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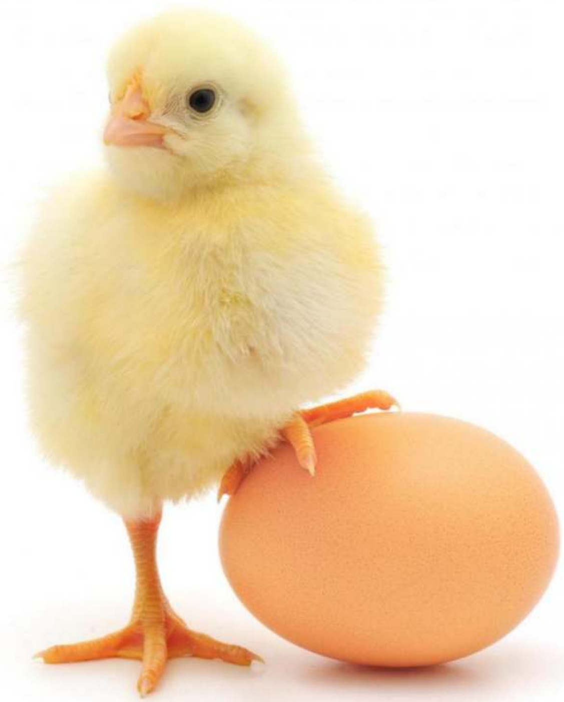

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Pigeon Pea [*Cajanus cajan (L.) Millsp.*] Seed Meal in Layer Diets: 1. Performance of Point of Lay Pullets Fed Raw or Processed Pigeon Pea Seed Meal Diets

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Abstract: Performance of point of lay black Bovan Nera pullets fed raw or processed pigeon pea seed meal (PSM) diets was determined with 150 (20 week old) pullets. They have not been fed any PSM diet before the study. The seeds (brown colored) were used as raw or processed (toasted for 30 minutes, boiled for 30 minutes, or soaked in water for 24 hours), all of which were milled. Each treatment had three replicates; each replicate had 10 birds in a completely randomized design (CRD). The experimental diets were isoenergetic and isonitrogenous. Measurements were feed intake, live weight, hen-day and hen-housed egg production, mortality, age at 1st, 25 and 50% egg production, external and internal egg quality characteristics. Raw PSM diet fed to point of lay pullets (POL) significantly ($P<0.05$) improved hen-day production (67.79%), feed intake (101.50 g), and lowered age at 50% egg production (180.67 d) more than other diets. Layers fed toasted PSM diet laid eggs with superior weight (66.17 g), width (4.51 cm) and the lowest shell weight (4.37 g). Also layers fed toasted PSM diet laid eggs with superior albumen (11.87 mm) and yolk (20.50 mm) heights, albumen weight (45.80 g), albumen + yolk weight (61.60 g) and significantly ($P<0.05$) higher Haugh unit (123.63) than the rest. It was concluded that 30% raw, toasted or soaked PSM diet could be fed to point of lay pullets without adverse effect on egg production, external and internal egg quality characteristics.

Key words: Pigeon pea seed meal, point of lay, layers, diets

Introduction

Hen eggs will continue to be an important part of human diets especially in a less developed country like Nigeria. Although eggs contain about 75% water, they are rich sources of high-quality protein, unsaturated fatty acids, minerals and vitamins A, K and B (Watkins, 1995). They provide well-balanced source of nutrients for persons of all ages (Mine, 2002).

Efforts at large scale egg production and at low cost too have been hampered by high feed cost occasioned by high cost of conventional feedstuffs like maize, soybean meal and fish meal (Amaefule *et al*., 2006). This necessitates the continued development of such un-conventional feedstuff as pigeon pea seeds for poultry, especially layers (Nwokolo, 1987; Udedibie and Igwe, 1989; Amaefule and Nwagbara, 2004).

Udedibie and Igwe (1989) reported that Harco layers at their 7th week of lay could tolerate 20% raw pigeon pea seed meal diet. They recommended heat treatment of the raw seeds to allow higher levels of the seed meal to be included in the diets. Agwunobi (2000) fed 55% autoclaved pigeon pea seed meal diet to point of lay Hubbard pullets and reported significantly lower feed intake and poor performance of layers compared to those fed soybean meal or control diets.

