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Growth Performance and Egg Quality of Laying Chickens Fed Cassava (*Manihot esculenta*) Plant Meals-Based Diets

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ABSTRACT

The study evaluated the suitability of three developed Cassava Plant Meals (CPM) as a replacement for maize in diets of laying pullets in a 27-week feeding trial. A total of 600 Isa Brown laying pullets of 8-weeks old were randomly distributed among four dietary groups to assess their growth and egg laying performance during 8 and 21 weeks, and 22 to 35 weeks of age. Group 1 were fed with diet 1 which contained 50% maize and served as the control while groups 2, 3 and 4 were fed with diets containing CPMs I, II and III as complete replacement of the control. The results showed CPM III diet promoted the fastest growth (833.32 g/bird) which was comparable (844.96 g/bird) to those fed the control diet. The birds fed CPM III had a better feed efficiency, while FCR/Kg egg mass was comparable (1.99, 1.90 and 1.82) among dietary groups (CPMs II, III and control, respectively). Interestingly, CPM III diets improved the early age at first egg lay which was similar ($p>0.05$) to the group fed the control diet. Furthermore, CPM III diet improved ($p<0.05$) the egg length, shell weight and albumen height while CPM I diet promoted egg yolk index and yolk coloration. It could be concluded that, CPM III diet promoted superior body weight gains, feed conversion ratio at 8 to 21 weeks, and exhibited better egg laying performances that were comparable to those fed the maize-based diets. The CPM I diet could be recommended owing to the better egg yolk coloration, a quality that is especially desirable for the egg consumers and processors.

INTRODUCTION

In recent time, the use of cassava plant meals (CPM) in diets of monogastric animals especially poultry have received consistent attention. The crude protein contents of CPMs although variable (10 – 13 %), are higher than maize (Adeyemi and Akinfala, 2019; Ogundeji and Akinfala 2020) and the essential amino acid is more balanced than maize (Akinfala *et al*., 2019). It is also higher in B-complex vitamins and an excellent source of linolenic and arachidonic acids (Adeyemi 2023). Based on the performance of laying chickens (Ogundeji and Akinfala, 2020) fed graded levels of CPM in replacement of maize, it appears that CPM is equivalent or superior to maize as source of energy feedstuff.

Research in the use of cassava as diets for poultry is not new. The renewed interest nowadays could be due to the global concern on sustainable poultry production amidst varying climate and its numerous effects on crop production and yield (Morgan and Choct, 2016; Okrathok *et al.*, 2023). Nigeria is the highest global producer of cassava with mean yield of 63.031 million MT in 2023 (FAOSTAT, 2023). Despite that, adoption of cassava meals in diets of laying birds is yet unpopular due to the poor nutrient content of cassava root meal (Adekanye *et al.*, 2013; Morgan and Choct 2016; Bakare *et al.*, 2021).

Several researchers have evaluated the responses of laying birds to different cassava plant parts namely the roots (Kana *et al.*, 2013; Kyawt *et al.*, 2014; Chanaksorn *et al.*, 2019), leaves (Simao *et al.*, 2013; Morgan and Choct, 2016) and peels (Ogunwole *et al*., 2017). The variations in the performance of the experimental birds could be the limiting factor preventing widespread use and adoption. Interestingly, substantial studies conducted on cassava plant parts showed suitability at some inclusion levels with cost effective advantage (Adesehinwa *et al.*, 2016; Adeyemi and Akinfala, 2019; Akinfala *et al.*, 2019; Ogundeji and Akinfala, 2020). Meanwhile, Akinfala and Tewe (2004) suggested the inclusion of all the cassava plant parts to improve the inadequacies of cassava root meals especially in diets of laying birds.

