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Egg production performance and egg quality of laying birds fed cassava plant meal based diet

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Target Audience: *Poultry Farmers, Monogastric Animal Nutritionists*

Abstract

The study assessed the efficiency of egg production and the egg quality characteristics of laying birds fed varying levels of cassava plant meal (CPM) in replacement of maize in their diets. One hundred and fifty laying birds (Isa brown strain) of 26 weeks old were randomly assigned to five dietary treatments with 30 birds per treatment. The diets contained 0, 12, 24 and 36 % replacement of maize with CPM. Production performance data were obtained daily. Ten eggs per diet were collected weekly for egg quality analysis. The experiment lasted for 10 weeks. Data were subjected to T–test and one–way analysis of variance using SAS 2009 software. The proximate composition of CPM differs (P<0.05) from maize. The proximate diet composition and efficiency of production differ significantly across the diet. Significant differences (P < 0.05) existed for internal and external egg quality parameters. Complete replacement with CPM improved egg yolk colour by 44.80 %, egg weight (2.59 %), yolk height (8.62 %) and albumen height (8.91 %). It was concluded that 36 % replacement of maize with CPM in laying birds diet gave similar hen day production (69.75 %) compared to complete maize diets while complete replacement improved external and internal egg qualities with (P < 0.05) increase.

Key words: *Egg production, cassava plant meal, yolk height*

Description of the Problem

Poultry production in the humid tropics are constrained by seasonal feed deficits, high cost, erratic supply of feed ingredients and competition between humans and animals for available feed resources (1). Maize constituted about 40 – 60 % by weight of a balanced poultry ration but its exorbitant price, pressure by human population and livestock feed millers had dictated the need to find a cheaper alternative dietary energy source for livestock production (2). Cassava has long been recognized by researchers in Nigeria as an appropriate animal feed and has been used as a cheap alternative feedstuff despite its limitations (3). Several researchers (4, 5) had investigated the potentials of cassava meal as substitute for maize in pigs and poultry diets but their studies centered on the use of flour or peels or leaves with no standardization. Cassava root meal is deficient in protein, essential amino acids, carotene and other carotenoids. Hence, the need to enhance the nutrient profile of cassava meal evolved the development of cassava plant meal (unpeeled tubers + tender stems + leaves) to replace maize in the diets of poultry (6, 7 and 8). The adoption of cassava meal (peels and flour) by poultry farmers involved in egg production had been very poor due to its poor egg yolk colouration and nutrient composition (9). Hence, the study envisaged standardization of

cassava leaves and tender stems with the flour and peels to take advantage of the high protein and carotene content. The study however evaluated the growth performance and egg quality of laying birds fed cassava plant meal based diet and their effects in improving the egg yolk colouration and egg nutrient composition.

Materials and Methods

Experimental location

The study was carried out at the Poultry Unit of the Obafemi Awolowo University (OAU) Teaching and Research Farm, Ile – Ife (latitude 7^0 28'' N and longitude 4^0 33'' E) and Poultry Meat and Reproductive Physiology laboratories of the Department of Animal Sciences Obafemi Awolowo University, Ile –Ife.

Collection and Processing of test ingredients

The cassava roots (TMS 30572) harvested at 2 years old were purchased from a commercial farm around Ile –Ife. The tender cassava stems were harvested at 5 cm from top of the plants constituting 4.17 – 5.32 % of the stem depending on its length while cassava leaves were harvested from the plant stem. After harvesting, cassava roots were chopped into small sizes of about 2 mm in diameter and sundried for 4 -7 days on concrete floor and milled using hammer milling machine with the sieve size of 0.02 mm and packed in a jute sack bag. The harvested leaves and tender stem were sundried for 3 – 7 days and were milled using a rotatory fine grinder and packed separately into different jute sacks.

Cassava Plant Meal Product Development

The cassava plant meal products were developed using the protocol of (10). The sun – dried unpeeled cassava root meal, cassava leaf meal and tender stem meal were mixed at ratios of 2:1 while the ratio of the leaves to tender stems was 5:1. (66.67 % unpeeled cassava root meal, 27.78 % leaf meal and 5.63 % tender cassava stem meal).