Studies in our station have shown that pullet chicks could be fed 10% raw or processed (boiled, toasted and soaked) pigeon pea seed meal (PSM) diet (Amaefule and Obioha, 2005) and that PSM could be a good protein and energy source for grower (9-week old) pullets, which could be incorporated into the diets at 20% of the whole diet without any adverse effect on growth performance (Amaefule *et al*., 2006). The aim of the present study was to determine the performance of point of lay pullets fed raw or processed pigeon pea seed meal diets.

Materials and Methods

Processing of seeds: The pigeon pea seeds (brown colored) were used raw, boiled, toasted or soaked in water. Boiling was for 30 minutes with a big cooking pot heated with a gas stove. Soaking of raw seeds in water was for 24 hours in a 200 litre capacity plastic container. The seed: water ratio was 30 kg per 100 litre water. The raw (unprocessed) or processed pigeon pea seeds were milled with a local milling machine powered by a 2.0 hp diesel Lister engine to pass through a 2 mm sieve. The processing of the seeds had been described by Amaefule and Nwagbara (2004), Amaefule and Obioha (2005) and Amaefule *et al*. (2006).

Experimental diets: Five isoenergetic and isonitrogenous layers diets were formulated with raw,

Table 1: Percentage composition of raw or processed pigeon pea seed meal diets fed to point of lay pullets

Feedstuffs %	Control	Raw	Boiled	Toasted	Soaked
Maize	36.00	28.50	28.50	28.50	28.50
Local Fish meal	3.00	3.00	3.00	3.00	3.00
Spent grain	8.00	-	-	-	-
Maize gluten feed	15.00	5.00	5.00	5.00	5.00
Wheat offal	10.00	10.00	10.00	10.00	10.00
Soybean meal	18.50	14.00	14.00	14.00	14.00
PSM	0.00	30.00	30.00	30.00	30.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Oyster shell meal	6.00	6.00	6.00	6.00	6.00
Vitamin premix*	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100	100
Calculated:					
CP (%)	18.26	18.50	18.50	18.50	18.50
CF (%)	6.20	5.51	5.40	4.31	5.40
ME (Mjkg^{-1})	12.30	12.77	12.77	12.77	12.77
Ca (%)	3.40	3.40	3.40	3.40	3.40
Avail. P (%)	0.54	0.54	0.54	0.54	0.54
Analyzed:					
Dry Matter (%)	86.50	87.50	85.20	85.00	82.50
Crude Protein (%)	18.32	18.18	18.37	18.06	18.40
Ether Extract (%)	2.00	1.00	1.00	2.00	1.00
Crude Fibre (%)	3.50	4.00	4.09	6.00	4.50
Crude Ash (%)	15.50	13.00	17.50	15.50	18.00
Nitrogen Free Extract (%)	47.18	51.32	44.24	43.44	40.60
Energy (Mjkg^{-1})	15.43	14.43	15.31	16.23	15.60

*Premix supplied Vitamin A 200000 IU, Vit. D_3 400000 IU, Vit. E 8.00 g, Vit. K_3 0.40 g, Vit. B_{12} 0.32 g, Vit. B_2 0.96 g, Vit B_6 0.56 g, Vit. C 2400 mg, Vit. B_{12} 400 mg, Folic acid 0.16 g, Biotin 8.00 mg, Choline 48.00 g, Ca Pantothionate 1.60 g, Mn 16.00 mg, Fe 8.00 mg, Zinc 7.20 g, Copper 0.32 g, Iodine 0.25 mg, Cobalt 36.00 mg, Selenium 16.00 mg, BHT 32.00 g.

boiled, toasted and soaked PSM. Each was included at 30% of the whole diet. The control diet had 0% PSM (Table 1). The raw or processed PSM replaced part of soybean meal and maize in the diets.