Several authors have studied the response of laying birds to cassava diets. Recently, Ogundeji and Akinfala (2020) evaluated egg production performance of Isa brown laying chickens fed CPM diets. The authors found comparable performance with birds fed maize-based diet. However, growth, development and maturation of reproductive birds for onset of egg lay and peak production as well as other egg quality indices are essentially related to nutrition (Souza *et al.*, 2021). Laying birds require an excellent plane of nutrition to build the skeletal structure, gain weight, and develop their reproductive organs actively between the growth phase of 8 and 22 weeks for Isa brown breed (Bendezu *et al.,* 2015; Anene *et al.,* 2020). To the best of our knowledge, information on total replacement of maize with different CPMs products in diets of laying birds reared from 8 weeks untill peak of egg lay and egg production performance remain yet unexplored. The study seeks to fill this gap and provide information on the production performance, age at first egg lay, and egg quality indices of laying birds fed cassava plant meals-based diets.

MATERIALS AND METHODS

Description of study area

The study was carried out at the Poultry Unit of the Teaching and Research Farm, Olusegun Agagu University of Science and Technology (OAUSTECH) Okitipupa, Nigeria. The OAUSTECH is located within the rainforest zone, Latitude 5º 28’ N and longitude 4º 46’ E at an elevation of about 200 m above sea level.

Collection and preparation of test ingredients

The cassava variety (TMS 30572) of 24 months old was carefully lifted and soil shaken off the tubers, washed, chopped into small pieces and sundried on clean concrete floor. The leaves were harvested from the stem while the tender cassava stem was harvested at 5 cm, usually 6 to 7 nodes from the top of the plant. All the cassava components were sundried for an average of 2 to 3 and 4 to 5 days for the unpeeled cassava tuber and leaves/tender stems respectively, depending on the intensity of sun light. After sun-drying the different cassava components to about 10 % moisture content, each of the components were separately milled using locally fabricated hammer mill machine of 2 mm sieve, and packed in air tight bags.

Development of cassava plant meal products

The cassava plant meal (CPM) products were developed using the procedure of Akinfala *et al.* (2002). Three CPM products were developed by mixing sundried unpeeled cassava root meal with sundried cassava leaf meal and tender stem meal at ratios 2:1, 2.5:1 and 3:1 while the ratio of the leaf meal to the tender stem meal was 5:1 for all the products.

Table 1: Composition of experimental diets fed experimental birds from 8 to 35 weeks

	DIETS			
Ingredients (%)	**Maize**	**CPM I**	**CPM II**	**CPM III**
Maize	50	-	-	-
CPM	-	50	50	50
Groundnut cake	6	6	6	6
Soybean meal	11	11	11	11
Wheat offal	10	10	10	10
Palm kernel cake	12.80	12.80	12.80	12.80
Fish meal	1.00	1.00	1.00	1.00
Bone meal	5.50	5.50	5.50	5.50
Oyster shell	3.0	3.0	3.0	3.0
*Premix	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Metabolisable energy (Kcal/Kg)	2752.62	2610.66	2633.74	2685.51
Crude protein (%)	17.00	18.13	18.14	18.30
Crude fibre (%)	5.13	6.65	6.08	5.74
Calcium (%)	2.55	2.64	2.70	2.72
Phosphorus (%)	1.15	1.04	1.05	1.05
Lysine	0.82	0.99	0.92	0.96
Methionine	0.41	0.45	0.42	0.45

CPM 1: Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5; CPM 2: cassava leaves + Tender stem + unpeeled tuber at ratio 2.5:1: 5; CPM 3: Cassava leaves + Tender stem + unpeeled tuber at ratio 3:1: 5

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

*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.

In other words, CPM I comprised of 66.67%, 27.78% and 5.55%; CPM II comprised of 71.43%, 23.81% and 4.76% while CPM III comprised of 75%, 20.83% and 4.17% of unpeeled tuber meal, leaf meal and tender stem meal respectively. The mixing ratios were with a view to obtain a comparable minimum crude protein content of 10 % as maize.

Experimental pullets, treatments and diets

A total of 600 Isa Brown pullets of 8-weeks old were used for this study. The experimental pullets were randomly assigned to four experimental diets. For each treatment, there were 10 replicates with each replicate comprising 15 laying pullets, housed separately in a battery cage with a dimension of 77 x 86 inches, and containing three experimental birds per cell. Routine and occasional vaccination and medication schedules were carried out on treatment basis. Feed was supplied based on weekly body weight gain while water was provided *ad libitum* throughout the experimental duration of 27 weeks.

