaching and Research Farm of Ekiti State University, Ado-Ekiti, Nigeria.

Site preparation

The experimental site was properly cleaned and disinfected. The experimental site was partitioned into twelve separate pens of equal sizes (90 x 80 cm) using wooden poles and wire nets. The floor of the pens was covered with dry litter (wood shaving) up to about 5 cm deep.

Experimental design

The experiment was a 2 x 4 factorial arrangement in a completely randomized design achieved by feeding two forms of diets (mash and pellet) with a mash diet form and three varying diet sizes (2, 4 and 6 mm), respectively. There were 4 dietary treatments in which diet 1 (mash feed) was the control diet while diets 2, 3 and 4 were the pelleted diets with varying pellet diameters of 2, 4 and and 6 mm, respectively. Each treatment was replicated thrice with each replicate having 20 birds at the commencement of experiment making a total of 240 birds.

Experimental animals and management

A total of 240 agile birds were randomly selected from the initial population at 28 days of age of birds. They were redistributed into 4 treatments ensuring equal weight and sex per treatment. The birds were raised on conventional deep litter system, where they were supplied with feed and clean with water *ad-libitum*. All the pens were located in one house to have similar environmental condition. Natural ventilation was ensured in each pen throughout the period of the experiment.

Experimental diets

Three pellet diets of different diameters (2, 4 and 6 mm) were used as experimental diets 2, 3 and 4. The control diet (diet 1) in this experiment was a mash feed (Table 1). Particle sized screen was achieved by using a hammer mill with small diameters of screen openings. Manufactured experimental feeds were made into pellets using diesel flat die feed pellet mill with customized diameters of 2.0/3.0/4.0/6.0/8.0 mm. Power rating is 8-55 HP and has a capacity of 70-1000 kg/h.

Data collection

The weights of the experimental birds were taken every 3 days to record the weight gain. Feed consumption was recorded on daily basis. Nitrogen digestibility trial was carried out for each study to determine the nitrogen retention and utilization. Carcass and relative organs characteristics were recorded at dissection after slaughter when the experiment was terminated. Haematological parameters such as haemoglobin concentration, HBC; packed cell volume, PCV; red blood cell, RBC; erythrocyte sedimentation rates, ESR; mean corpuscular volume, MCV; mean corpuscular haemo-globin, MCH and mean corpuscular haemoglobin concentration, MCHC were determined from blood samples collected from experimental birds when slaughtered at the termination of experiment. Biochemical components such as total serum protein, albumin, globulin and albumin/globulin ratio were also determined. Cost benefit analysis was carried out.

Carcass, muscle and organ measurements

After slaughtering, the carcasses were scalded at 75°C in a water bath for about 30 s before defeathering. The dressed chicks were later eviscerated. The measurement of the carcass traits (dressed weight %, eviscerated weight %, thigh, drumstick, shank, chest, back, neck, wing, belly fat and head) were taken before dissecting out the organs. The organs measured were the liver, kidneys, lungs, pancreas, heart, spleen, bursa of fabricus and gizzard.

Estimation of nitrogen retention, nitrogen digestibility and protein efficiency ratio

Total droppings (faeces and urine) voided during the last 5 days were collected, weighed, dried at 65-70°C in an air circulating oven for 72 h and preserved while the corresponding feed consumed was also recorded for nitrogen studies. The nitrogen contents of the samples were determined by the method of AOAC (2010).

Blood sampling

At the end of the feeding trial, a male chick per replicate was randomly selected, weighed and scarified by severing the jugular vein and blood allowed to flow freely into labeled bottles one of which contained a speck of EDTA while the other without EDTA was processed for serum. The serum was kept deep frozen prior to analysis. The packed cell volume (PCV%) was estimated in heparinized capillary tubes in an haematocrit microcentrifuge for 5 min while the total RBC count was determined using normal saline as the diluting fluid. The haemoglobin concentration (Hbc) was estimated using cyanomethaemoglobin method while the MCHC, moglobin MCH and the MCV were calculated.

Economic analysis

The cost of birds, feed and medication incurred during the two phases of the experiment were collected from the income and expenditure statements. Revenue generated from the sale of the birds was recorded. The cost per kilogram gain, total profit and returns to naira invested were also calculated.

Table 1. Composition of the experimental diets (28-56 days).