Experimental birds and their management: Point of lay black Bovan Nera pullets (20 weeks old) that had not been fed any PSM diet was used for the study. The pullets in each replicate were brooded and reared in a deep litter (wood shavings) pen of a tropical-type, open-sided poultry house whose sides and demarcations between pens were covered with wire-gauze (Amaefule and Obioha, 2005). The pullets were fed a chick diet (maize 45%, soybean meal 25%, maize gluten feed 8%, local fish meal 2%, spent grain 10%, wheat offal 6.50%, bone meal 3% vitamin premix 0.25% and salt 0.25%) that contained 20.57% CP, 3.70% CF, 1.32% Ca, 0.67% P, 1.07% lysine, 0.30% methionine and 12.97 MJkg^{-1} ME at the pullet chick (0-56 days) stage. At the grower stage (56-126 days), the pullets were fed a grower diet containing 37% maize, 1% local fish meal, 12% spent grain, 22.50% maize gluten feed, 15% wheat offal, 9% soybean meal, 3% bone meal, 0.25% vitamin premix and 0.25% salt. The CP, CF, Ca, P, lysine, methionine and ME contents were 15.24, 4.27, 1.03, 0.51, 0.69, 0.26% and 12.65 MJkg^{-1}, respectively.

The layers were housed in a 2-tier battery cage located in an open-sided poultry house covered with wire gauze but roofed with corrugated iron sheets. The battery cages were equipped with open (manual) feeder troughs and nipple drinkers. Water supply to the nipple drinkers was from an over-head 500 litre water tank. Each cage cell (60 cm x 42 cm x 40 cm) contained two layers. The ambient temperature of the experimental poultry house measured with a thermometer hung above the cages ranged between 23 and 25^{o}C (average 24^{o}C) throughout the period of the experiment. The layers were vaccinated against Newcastle (I/O, *Lasota, Kamorov*), *Gumboro* and fowl pox diseases during the rearing period. They were not de-beaked but were de-wormed at 18 weeks of age.

The feeder troughs were demarcated with flat aluminum sheets to prevent feed from one replicate or treatment mixing with another and this also prevented birds from one replicate feeding from another. The layers were fed 2 times daily (7.30-8.00 am and 1.30-2.00 pm), with a feed allowance of 120 g per layer per day. Water was provided *ad libitum*.

Experimental design and data collection: The experimental design was completely randomized design (CRD). There were five treatments, each replicated three times. There were 10 birds per replicate.

The number of eggs laid per replicate was recorded and collected twice daily (11.30 am and 5.00 pm) while egg weight, shell weight and thickness, shape index,

Table 2: Proximate composition of raw or processed pigeon pea seed meal (% DM Basis)

Composition	Raw	Boiled	Toasted	Soaked
Dry matter (%)	88.50	88.50	87.00	89.00
Crude protein (%)	26.25	27.34	25.37	27.12
Ether extract (%)	2.10	2.03	1.05	1.94
Crude fibre (%)	5.00	7.50	6.50	7.50
Crude ash (%)	5.50	4.00	6.10	4.00
Nitrogen free extract (%)	49.65	47.63	47.98	48.44
Gross energy ($MJkg^{-1}$)	16.02	16.52	16.18	16.30

albumen and yolk weight, yolk index and Haugh unit were determined monthly. The layers were weighed individually and on a monthly basis. Egg mass was calculated as number of eggs x egg weight, percent hen-day production as number of eggs produced divided by the number of hen-days x 100% and percent hen-housed production as number of eggs produced divided by (number of hens housed x number of days) x 100%. Record of number of cracked eggs and mortality were maintained for each replicate throughout the period of the experiment. Feed efficiency was calculated as the number of eggs laid per kg feed consumed.

Egg quality measurements: The average weight of eggs laid by birds in each replicate was determined monthly (mid-month of lay) using an Acculab electronic (0.1g) weighing scale. The length and diameter of the eggs were measured with a Venier Caliper. Shell thickness was determined using Ames micrometer screw gauge (Ames 25M5), albumen and yolk heights with Ames (S-6428, 0.1mm) Tripod thickness measure, yolk diameter with Venier Caliper, while albumen and yolk weights were measured with Acculab electronic scale. Yolk index was calculated as yolk height divided by yolk diameter. Haugh unit was determined using interior quality calculator for eggs (USDA Chart for scoring broken-out eggs, Catalog 4-4200 American Instrument Co. Inc. Silver Spring, MD.) while shape index was calculated as egg length divided by the width.