Four experimental diets were formulated as shown in Table 1. Diet I contained 50% maize and served as the control while diets II, III and IV contained 100% of maize in diet I replaced with cassava plant meal products I, II and III respectively.

Chemical analysis and measurement of egg quality parameters

The proximate analysis of the experimental diets was carried out as outlined by AOAC (2010). A total of 100 eggs (25 eggs per treatment) were randomly collected for weekly egg quality analysis. The indices determined were as follows;

i. Egg Length and circumference (cm): This was determined using a pair of calipers and read on a ruler calibrated in centimetres. Egg circumference was taken as the length of a thread tightly wrapped around the egg and read on a ruler calibrated in centimetres
ii. Egg shell index: This was determined as a ratio of the egg shell weight to its shell surface multiplied by 100 percent, according to the following:
iii. Egg Shell Weight (%): Each egg was carefully broken and dried after which the egg shell weight was determined using a weighing balance. The percentage egg shell weight was determined using:
iv. Egg Shell Thickness (mm): This was determined by removing the shell membrane immediately the egg was broken. The shell was allowed to dry at room temperature after which the thickness was measured using a micrometer screw gauge, calibrated in millimetres.
v. Egg Shape Index: The egg shape index was calculated as the proportion of egg length to the egg breath.
vi. Albumen Height (cm): The egg upon weighing was broken unto a flat dissecting stainless plate positioned on a flat surface. The albumen height was measured using a Vernier caliper read on a ruler calibrated in centimetres.
vii. Yolk Height and diameter (mm): The egg upon weighing was broken unto a flat dissecting stainless plate positioned on a flat surface. The yolk height was measured using a Vernier caliper and read on a ruler calibrated in centimetres. 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 centimetres.
viii. Yolk and Albumen weight (%): The egg upon weighing was broken unto 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 expressed in grams. The percentage yolk and albumen weight were taken as:
ix. Yolk Index: The yolk index was calculated as the proportion of yolk height to diameter.
x. The shell surface area (SSA): This was determined following the methods of Hughes (1984) as follows: Egg weight $^{0.667}$ x 4.67.
xi. The Haugh unit was determined using the formula of Haugh (1937) as follows:

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 (Touhoku Rhythm Co. Ltd., Tokyo, Japan). The colour of the fan was compared with those of the egg yolks to determine which number that best matched the yolk under consideration.

Growth performance of experimental birds

The body weight of the pullets was taken on the basis of treatment, between the eight (8) and twenty-first (21) weeks of pullets age. The daily feed intake, time to first egg lay, number and weight of eggs were recorded on treatment basis.

Statistical analysis

Data were analysed using One-way Analysis of Variance procedure of SAS (2009) using the model:

$Yij = \mu + Ti + eij$

in which Y is the dependent variable; i is for diets maize, CPMs I, II, III; j is for replicates 1, 2, 3, or 4; μ is the overall/group mean, T is the treatment effect of diets; and e is the random error associated with completely randomized design. Standard error of the mean is for n = 4; means were separated using Duncan Multiple Range Test at 95% significant level.

RESULTS

Proximate composition of experimental diets

The proximate composition of the experimental diets is shown in Table 2. The crude protein (CP) content varied between 16.72% and 17.88%. The CP contents of the CPMs I, II and III were 6.74%, 3.23% and 4.90% superior to the control (maize-based) diet. The crude fibre (CF) content increased across CPMs I through III with the maize-based diet having the least fibre content. The CPMs I, II and III had 30.0%, 31.13% and 32.0% more fibre contents than the maize meal. Similarly, all the CPMs diets had lower ether extract (EE) contents compared to the maize-based diet. Whereas, CPMs I, II and III contained 13.7%, 16.33% and 19.18% higher ash content than was obtained in maize-based diet.