Ingredients	Dietary treatments			
	1	2	3	4
	Mash	Pellet diameters		
		2 mm	4 mm	6 mm
Maize (9%)	43.0	43.0	43.0	43.0
Soya bean meal (45% CP)	32.6	32.6	32.6	32.6
Maize offals	18.0	18.0	18.0	18.0
Fish meal (68% CP)	2.0	2.0	2.0	2.0
Bone meal	2.50	2.50	2.5	2.5
Oyster shell	0.50	0.50	0.5	0.5
Salt (NaCl)	0.50	0.50	0.5	0.5
DL-methionine	0.20	0.20	0.2	0.2
L-lysine	0.20	0.20	0.2	0.2
Premix	0.50	0.50	0.5	0.5
Total Calculated:	**100**	**100**	**100**	**100**
Crude protein,%	21.2	21.2	21.2	21.2
Me(kcal/kg)	2809.7	2809.7	2809.7	2809.7
Crude fibre,%	3.3	3.3	3.3	3.3
Ether extract,% Analysed (as fed):	8.1	8.1	8.1	8.1
Ash,%	8.8	8.3	8.3	8.3
Moisture content,%	14.8	16.2	16.2	16.2
Crude protein,%	21.6	21.8	20.7	20.7
Ether extract,%	3.7	3.7	3.7	3.7
Crude fibre,%	3.7	3.7	3.7	3.7

% CP, Percentage crude protein; broilers vitamin premix supplied the following vitamins and trace elements per kg of diet: Vit A 7812.50IU; Vit D 1562.50IU; Vit E 25mg; Vit K 1.25mg; Vit B1 1.88mg; Vit B2 3.44mg; niacin 34.38mg; calcium pantothenate 7 .19 mg; V it B 36 .13 mg; Vit B 102.016 mg; Choline chloride 312.50 mg: Folic acid 0.62 mg; Biotin 0.05; Mn 75mg; Fe 62.5mg: Zn 50mg; Cu 5.31 mg; Iodine 0.94 mg; Co 0.19 mg; Se 0.07mg and Antioxidant 75 mg.

Statistical analysis

All recorded and calculated data were statistically analyzed with the standard procedures of analysis of variance (One way ANOVA) technique by a computer using Minitab statistical computer software package (2005 version). Results were expressed as mean ± standard deviation of two measurements.

RESULTS

Average growth performance

Average growth performance indices are shown in Table 2. The average daily feed intake (FI) value was lowest at 113.4±0.18 g/bird/day for birds on mash diet (diet 1). Birds on 2 mm pellet diet (diet 2) had the highest FI at 119.2±0.04 g/bird/day but similar (P>0.05) to the FI value obtained for birds on 6 mm pellet diet (diet 4) at 118.9±0.04 g/bird/day. The average daily weight gain (WG) value obtained for birds fed 4 mm pellets (diet 3) was highest at 59.1±0.54 g/bird/day but similar (P>0.05) to average daily weight gain obtained for birds on 2 mm pellets (diet 2) and 6 mm pellets (diet 4) at 54.6±2.87 and 57.3±1.77 g/bird/day, respectively. The birds on mash (diet 1) had the lowest WG value at 47.8±4.19 g/bird/day, but also similar (P>0.05) to the WG values obtained for birds fed 2 mm pellet diets (diet 2) and 6 mm pellet diets (diet 4).Birds fed 4 mm pellet diets (diet 3) had the best feed conversion ratio at 2.11±0.03 but similar (P>0.05) to the value of birds fed 6 mm pellet diets (diet 4) at 2.35±0.07. The birds fed mash in the control diet (diet 1) had the highest FCR value at 2.71±0.13 which indicated low feed conversion ratio and it was similar (P>0.05) to the value obtained for the birds fed 2 mm (diet 2) pelleted feed form at 2.48±0.05.The protein efficiency ratio (PER = gain in body weight/protein intake, g) seemed to increase from birds on the mash diets (control diet) at 1.94±0.16 to 2.08±0.11 for birds on 2 mm pellet diets (diet 2) and finally peaked at 2.50±0.04 for birds on 4 mm pellet diet (diet 3) before a decline for birds on 6 mm pellet diet (diet 4) at 2.36±0.06.

Nitrogen utilization

Nitrogen utilization for broiler finisher phase is shown in Table 3. Birds on 2 mm pellet diet (diet 2) had the highest nitrogen retention value of 2.65±0.45 gN/bird/day.

Table 2. Average growth performance of broilers fed various feed forms (28– 56 days).