Management of Experimental animals

One hundred and fifty laying birds (Isa brown) of 26 weeks old were randomly allotted to five (5) dietary treatments. Thirty birds made a treatment with ten birds per replicate housed separately in a battery cage with dimension 77 x 86 inches containing three birds per cell. The temperature of the pen was between 32 ^{0}C to 34 ^{0}C. Feed and water were supplied *ad libitum*. Routine and occasional management practices were carried out on the birds. The experiment lasted for ten (10) weeks.

Experimental Diets

Five experimental diets were formulated. Diet 1 contained 48 % maize while Diets II, III, IV and V had 12, 24, 36 and 0 % of maize in diet 1 replaced with CPM respectively as shown in (Table 1).

Egg Production Performance

The production performance parameters were determined as follows:

Feed intake (Recorded on daily basis) = Feed given – leftover

Feed Conversion Ratio/dozen eggs = $\frac{\text{Quantity of feed consumed}}{\text{Dozen of eggs produced}}$

Feed cost/kg egg laid = Cost of 1kg of feed × Feed conversion ratio

Dozens of Egg Produced per bird (dozen) = $\frac{\text{Total egg number produced per bird}}{12}$

Hen-day Production (%) = $\frac{\text{Average number of eggs produced per day}}{\text{No of birds alive}} \times 100$ %

Feed conversion ratio / kg egg mass = $\frac{\text{Feed intake (kg)}}{\text{Kg of egg laid}}$

Chemical analysis: The proximate composition of the experimental diet and test ingredient were carried out in the laboratory using the procedure of (11).

Data collection and analysis: Data obtained were subjected to analysis using T – test and one – way Analysis of variance (ANOVA) procedure while means were separated using (12) Duncan Multiple Range Test using (13) package.

Table 1: Gross composition of experimental diet fed to laying birds

	DIETS				
Ingredients %	**1**	**2**	**3**	**4**	**5**
Maize	48.00	36.00	24.00	12.00	-
Cassava plant meal	-	12.00	24.00	36.00	48.00
Groundnut Cake	6.00	6.00	6.00	6.00	6.00
Soy bean meal	11.00	12.00	12.00	12.00	12.00
Wheat offal	10.00	13.80	13.80	13.80	13.80
Palm Kernel Cake	14.80	12.00	12.00	12.00	12.00
Fish meal	1.00	1.00	1.00	1.00	1.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Oyster shell	5.50	3.50	3.50	3.50	3.50
*Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Methionine (₦4.80/ kg diet)	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis					
Metabolizable energy (kcal/kg)	2717.96	2660.10	2640.24	2620.24	2602.24
Crude protein (%)	17.01	17.37	17.46	17.91	18.35
Crude fibre (%)	4.61	4.97	5.39	5.82	5.94
Calcium (%)	3.59	3.50	3.53	3.56	3.59
Phosphorus (%)	0.57	0.63	0.61	0.59	0.57

**ME= Metabolizable energy calculated using the formula of Pauzenga, (1985): ME= 37× % CP + 81 × % EE + 35.5 × NFE.*

**Layer's premix Per 1 kg: Vit A 5,000 I U Vit D3, 1,000,000 I U ; Vit E 15,000 mg; Vit K3 1,000 mg Vit B1, 1,2000 mg; Vit B2, 2,400 mg; Vit B6 2,400 mg; Niacin 16,000 mg, Calcium pantothenate 4,000 mg; Biotin 32 mg; Vit B12 10 mg; Folic Acid 400 mg, Choline Chloride 120,000 mg; Manganese 40,000 mg; Iron 20,00 mg, Zinc 18,000 mg; Copper 800 mg; Iodine 620 mg; Cobalt 100mg; Selenium 40mg.*

Diet 1: 0 % Cassava Plant meal Diet 2: 12 % Cassava plant meal Diet 3: 24 % Cassava plant meal
Diet 4: 36 % Cassava plant meal Diet 5: 48% Cassava plant meal
Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5

Egg Quality Analysis

Fifty (50) eggs (10 eggs per treatment) were randomly selected on weekly basis for egg quality analysis. The indices determined are as follows:

a) Egg Shell Weight (%): Each egg was carefully broken and dried after which the eggshell weight was determined using a weighing balance. The percentage egg shell weight was determined using:

$$\% \text{ Egg shell weight} = \frac{\text{Egg shell weight (g)}}{\text{Weight of egg (g)}} \times \frac{100}{1}$$

b) Egg Shell Thickness (mm): This was determined by removing the shell membrane immediately the egg was broken. The shells were allowed to dry at room temperature after which the thickness was measured using a micrometer screw gauge calibrated in millimetre.