Growth and egg laying performance of experimental pullets fed experimental diets

The growth and egg laying performance of the experimental pullets fed experimental diets are presented in Table 3. The weight of the pullets at 21 weeks varied significantly ($p<0.05$) among treatment groups. The groups fed the control diet had the highest weight while those fed the CPM I had the least. The weight gain in between the 8th and 21st week showed similar trend as the weight recorded at the 21st week with the groups fed maize-based diet having 5.06%, 3.10% and 1.38% superior performance over those fed CPMs I, II and III respectively. The experimental birds fed the CPMs II and III as well as maize-based diet consumed -3.47%, -6.37% and -8.98% lesser feed respectively, compared with the groups fed CPM I. The feed conversion ratio was best among treatment group fed maize-based diet and poorest in the group fed CPM I.

For all the evaluated egg laying performance of the experimental birds, age at first laying and FCR/Kg egg mass were significantly ($p<0.05$) different across treatment groups. The age at first egg lay was highest in treatment group fed CPM 1 and least in those fed maize-based diet. For the FCR/Kg egg mass, the highest and least values were found in experimental pullets fed CPM I and maize-based diet, respectively. Meanwhile, the FCR/Kg egg mass of Isa Brown birds fed CPMs II and III were not significantly different ($p>0.05$) from either of CPM I or maize-based diets.

Egg quality indices of laying birds fed experimental diets

The egg quality parameters of the experimental laying birds fed cassava plant meal diets is shown in Table 4. For the external egg quality parameters, the egg shell weight and egg length varied significantly ($p<0.05$) across dietary groups. For the egg shell weight, the heaviest and lightest weights were recorded among the groups fed CPM III and maize-based diets, respectively while for the egg length, the longest and shortest eggs were found in experimental birds fed CPMs III and II, respectively.

The yolk height, yolk index, albumin height and yolk colour were the internal egg quality parameters that differed significantly across dietary groups. The dietary groups fed CPMs II, III and maize-based diets had -3.8%, -4.5% and -4.5% inferior yolk heights compared to those fed CPM II. Similarly, the birds fed CPM II diet had 4.6%, 5.2% and 5.9% better yolk index compared to those fed the control (maize-based diet) as well as CPMs II and III diets, respectively. Conversely, the experimental birds fed CPM III had the better albumin height while those fed CPM I had the least. However, for the yolk colour, the birds fed CPM I had the deepest yolk coloration while those fed the maize-based diet gave the lightest yolk colour.

DISCUSSION

The higher CP contents of CPMs (I, II and III) diets compared to the maize-based could be due to the inclusion of lush cassava leaf and tender stem meals in the unpeeled cassava root mix. Similar results were reported by Adeyemi and Akinfala (2019); Akinfala *et al.*, (2019); Ogundeji and Akinfala (2020) on use of cassava plant meals in diets of growing pigs, weaning pigs and for laying hens, respectively.

Table 2: Proximate composition of experimental diets

Parameters (%)	Maize	Cassava Plant Meals (CPM) CPM I	CPM II	CPM III	SEM	P-value
Dry Matter	90.28	92.31	90.28	90.85	3.98	0.10
Crude Protein	16.72	17.88	17.26	17.54	0.24	0.04
Crude Fibre	4.53	5.89	5.94	5.98	0.38	0.032
Ether Extract	2.29	1.02	0.87	0.76	0.19	0.043
Ash	4.90	5.57	5.70	5.84	0.35	0.029
Nitrogen Free Extract	70.26	68.79	68.43	68.20	2.25	0.54

CPM 1: Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5; CPM 2: cassava leaves + Tender stem + unpeeled tuber at ratio 2.5:1: 5; CPM 3: Cassava leaves + Tender stem + unpeeled tuber at ratio 3:1: 5

Table 3: Growth and egg laying performance of Isa Brown pullets fed experimental diets