Chemical and data analyses: Feed samples were analyzed for proximate composition according to methods of A.O.A.C. (1990). The gross energy of PSM and experimental diets were determined using Adiabatic Oxygen Bomb Calorimeter (1241 Adiabatic Calorimeter, PARR Instrument Co., Illinois, USA) technique. All data collected were subjected to analysis of variance (ANOVA) and differences among treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955). All statistical procedures were according to Steel and Torrie (1980).

Results

The proximate composition of the raw, boiled, toasted or soaked PSM had no major (unanalyzed) differences among each other as shown in Table 2. The experimental diets had no differences in their proximate composition as they were meant to be isoenergetic and isonitrogenous. The performance of layers fed raw or processed PSM diets from point of lay (POL) stage of life (Table 3) showed that there were no significant ($P>0.05$) differences among the layers fed the treatment diets in average hen-housed production, percent hen-day production, number of cracked eggs, mortality and egg mass produced. Significant ($P<0.05$) differences existed only in daily feed intake and FCR, two of which had the same trend, while layers fed the control diet had significantly ($P<0.05$) lower values for the two parameters than layer feed raw or processed PSM diets. There was no significant difference ($P>0.05$) between layers fed raw, toasted, boiled and soaked PSM diets in feed consumption and FCR. Average hen-housed production (HHP), which was of the same trend as percent hen-day production (Fig.1) reached peak at 2nd month of lay at about 23 eggs per bird and dropped sharply to 16 at the 3rd month before a gradual rise to another peak at week 7. The exception here was by layers fed the control diet that had a higher peak close to 25 that was reached at the 4th month before dropping at 6th week. Layers fed the raw or processed PSM diets had no significant ($P>0.05$) differences in their age at first egg lay but all had significantly ($P<0.05$) lower age at first egg lay than layers fed the control diet. Also, age at 25 and 50% egg production were of the same trend as age at first egg lay.

External egg characteristics: All external egg quality parameters except shell thickness were significantly ($P<0.05$) affected as a result of feeding raw or processed PSM based diets to point of lay (POL) pullets. Layers fed raw and toasted PSM diet laid eggs that had significantly ($P<0.05$) higher weight than the eggs of those fed boiled PSM diet, which were in turn significantly ($P<0.05$) higher than the eggs laid by those fed soaked PSM diet (Table 4). Egg width (diameter) of layers fed toasted PSM diet was significantly ($P<0.05$) higher than that of eggs laid by layers fed raw PSM diets, which was in turn significantly ($P<0.05$) higher than that of those fed boiled and soaked PSM diets. Egg length followed the same trend as egg width except that there was no significant ($P>0.05$) difference in egg length of layers fed raw and toasted PSM diets. Shape index was only significantly different ($P<0.05$) between eggs laid by birds fed toasted and raw PSM diets. Eggs laid by layers fed raw, boiled and soaked PSM diets had non-significant ($P>0.05$) differences in their shell weight, while they were all significantly ($P>0.05$) higher than the shell weight of eggs laid by birds fed toasted PSM diets. All treatment diets produced eggs with non-significant ($P>0.05$) differences in their shell thickness. For egg weight, diameter, length and shape index, the control diet did not differ significantly ($P>0.05$) from boiled PSM diets.

Table 3: Performance of layers fed raw or processed PSM diets from point of lay stage of life