Parameters	Dietary Treatments			
	1	2	3	4
	Control/mash	Diameters of pelleted feed form		
		2 mm	4 mm	6 mm
Ave. Daily Feed Intake (g/bird/day)	$113.4^{a}\pm0.18$	$119.2^{b}\pm0.04$	$118.7^{c}\pm0.09$	$118.9^{bc}\pm0.04$
Ave. Daily Weight Gain (g/bird/day)	$47.8^{a}\pm4.19$	$54.6^{ab}\pm2.87$	$59.1^{b}\pm0.54$	$57.3^{ab}\pm1.77$
Feed Conversion Ratio (FCR)	$2.71^{a}\pm0.13$	$2.48^{ac}\pm0.05$	$2.11^{b}\pm0.03$	$2.35^{bc}\pm0.01$
Protein Efficiency Ratio(PER)	$1.94^{a}\pm0.16$	$2.08^{a}\pm0.11$	$2.50^{b}\pm0.04$	$2.36^{ab}\pm0.06$

Means within a row with different superscript are significantly different (P<0.05).

Table 3. Nitrogen utilization of broilers fed various feed forms (28–56 days).

Parameters	Dietary Treatments			
	1	2	3	4
	Control/mash	Diameters of pellet feed form		
		2 mm	4 mm	6 mm
Nitrogen Intake (g/day)	4.19±0.75	4.26±0.50	3.84±0.61	3.92±0.72
Faecal Nitrogen (g/day)	2.23±0.41	1.61±0.63	1.23±0.52	1.41±0.76
Nitrogen Retention (g/day)	1.96±0.73	2.65±0.45	2.61±0.73	2.52±0.55
Apparent nitrogen digestibility (%)	$46.70^{a}\pm0.08$	$62.13^{b}\pm0.06$	$68.01^{c}\pm0.10$	$64.18^{d}\pm0.05$

Means within a row with different superscript are significantly different (P<0.05).

However, this value was similar (P>0.05) to the nitrogen retention value obtained for birds on 6 mm pellet diet (diet 4) and 4 mm pellet diet (diet 3) at 2.52±90.55 and 2.61±0.73 gN/bird/day, respectively. The significantly lowest (P>0.05) value of 1.96±0.73 gN/bird/day was obtained for those birds fed mash diet in the control diet (diet 1).

The apparent nitrogen digestibility (AND) value obtained for birds on 4 mm pellet diets (diet 3) was the highest at 68.01±0.10% followed by 6 mm pellet diets (diet 4) at 64.18±0.05%, 2 mm pellet diet (diet 2) at 62.13±0.06% and mash (control diet, diet 1) at 46.70±0.08% in that order. There were significant differences (P<0.05) among the AND values obtained for all experimental birds. There was a significantly better apparent nitrogen digestibility (AND) for broiler finisher birds on 4 mm pellet diets over the other feed form and diameters.

Carcass characteristics and organ weights

Carcass characteristics of broiler fed various feed forms are presented in Table 4. All live weight values were statistically similar (P<0.05) for experimental birds on mash (diet 1), 2 mm pellet diets (diet 2), 4 mm pellet diets (diet 3) and 6 mm pellet diets (diet 4) at 2534.0±12.5, 2540.0±10.7, 2632.0±9.7 and 2557.0±10.5 g, respectively. The average value of dressed weights for birds on mash (diet 1), 2 mm pellet diets (diet 2), 4 mm pellet diets (diet 3) and 6 mm pellet diets (diet 4) were also similar (P>0.05).

Eviscerated weight obtained for birds on 4 mm pellet diets (diet 3) was the highest at 2197.0±10.2 g. While the lowest eviscerated weight value was obtained for birds on the mash (diet 1) at 1915.0±10.5 g.

The value obtained for carcass weight revealed that the average weight of the carcasses of birds placed on mash diet at 1541.0±10.7 g was significantly different (P<0.05) from 4 mm pellet diets (diet 2) at 1858±7.7 g, but was similar (P>0.05) to the average carcass weights obtained for birds on 2 mm pellet diets (diet 2) and 6 mm pellet diets (diet 4).

The birds fed 4 mm pellet diet (diet 3) had the highest dressing percentage at 70.59±0.61% which was significantly different (P<0.05) from the dressing percentages birds on other diets. Other carcass cuts had either similar weights or better weight values for cuts obtained from birds on 2 mm pellet diet (diet 4).