Parameters	DIETS					
	Maize	CPM I	CPM II	CPM III	SEM	P-value
Growth performance of pullet (8 – 21 weeks)						
Weight at 8 weeks (g/bird)	565.04	548.00	553.81	557.90	2.52	0.38
Weight at 21 weeks (g/bird)	1410.00[a]	1350.23[c]	1372.60[bc]	1390.42[ab]	8.71	0.01
Weight gain (g/bird)	844.96[a]	802.23[c]	818.79[b]	833.32[a]	6.16	0.002
Feed intake 8 – 21 weeks (g/bird)	5261.67[d]	5781.00[a]	5580.38[b]	5412.97[c]	73.08	<0.0001
Feed conversion ratio	6.22[d]	7.04[a]	6.82[b]	6.50[c]	0.11	0.0006
% Mortality (8 – 21 weeks)	3.34	3.33	3.30	3.33	0.02	0.15
Egg laying performance of pullets (22 – 35 weeks)						
Age at 1st egg (days)	156[c]	176[a]	165[ab]	159[c]	3.21	0.010
Average feed intake (g/bird/day)	108.00	120.01	115.00	112.00	2.51	0.47
Egg weight (g)	59.26	54.75	57.70	59.00	1.93	0.90
Egg mass index	50.88	46.72	49.84	52.65	2.06	0.86
Hen day production (%)	85.86	85.34	86.38	89.24	2.24	0.96
FCR/Kg egg mass	1.82[b]	2.19[a]	1.99[ab]	1.90[ab]	0.06	0.014
FCR/dozen egg	1.30	1.50	1.45	1.40	0.04	0.46

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[a,b,c,d] means within the same row with different superscripts are significantly different ($P \leq 0.05$)

Table 4: Egg quality indices of laying birds fed experimental diets

Parameters	DIETS					
	Maize	**CPM I**	**CPM II**	**CPM III**	**SEM**	**P-value**
External egg quality						
Average egg weight (g)	59.26	54.75	57.70	59.00	1.69	0.86
Egg shell thickness (mm)	0.39	0.44	0.45	0.41	0.03	0.91
Egg shell weight (%)	11.82^{c}	12.32^{b}	12.56^{b}	13.16^{a}	0.23	0.03
Egg circumference (cm)	4.90	4.88	4.72	4.92	0.06	0.79
Egg length (cm)	5.22^{b}	5.24^{b}	5.13^{c}	5.37^{a}	0.04	0.001
Shell index	0.76	0.76	0.76	0.78	0.01	1.00
Shell surface area	68.80	69.53	73.34	74.93	1.70	0.63
Internal egg quality						
Haugh Unit Score (%)	92.84	92.79	92.94	92.99	1.91	1.00
% Yolk weight	24.20	23.90	24.95	24.01	1.28	0.98
Yolk height (cm)	1.27^{b}	1.33^{a}	1.28^{b}	1.27^{b}	0.02	0.001
Yolk diameter (cm)	3.41	3.43	3.48	3.50	0.14	0.87
Yolk index	0.370^{b}	0.388^{a}	0.368^{b}	0.365^{b}	0.03	0.031
% Albumen weight	53.02	56.17	54.48	56.82	4.04	0.83
Albumen height (cm)	0.88^{b}	0.87^{b}	0.90^{b}	0.97^{a}	0.01	0.012
Yolk colour	5.87^{c}	9.54^{a}	7.85^{b}	7.75^{b}	0.49	<0.001

CPM 1: Cassava Plant Meal 1: cassava leaves + Tender stem + unpeeled tuber at ratio 2:1: 5; CPM 2: cassava leaves + Tender stem + unpeeled tuber at r68atio 2.5:1: 5; CPM 3: Cassava leaves + Tender stem + unpeeled tuber at ratio 3:1: 5

The authors also reported higher CF and ash contents of CPMs diets which could be attributed to the high proportion of fibre rich and mineral contents of the cassava plant parts. Studies (Gomes *et al.,* 2005; Nuss and Tanumihardjo, 2010) have established cassava meal as poor source of lipid, and was similarly obtained in this study. Meanwhile, the variations observed in the NFE values reported in this study could be due to the variations in other proximate parameters. Generally, the similarities obtained in the proximate parameters among experimental diets could be suggestive of the potential CPMs as suitable replacement for maize in diets of laying pullets.