Parameters	Control	Raw	Boiled	Toasted	Soaked	SEM
Hen-housed production (%)	76.31	74. 41	74.29	76.97	75. 57	2. 27
Hen-day production (%)	65.56	67. 79	63.88	62.79	64.91	2.10
Daily feed intake (g)	88.15^{b}	101.50^{a}	99.93^{a}	94.81^{ab}	100.69^{a}	4.73
No. of cracked eggs	4.33	3.00	2.00	3.67	2.00	1.26
Average mortality (%)	0.00	1. 00	1.50	0.00	1.50	0.56
Average egg weight (g)	61.01	61. 93	62.28	62.89	60.23	1.12
F C R	3.17^{b}	3. 43^{ab}	3.66^{ab}	3.53^{ab}	3.75^{a}	0. 16
Egg mass prod. (g)	1200.07	1187.82	1192.66	1247.74	1173.28	209.58
Age at 1st egg (days)	155.33^{b}	172.33^{a}	172.67^{a}	172.67^{a}	172. 00^{a}	1.28
Age at 25% production (d)	158.33^{b}	174.00^{a}	175.33^{a}	177.00^{a}	175.33^{a}	1.37
Age at 50% production (d)	165.00^{b}	18.67^{a}	178.67^{a}	184.67^{a}	182.67^{a}	3.27
Initial live weight (kg)	1.53	1.54	1.55	1.52	1.51	0.01
Final live weight (kg)	1.90	1.99	2.20	2.05	2.00	0.17

a, b Means in the same row followed by different superscripts are significantly different (P<0. 05). SEM = Standard Error of mean. d = days

Table 4: Effect of feeding raw or processed PSM based diets to point of lay pullets on external egg quality

Parameters	Control	Raw	Boiled	Toasted	Soaked	SEM
Egg weight (g)	57.32^{bc}	65.93^{a}	58.00^{b}	66.17^{a}	54.75^{c}	0.85
Egg width (cm)	4.30^{bc}	4.36^{b}	4.18^{c}	4.51^{a}	4.20^{c}	0.05
Egg length (cm)	5.80^{bc}	6.19^{a}	5.51^{c}	6.00^{ab}	5.60^{c}	0.11
Shape index	0.742^{ab}	0.703^{b}	0.715^{ab}	0.753^{a}	0.750^{ab}	0.02
Shell weight (g)	4.63^{bc}	5.30^{a}	5.60^{a}	4.37^{c}	5.13^{ab}	0.17
Shell as % of egg weight	8.08	8.04	9.66	6.60	9.37	-
Shell thickness (mm)	0.37	0.42	0.40	0.41	0.38	0.01

a, b, c Means in the same row with different superscripts are significantly different (P<0.05). SEM = Standard Error of mean.

Internal egg characteristics: Significant differences occurred in the internal egg quality measurements as a result of feeding raw or processed PSM diets to point of lay (POL) pullets (Table 5). Birds fed raw and toasted PSM diets laid eggs with significantly (P<0.05) higher albumen height than those eggs laid by birds fed boiled, soaked PSM or control diets. Yolk height of eggs produced by layers fed the treatment diets did not significantly (P>0.05) differ from each other, except that layers fed the toasted PSM diet had eggs with a significantly (P<0.05) higher yolk height than the rest of the treatments. Albumen weight had the same trend as albumen height. Yolk weight of the eggs laid by the birds fed the raw, processed PSM or control diets was not significantly different (P>0.05) from each other, while yolk index of eggs laid birds fed toasted PSM diet was significantly (P<0.05) higher than the rest. Albumen + yolk weight was not significantly (P>0.05) different between eggs laid by layers fed raw and toasted, boiled and control diets and between soaked and control diets, while eggs produced by birds fed soaked PSM diets had a significantly (P<0.05) lower albumen + yolk weight than eggs from birds fed raw, toasted and boiled PSM diets. For Haugh unit, the only significant (P<0.05) difference was that eggs laid by layers fed toasted PSM diet had significantly (P<0.05) higher Haugh unit than eggs laid by birds fed boiled PSM diets.

Discussion

Performance: The feeding of raw or processed PSM diets to point of lay pullets affected daily feed intake and FCR of the layers. Toasted PSM diet caused a reduction in average daily feed consumption more than any other diet and did not compare favourably with the control diet. The higher intake of raw and soaked PSM diets may have been an attempt for the layers to meet their nutrient requirement from a diet that contained antinutritional substances as has been the experience with broilers (Amaefule and Onwudike, 2000; Amaefule and Obioha, 2001). The feed intake of layers fed raw PSM diet was higher than that reported by Udedibie and Igwe (1989) and Agwunobi (2000). Raw or processed PSM diets increased feed conversion ratio (FCR), with the highest increase from layers fed soaked PSM diet. This was attributed to the higher feed intake of layers fed raw or processed PSM diets without concomitant increase in egg production.