c) Egg Length and Diameter (cm): This was determined using a pair of calipers and read on a ruler calibrated in centimeter.

d) Egg Shape Index: The egg shape index was calculated as the proportion of egg length to the egg breath.

e) Albumen Height (cm): The eggs after weighing were broken into a flat dissecting stainless plate positioned on a flat surface. The albumen height was measured using a vernier calliper read on a ruler calibrated in centimeter.

f) Yolk Height and Diameter (mm): The eggs after weighing were broken into a flat dissecting stainless plate positioned on a flat surface. The yolk height was measured using a vernier calliper and read on a ruler calibrated in centimeter. Yolk diameter was taken as the maximum cross-sectional diameter of the yolk using a pair of calipers and read on a ruler calibrated in centimeter.

g) Yolk and Albumen weight (%): The eggs after weighing were broken into a flat dissecting stainless plate positioned on a flat surface. The yolk and albumin contents were separated in a different beaker and weighed using an Electronic balance (D & G sensitive scale) expressed in grammes.

The percentage yolk and albumen weight was taken as:

$$\frac{\text{weight of yolk / Albumen}}{\text{Weight of egg}} \times \frac{100}{1}$$

h) Yolk Index: The yolk index was calculated as the proportion of yolk height to diameter.

i) The shell surface area (SSA): This was determined according to the method of (14) as follows: Egg weight $^{0.667}$ x 4.67.

j) The Haugh unit was determined using the formula:

$$Hu = 100 \log H + 7.57 - 1.7W^{0.37} \quad (15)$$

Where Hu = Haugh unit % , H = albumen height

W= egg weight (g)

The egg yolks were separated from the egg albumen using a spoon and the yolk colour was measured with the aid of Roche Yolk Colour Fan. The yolk colour of the fan was compared with the egg yolks and the number on the chart that best matched a particular yolk was taken.

Data analysis: the data obtained were analyzed using one - way analysis of Variance (ANOVA) while the means are separated using (12) test of (13) package.

Result and Discussion

Proximate composition of Test Ingredient and Maize

The proximate composition of test ingredient and maize is shown in Table 2. The cassava plant meal (CPM) product had comparable value with maize in the crude protein, dry matter and nitrogen free extracts. Although, Significant differences ($P < 0.05$) existed in the values obtained for the crude fibre, ether extract and ash with maize having

the lowest values compared to CPM product. The improved proximate composition of the CPM product could be due to the incorporation of nutrient rich and highly fibrous components (cassava leaves and tender stem) into the cassava root mixture. (16 and 17) reported similar observation that cassava leaves are higher in protein, lipid and mineral contents.

Table 2: Proximate composition of Test Ingredient and Maize

Parameters (%)	Maize	CPM	SEM (±)	Pr > t
Crude Protein	10.38	12.62	0.73	0.118
Dry Matter	88.05	90.18	1.03	0.401
Crude Fibre	2.57	6.81	0.66	0.018
Ether Extract	4.53	5.38	0.28	0.005
Ash	2.82	6.69	1.12	0.001
Nitrogen Free Extract	67.75	58.68	3.14	0.154
Metabolisable Energy (Kcal/kg)	3156.12	2907. 33	84.04	0.150

Proximate Composition of Experimental diets fed to Laying birds

The proximate composition of experimental diet fed to laying birds is shown in Table 3. The ether extract (EE) value ranged ($P < 0.05$) from 0.78 % (diet 5) to 2.26 % (diet 4). The crude fibre (CF) value ranged ($P < 0.05$) from 4.28 % (diet 1) to 5.92 % (diet 5). The crude protein (CP) value ($P < 0.05$) ranged from 16.91 % (diet 1) to 18.66 % (diet 5). The ash, CF and CP values increased with an increase in CPM of the diet and similar to the findings of (22). The values obtained were within the range recommended by (18) and (19) for laying birds. The increased CP of the diet may be due to higher CP value of the CPM product.