The similarities in weight gain and weight (at 21 weeks) of experimental laying pullets fed the control and CPM III diets indicated the inherent potential of the CPM product to completely replace maize in diets of laying pullets. This has been reported in the study of Raphael *et al.* (2013) when fed cassava diets as replacement for maize. Also, in the studies conducted by Akinfala *et al.* (2002) and Matanmi *et al.* (2004) on use of whole cassava plant as replacement for maize in diets for broiler chickens and cockerels revealed that cassava-based diets had comparable performance with those fed the control diet. The observed reduction in feed intake of the experimental birds fed CPMs diets could be due to the improvement in energy density due to increased quantity of unpeeled cassava tuber meal in the different CPM products. These observations had been reported earlier by Akinfala *et al.* (2002); Adeyemi and Akinfala (2019) that animals will eat to satisfy their daily nutrient requirements. Again, level of dietary fibre in the feed could also influence the quantity of feed intake.

Similarly, FCR/Kg egg mass worsen as the quantity of unpeeled tuber meal in the CPM products reduced. This corroborates the earlier findings of Raphael *et al.* (2013); Olarotimi and Adu (2017) that any inadequacies in nutrient supply could reduce egg production performance.

The age at first egg lay was comparable in treatment groups fed the control and CPM III diets. This finding agreed with those of Raphael *et al.* (2013) who reported that feeding cassava diets as replacement for maize had no deleterious effects on production performance and age at first egg lay. This could imply that, birds fed CPM III stimulated as much growth as those fed the control diets. Feeding laying chickens the CPM III diet would promote similar growth and structural body development as those fed maize-based diet. This agreed with the reports of Souza *et al.* (2021) that nutrition had crucial roles in stimulation and development of reproductive organs. The birds fed CPMs II or III had comparable FCR/Kg egg mass as those fed either CPM I or the control diet. This may imply that, either the laying chickens fed CPM II or III could produce similar performance as those fed either the control or CPM I diet. The finding of this study agreed with those of Raphael *et al.* (2013) but disagreed with the findings of Ogundeji and Akinfala (2020), who found contrasting egg laying performance between the groups fed total replacement of maize and CPM I diets. The differences in response of the experimental laying pullets between these studies could be due to animal (such as strain or age of the experimental birds) or environmental (nutrition, water and light) factors. Since older birds lay fewer eggs while an inadequate supply of water and quality nutrition have been found to adversely affect production performance of laying birds (Sharma *et al.*, 2022).

The observed increase in egg shell weight of experimental laying pullets fed the CPMs diets could be due to the increase mineral contents (Calcium, magnesium, sodium and potassium) of the experimental diets with increasing inclusion level of the unpeeled cassava tuber meal. Previous studies (Zanu and Avukpor, 2013; Oresegun *et al.*, 2016) revealed that cassava meals are good sources of calcium, magnesium and sodium. Also, studies by Ogundeji and Akinfala (2020) found egg weight to be highest among treatment group fed total replacement of maize with CPM I. The variations in egg length across treatment groups did not seem to follow any trend. The yolk height of eggs laid by pullets fed the experimental diets decreased across treatment groups from CPM I through III. This could be related to the quantity of nutrients especially the amino acids, calcium, phosphorus, energy level and β-carotene contained in the different CPMs products. This was because, as the nutrient density increased, the egg yolk height and weight also increased and this finding had been reported by Wu *et al.* (2007) and Calislar (2019). The significant variation observed in the values of yolk index of the experimental laying pullets could be an indication of the freshness of the eggs. Similar reason could be responsible for the values obtained for the albumen heights of the eggs laid by the pullets. Evidently, the eggs laid by the experimental birds fed CPM I had the highest yolk pigmentation and could be attributable to the higher concentration of β-carotene previously reported by Galon *et al.* (2017); Sumiati *et al.* (2020) in their studies on improvement of egg quality parameters in laying birds fed cassava leaf meal diets.

CONCLUSION

It can be concluded that CPM III diet promoted superior body weight gains, feed conversion ratio of pullets at 8 to 21 weeks of age, and exhibited better egg laying performances that were comparable to those fed the maize-based diets. However, for egg yolk colouration, CPM I diet would be recommended for egg consumers and processors.

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