Table 5 shows the visceral organs characteristics of birds fed various pellet diameters of experimental feeds. There were no significant differences (P>0.05) in the values of gizzard weights obtained for birds fed mash (diet 1), 2 mm (diet 2), 4 mm (diet 3) and 6 mm (diet 4) pellet feeds at 39.0±0.53, 38.0±0.33, 37.0±0.41 and 37.0±0.68 g, respectively.

Most visceral organs examined had similar (P>0.05)

Table 4. Carcass characteristics of broilers fed various feed forms (28-56 days).

Parameters	Dietary treatments			
	1	2	3	4
	Control/mash	Diameters of pelleted feed form		
		2 mm	4 mm	6 mm
Live weight (g)	2534.0±12.5	2540.0±10.7	2632.0±9.7	2557.0±10.5
Dressed weight (g)	2265.0±12.7	2230.0±10.2	2392.0±10.7	2245.0±9.6
Eviscerated weight (g)	1915.0^{a}±10.5	1985.0^{ab}±11.8	2197.0^{b}±10.2	1932.5^{ab}±7.7
Carcass weight (g)	1541.0^{a}±10.7	1604.0^{ab}±6.3	1858.0^{b}±7.7	1637.0^{ab}±6.5
Dressing percentage (%)	60.81^{a}±0.51	63.15^{ac}±0.58	70.59^{b}±0.61	64.02^{c}±0.71
Carcass Cuts (g)				
Head	48.2^{a}±0.50	54.0^{bc}±0.52	53.0^{c}±0.64	66.0^{d}±0.71
Neck	109.0^{a}±0.56	107.0^{a}±0.51	133.0^{b}±0.44	112.0^{c}±0.77
Wing	213.0^{a}±0.55	202.0^{b}±0.74	227.0^{c}±0.67	189.0^{d}±0.75
Thighs	221.0^{a}±0.41	229.0^{b}±0.73	285.0^{c}±0.66	252.0^{d}±0.72
Drumstick	264.0^{a}±0.67	240.0^{b}±0.71	268.0^{c}±0.51	259.0^{d}±0.73
Breast	564.0^{a}±0.42	608.0^{b}±0.71	793.0^{c}±0.62	598.0^{d}±0.55
Back	234.0^{a}±0.71	234.0^{a}±0.66	261.0^{b}±0.71	268.0^{c}±0.45
Shank	83.0^{c}±0.72	74.0^{b}±0.61	87.0^{a}±0.42	82.0^{c}±0.52

Means within a row with different superscript are significantly different (P<0.05).

Table 5. Relative organs weights broiler chicks fed various feed forms (28-56 days).

Parameters	Dietary treatments			
	1	2	3	4
	Control/mash	Diameters of pelleted feed form		
		2 mm	4 mm	6 mm
Gizzard	39.0±0.53	38.0±0.33	37.0±0.41	37.0±0.68
Liver	46.0^{a}±0.50	43.0^{b}±0.71	47.0^{a}±0.63	45.0^{ab}±0.87
Heart	7.0^{a}±0.52	11.0^{b}±0.79	11.0^{b}±0.61	8.0^{a}±0.74
Kidney	9.0^{a}±0.60	11.0^{ab}±0.51	13.0^{b}±0.56	13.0^{b}±0.72
Spleen	4.0±0.55	3.0±0.71	2.0±0.43	3.0±0.56
Lungs	19.0^{a}±0.76	11.0^{b}±0.67	15.0^{c}±0.53	13.0^{bc}±0.64
Proventriculus	9.0±0.44	7.0±0.65	7.0±0.80	9.0±0.61
Crop	25.0^{a}±0.54	52.0^{b}±0.83	44.0^{c}±0.64	18.0^{d}±0.73
Intestine	21.0^{a}±0.58	96.0^{b}±0.67	141.0^{c}±0.72	120.0^{c}±0.76
Bursa of fabricius	2.0±0.64	1.0±0.60	2.0±0.71	1.0±0.58
Pancreas	4.0±0.74	4.0±0.55	4.0±0.67	5.0±0.73

Means within a row with different superscript are significantly different (P<0.05).

values or significant values (P<0.05) for organ dissected from birds on 4 mm pellet diets (diet 4). Most visceral organs such as liver, heart, kidney, lungs, proventriculus, crop, intestine and pancreas showed similarity of growth at broiler starter and finisher phases of the indicating similar organ development.