Table 3: Proximate Composition of Experimental Diets fed to Laying birds

	Diets						
Parameters (%)	1	2	3	4	5	SEM (±)	P value
Dry Matter	88.33	87.93	86.45	86.62	88.98	0.37	0.075
Ash	3.99	4.08	4.85	4.98	5.28	0.19	0.055
Crude Fibre	4.28	4.39	4.53	4.72	5.92	0.21	0.016
Ether Extract	1.18	1.09	1.66	2.26	0.78	0.17	0.002
Crude Protein	16.91	16.94	17.35	17.94	18.66	0.42	0.032
Nitrogen free Extract	61.97	61.43	58.06	56.72	58.34	0.66	0.286

Diet 1: 0 % Cassava Plant meal Diet 2: 12 % Cassava plant meal Diet 3: 24 % Cassava plant meal Diet 4: 36 % Cassava plant meal Diet 5: 48% Cassava plant meal
Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5

Egg Production Performance and Gross Margin of Laying Birds fed Experimental Diet

The egg production performance and gross margin of laying birds fed experimental diet is shown in Table 4. The average daily feed intake (ADFI) ranged ($P < 0.05$) from 0.109 kg/bird/day (diet 2) to 0.117 kg/bird/day (diet 5). The highest ADFI of diet 5 birds may

be due to the high CF of the diet, which might have resulted in low metabolisable energy hence, birds tend to eat more to satisfy their energy requirement (20). The hen day production (HDP) ranged ($P < 0.05$) from 66.97 % (diet 5) to 72.14 % (diet 1). (19) reported higher HDP value range (96.33 – 98.33 %). The lower HDP recorded may be due to variation in CF of the diets, which form complex with other nutrients preventing their breakdown and utilization (22). The similarities in HDP value of diets 1, 2, 3 and 4 birds, indicated that inclusion of CPM product in laying bird diets up to 75 % would adequately maintain body weight and sustained egg production efficiency. The probable explanation for higher ($P < 0.05$) HDP of diet 1 birds may be due to ability of the birds to utilize their feed more efficiently.

The dozen egg mass ($P < 0.05$) decreased with increase in feed intake indicating that dozen egg mass production depends significantly on feed intake. The feed conversion/kg egg mass (FCR/kg egg mass) and feed conversion ratio/ dozen egg ($P < 0.05$) increased with increased in feed intake and CPM of the diet. The ($P < 0.05$) variation in values may be due to differences in the metabolisable energy, crude fiber content of the diet (23) and powdery nature of the CPM product (24).

Table 4: Egg Production and Gross Margin of Laying Birds fed Experimental Diet

	Diets						
Parameters	**1**	**2**	**3**	**4**	**5**	**SEM (±)**	**P value**
ADFI (kg/b/d)	0.110^{ab}	0.109^{b}	0.113^{ab}	0.115^{ab}	0.117^{a}	0.01	0.03
Hen Day Production (%)	72.14^{a}	70.42^{a}	70.68^{a}	69.75^{ab}	66.97^{b}	0.63	0.04
Dozen egg mass	3.37^{a}	3.29^{b}	3.18^{bc}	3.14^{c}	3.13^{c}	0.03	0.02
FCR/dozen egg	1.84^{c}	1.86^{c}	1.92^{bc}	2.01^{b}	2.09^{a}	0.03	0.01
FCR/kg egg mass	2.73^{b}	2.77^{b}	2.96^{ab}	3.04^{a}	3.11^{a}	0.05	0.03
Feed cost/kg diet (₦)	150.56	148.46	146.36	144.26	142.16	5.19	0.99
Feed cost/kg egg mass (₦)	276.50	276.78	280.93	289.31	296.88	10.39	0.98

Means bearing different superscript in a row differ significantly ($P<0.05$)
ADFI: Average daily feed intake FCR: Feed Conversion ratio
Diet 1: 0 % Cassava Plant meal Diet 2: 12 % Cassava plant meal Diet 3: 24 % Cassava plant meal Diet 4: 36 % Cassava plant meal Diet 5: 48% Cassava plant meal
Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5

External and Internal Egg Quality Parameters of Birds fed Experimental diet

The external and internal egg quality parameters of birds fed experimental diet is shown in Table 5. The haugh unit ranged from 85.81 % (diet 2) to 86.16 % (diet 5). The values showed that eggs produced were within values of standard egg quality (25). The yolk weight ranged from 24.44 % to 25.30 % (26) reported higher range (15.65 – 25.93 g). The differences obtained may be due to variations in CP of the diet and the yolk protein deposition in the eggs (27). The yolk height ($P < 0.05$) ranged from 1.74 cm to 1.93 cm. The yolk diameter ($P < 0.05$) ranged from 3.81 cm to 3.89 cm. The yolk index ranged from 0.46 to 0.50. Complete replacement of maize with CPM product improved the albumen height ($P < 0.05$) with 8.91 %, yolk diameter with 0.52

%, yolk height with 8.62 % and yolk index with 8.70 %.