Average hen-housed production (HHP) and hen-day production (HDP) dropped after reaching the first peak at 2nd month of lay (Fig. 1) probably due to continued adjustment of the layers to the PSM diets, especially when compared with the production of layers fed control diet that had a different production pattern.

The feeding of raw or processed PSM diets to point of lay pullets increased the age at first egg lay (sexual maturity) over the age attained by birds fed control diet by about 16 days. This period may have been an adjustment time to a diet containing 30% PSM that could have caused upsets and alterations in the metabolic processes of the birds. This age of sexual maturity

Table 5: Effect of feeding raw or processed PSM based diets to point of lay pullets on internal egg quality

Parameters	Control	Raw	Boiled	Toasted	Soaked	SEM
Albumen height (mm)	9.78[b]	11.77[a]	9.73[b]	11.87[a]	9.23[b]	0.226
Yolk height (mm)	19.13[b]	18.47[b]	19.23[b]	20.50[a]	18.57[b]	0.281
Albumen weight (g)	36.65[b]	45.50[a]	36.77[b]	45.80[a]	34.63[b]	0.694
Yolk weight (g)	14.25	15.60	15.50	14.63	14.67	0.429
Yolk diameter (mm)	42.53[a]	39. 07[c]	41. 97[a]	39. 00[c]	40.03[b]	0.261
Yolk index	0.45[c]	0. 47[b]	0. 46[bc]	0. 53[a]	0.46[bc]	0.006
Albumen + yolk weight (g)	50.88[bc]	60.43[a]	52.27[b]	61.60[a]	49.30[c]	0.537
Haugh unit	98.73[ab]	105.27[ab]	96.10[b]	123.63[a]	97.87[ab]	8.228
USDA Quality Score	AA	AA	AA	AA	AA	-

a, b, c Means in the same row with different superscripts are significantly different (P<0.05). SEM = Standard Error of mean.

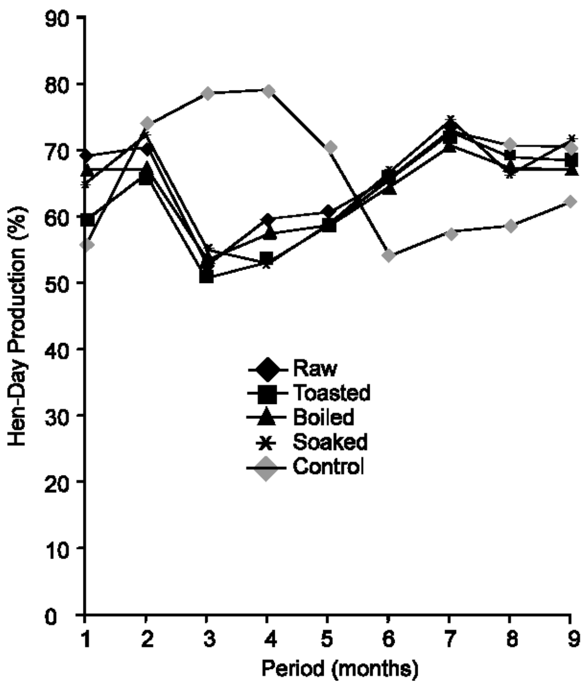

Fig. 1: Average hen-day production of layers fed raw or processed PSM diets from point of lay [POL] stage of life.