Haematological and serum biochemical parameters

Haematology and serum biochemistry are presented in the Table 6. Except for PCV, ESRs and MCHC, all other parameters examined were either similar (P>0.05) or had better values for the pellet diets. The albumin/globulin ratio values obtained for birds fed mash, 2, 4 and 6 mm were similar (P>0.05) at 1.38±0.70, 0.76±0.54, 1.45±0.57 and 2.12±0.42, respectively. The significant improvement in the Hbc, PCV and RBC contents of the birds on 2, 4 and 6 mm pellet diets could have been an indication of an increment in the oxygen carrying capacity of the animal's blood.

Economic analysis (cost benefit analysis)

The economic analysis of feeding various feed forms to

Table 6. Haematological and biochemical profile of broilers fed various feed forms (28– 56 days).

Parameters	Dietary treatments			
	1	2	3	4
	Control/mash	Diameters of pelleted feed form		
		2 mm	4 mm	6 mm
Hbc (g/dl)	6.57±0.45	9.04±0.67	8.21±0.78	8.21±0.53
PCV (%)	15 .00^{a}±0.57	25.00^{b}±0.73	25.00^{b}±0.62	23.00^{b}±0.81
RBC x10^{6} (mm^{3})	1.49±0.52	1.99±0.43	1.95±0.68	1.78±0.56
ESRs (mm$^{3/}$l)	6.00^{a}±0.64	3.00^{b}±0.50	4.00^{ab}±0.71	3.00^{b}±0.61
MCV x10^{-6} (µl)	0.10±0.77	0.13±0.62	0.13±0.80	0.13±0.53
MCH x10^{-6} (µg)	4.41±0.32	4.54±0.55	4.28±0.64	4.61±0.78
MCHC (g/dl)	43.80^{a}±0.70	36.16^{b}±0.51	32.84^{c}±0.73	36.69^{b}±0.84
Serum biochemical parameters (g/100 ml)				
Total serum protein	18.44^{a}±0.73	34.81^{b}±0.78	34.51^{b}±0.65	27.34^{c}±0.87
Albumin	10.69^{a}±0.81	15.06^{b}±0.75	20.40^{c}±0.63	18.57^{c}±0.82
Globulin	7.750^{a}±0.72	19.75^{b}±0.42	14.11^{c}±0.50	8.77^{d}±0.76
Albumin/globulin ratio	1.38±0.70	0.76±0.54	1.45±0.57	2.12±0.42

Means within a row with different superscript are significantly different (P<0.05).

Table 7. Economic analysis of the broilers fed various feed forms (28–56 day of age).

Parameters	Dietary treatments			
	1	2	3	4
	Control/mash	Diameters of pelleted feed form		
		2 mm	4 mm	6 mm
Total feed intake (kg/bird)	3.06	3.22	3.20	3.21
Feed cost/kg of diet (₦/kg)	116	137	133	133
Cost of feed intake/bird (₦/bird)	355.23	440.84	426.12	426.78
Cost of starter broiler (₦/bird)	500	500	500	500
Total cost of production/bird (₦/bird)	855.23	940.84	926.12	926.78
Ave. body wt. at 56th day of age(kg/bird)	2.37	2.45	2.61	2.50
Cost of 1kg of poultry meat (₦/kg)	750	750	750	750
Total revenue/bird (₦/bird)	1,777.5	1,837.5	1,957.5	1,875.0
Total net returns/bird (₦/bird)	922.27	896.66	1,031.38	948.22

Naira is Nigeria currency; 1 Nigerian Naira equals 0.0060 US Dollar ($). Labour and miscellaneous expenses are not included.

broilers is shown in Table 7. Expectedly, the cost of pellet feeds were higher than for mash diet as a result of the additional cost of processes leading to the pellet feeds. However, birds fed 4 mm pellet feeds (diet 3) had the best total net returns of ₦1031.38.

DISCUSSION

Average growth performance

Feed intake was observed to be higher in the pelleted diets 2, 4 and 6 mm as compared to mash. Pelleted diets increased feed intake in broilers (Moran, 1990; Bertechini et al., 1992; Behnke, 1994; Engber et al., 2002). In few instances where no differences were found in the feed intake between mash and pelleted feed, it was attributed to a low pellet quality (Moran, 1990).

The considerably higher feed intakes among finisher phase birds on pellet diets agreed with previous finding that older birds desire a feed in particulate form in order to conform to the changes in dimension of the oral cavity and the gut (Moran, 1990). Banerjee (1987) reported that feed intake is stimulated by granulation of the feed.