The yolk colour ($P < 0.05$) ranged from 5.22 (diet 1) to 9.12 (diet 5). The high yolk colour intensity of the cassava-based diet may be induced by the cassava leaf meal. This agreed with findings of (28) who reported the inability of laying birds to synthesize egg yolk pigments and egg yolk colour but depends mainly on the fat soluble vitamin pigments such as xanthophyll, lutein, zeaxanthine and β – carotene in their diets. The cassava leaf contained high carotene content, which enriched the yolk colour of the egg (22). The non-significant ($P > 0.05$) effect of shell thickness may be an indication of adequate calcium in the diets, which did not interfere with calcium metabolism in the laying hen (29). Complete replacement of maize with CPM product improved the yolk colour ($P < 0.05$) by 44.80 %.

The eggshell weight ($P < 0.05$) ranged from 11.55 % (diet 3) to 12.15 % (diet 5). This showed that shell deposition was not similar in all dietary treatments. The egg length ranged ($P < 0.05$) from 5.50 cm to 5.75 cm. The shell index ranged from 0.775 to 0.782. Complete replacement of maize with CPM product in the diet improved egg length ($P < 0.05$) by 1.08 % and egg shell weight ($P < 0.05$) by 7.40 %.

Table 5: External and Internal Egg Quality Parameters of Laying Birds fed Experimental Diet

	DIETS						
PARAMETERS	**1**	**2**	**3**	**4**	**5**	**SEM (±)**	**P value**
Haugh Unit Score (%)	85.83	85.81	86.02	85.95	86.16	0.06	0.391
Yolk Weight (%)	25.30	24.61	25.13	24.49	24.44	0.83	0.998
Yolk Height (cm)	1.78^{b}	1.79^{b}	1.83^{b}	1.74^{b}	1.93^{a}	0.02	0.003
Yolk Diameter (cm)	3.84	3.89	3.86	3.81	3.86	0.01	0.331
Yolk Index	0.47^{b}	0.46^{b}	0.48^{b}	0.46^{b}	0.50^{a}	0.04	0.004
Albumin Height (cm)	1.01^{b}	1.01^{b}	1.04^{ab}	1.04^{ab}	1.10^{a}	0.01	0.012
Albumen weight (%)	56.09	60.96	61.65	62.26	60.62	1.28	0.690
Yolk colour	5.22^{e}	6.15^{d}	7.61^{c}	8.35^{b}	9.13^{a}	0.12	<0.001
External Parameters							
Average Egg weight (g)	55.27	55.95	55.19	55.74	56.74	0.26	0.345
Egg Shell Thickness (mm)	0.33	0.36	0.36	0.38	0.39	0.01	0.725
Egg Shell weight (%)	11.65^{b}	11.96^{ab}	11.55^{b}	11.68^{b}	12.15^{a}	0.34	0.008
Egg width (cm)	4.28	4.31	4.26	4.26	4.29	0.16	0.200
Egg length (cm)	5.56^{b}	5.54^{b}	5.75^{a}	5.50^{b}	5.52^{b}	0.03	0.001
Shell Index	0.776^{a}	0.782^{a}	0.750^{b}	0.775^{a}	0.779^{a}	0.04	0.033
Shell Surface Index	67.81	68.34	67.81	68.16	68.95	0.22	0.431

Means bearing different superscript in a row differ significantly (P<0.05)
Diet 1: 0 % Cassava Plant meal Diet 2: 12 % Cassava plant meal Diet 3: 24 % Cassava plant meal Diet 4: 36 % Cassava plant meal Diet 5: 48% Cassava plant meal
Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5

Conclusion and Application

It can be concluded that:

1. Feeding cassava plant meal product up to 75 % replacement of maize in a laying bird ration gave percent hen day production comparable to maize;
2. Feeding cassava plant meal product to replace maize completely in the diets of laying birds improved external egg qualities such as egg shell weight, shell index and internal egg qualities such as yolk height,

yolk colour, yolk index, albumen weight and albumen height.

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