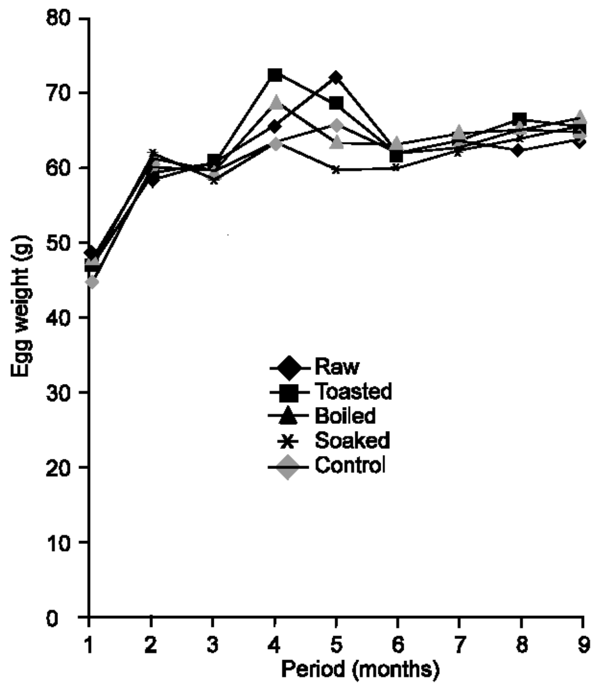

Fig. 2: Average weight of eggs laid by layers fed raw or processed PSM diets from point of lay [POL] stage of life.

agrees with the report of Hocking (1993) with broiler breeders and is lower than that of Elzubeir and Mohammed (1993) with commercial egg-type pullets. Raw or processed PSM diets also increased age at 25 and 50% egg production of layers over those fed the control diet and this was attributed to and bears relationship with age at sexual maturity (Shanawany, 1983). It was noticed that the processed PSM diets had no obvious advantage over raw PSM diet in the general performance of the layers when fed from pullet point of lay.

External egg characteristics: The feeding of PSM diets to pullets from POL affected all external egg quality measurements except shell thickness. The reduction in egg weight as a result of feeding soaked PSM diet to layers (Fig. 2) was not a surprise considering performance results obtained with pullets in an earlier study (Amaefule *et al.*, 2006), but the egg weight as a result of raw or toasted PSM diet was a surprise. It was expected that the antinutritional substances in the raw PSM diet would adversely affect egg weight as reported by Udedibie and Igwe (1989) and Agwunobi (2000). The increase in egg weight between the 3rd and 4th month of lay (Fig. 2) is in agreement with the observations of Jackson *et al.* (1987) and Awosanya *et al.* (1998) and could have been due to increased quantity of shell deposited on the egg as the hen ages (Jackson *et al.*, 1987) and an increase in yolk: albumen ratio as the layers increase in age (Awosanya *et al.*, 1998). The higher egg width and length by layers fed raw or toasted PSM diets may have been due to bigger egg size, while the lower shape index of eggs produced by layers fed raw PSM diet resulted from the relationship between egg width and egg length. Generally, the egg shape indices were considered normal and in agreement with the report of Ayanwale and Gado (2001) but slightly lower than that reported by Olerede and Longe (2000). Toasted PSM significantly decreased shell weight more than any other diet except the control diet, which makes it difficult to attribute it to the ineffectiveness of toasting to remove antinutritional substances in toasted PSM diet. Therefore the comparable shell weight of eggs laid by birds fed raw PSM diet with others and the reduction in shell weight as a result of feeding toasted PSM diet could be due to other factors unknown to the researcher. It was also observed that the feeding of PSM diets to layers from POL did not affect shell thickness.

Internal egg characteristics: PSM diets fed to POL pullets significantly influenced albumen height and weight, yolk height, albumen + yolk weight and Haugh unit. Yolk weight was unaffected. The higher albumen height and weight of eggs laid by layers fed raw and toasted PSM diets could be associated with the bigger eggs produced by these layers (Table 5) and this resulted in a corresponding higher albumen + yolk weight. Layers fed raw PSM diet laid eggs with the highest Haugh unit, which was similar to those of eggs from layers fed toasted, soaked and control diets. This could be attributed to unknown factors. The higher values of albumen height, albumen weight, yolk height, yolk weight and Haugh unit recorded in this study may be attributed to hybrid characteristics and the fact that the evaluation of the eggs' internal qualities were done when the eggs were fresh, not stored and had not undergone any changes in their internal constituents.

Conclusion: The conclusion was that raw or processed pigeon pea meal (PSM) could constitute 30% of the whole diet of point of lay pullets receiving PSM diet for the first time. Layers fed toasted PSM diet produced eggs with better external and internal egg quality characteristics than those fed boiled, soaked and control diets.

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