Bolton (1960) reported that pelleting improved weight gain and feed efficiency, but digestibility of nutrients was not affected. Relatively, recent research studies showed that poor feed forms had significant negative effects on body weight and feed efficiency of broilers fed maizebased diets (Cutlip et al., 2008; Kenny, 2008; Corzo et al., 2011) and wheat-based diets (Kenny, 2008). Cutlip et al. (2008) showed that broilers fed a maize-soy pelleted diet had a 433 g greater final body weight (39 days) and a decreased feed per gain (10 points) as compared to those fed the same diet as unprocessed mash.

Nitrogen utilization

Although earlier report on digestibility of nutrients of pelleted feeds (Bolton, 1960) indicated that pelleting improved weight gain and feed efficiency but failed to affect digestibility of nutrients; the present study indicated a significant improvement in the digestibility of nitrogen and subsequently, a better nitrogen retention by birds on pelleted diets. The thermal processing during the pelleting of feed must have improved the nutrient value of broiler diets which usually results in beneficial effects on performance (McCracken, 2002).

It had also been postulated that pellet diets in reducing maintenance energy expenditure would allow for an increase in productive energy value of the diet, thus providing more calories for protein and lipid synthesis in growing birds (Greenwood and Beyer, 2003). Heat increment and the energy from each unit of feed utilized by broiler birds were also reported to be better affected by feed form (Latshaw and Moritz, 2009) and utilized more for productive purposes than those fed mash.

Carcass characteristics and organ weights

Although most birds on pellet diets had carcass characteristics and organ weights similar to the values obtained for birds on mash diet, birds on 4 mm pellet diets significantly manifested better values for carcass characteristics and organ weights. Feed forms and diameters have been reported to cause significant effects on the digestive tract development and its morphology. Choi et al. (1986) reported that feeding pelleted diet during the finisher period (28-56 days) reduced weights of the digestive tract and gizzard as compared to those fed the mash diet.

These results suggested that birds may not fully develop their digestive tract when highly processed feeds are offered. The similarity in the gizzard weights of all experimental birds disagree with previous work (Munt et al., 1995) that reported a greater gizzard weight in broilers fed mash diets over pellet-fed birds. Nir et al. (1994) also reported that pelleting reduced the relative weight of the gizzard, as well as length of jejunum and ileum. A more recent similar study (Engberg et al., 2002) showed that pellet-fed birds had lower gizzard and pancreas weights than mash-fed birds. The increase in gizzard weight appeared to be due to a more developed muscular wall. The high but inconsistent values of the weights of crop and intestine of birds on diets 2 and 3 (2 and 4mm diameter pellets, respectively) may be as a result of the prolonged distention of these chambers from constant ingestion of pellet feeds. Mash feed can easily fill the crop and intestine in a more orderly manner. The uniformity in the growth rate and muscle development of most organs investigated compared favourably with previous standard growth pattern and muscle development of birds of the same age and strain (Oluyemi and Roberts, 1979; Rodehutscord et al., 2004).

Haematological and serum biochemical parameters

Increase in the haemoglobin may be accompanied by a rise in the RBC and packed cell volume (haematocrit) indicating absence of anaemia (Moss, 1999; Waugh et al., 2001). The ESRs of broiler starter and finisher birds were similar and compared with ESRs obtained for healthy birds in literature (Oluyemi and Roberts, 1979; Rodehutscord et al., 2004) indicating that the pellet diets did not predispose the birds to any known general infections, or malformation of any kind.

Economic analysis (cost benefit analysis)

It is imperative that birds fed 4 mm pellet diets at the broiler finisher phase generated more total net returns per bird and would be more profitable for the purpose of commercial broiler production. It is generally accepted that pelleting enhances the economics of production by improving growth and feed efficiency in broilers (Behnke and Beyer, 2002).

CONCLUSIONS AND RECOMMENDATIONS

The present study revealed that pelleting of broiler poultry feed had both nutritional and economic benefits as it attracted better feed intake, increased growth rate and better feed efficiency when a balanced diet of 4 mm pellet diets were fed to experimental birds for broiler finisher birds. The 4 mm balanced pellet diets also promoted a better uniform growth rate and carcass conformation. Heamatological and blood biochemistry indices were not adversely affected and in some cases were found to be optimally enhanced when broiler finisher birds were fed 4 mm pellet diets. A better total net return per bird was achieved for birds reared on the 4 mm pellet diameter diets.

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