ISSN 0189-0514
J. Anim. Prod. Res. (2018) 30(2):56-68

National Animal Production Research Institute
Ahmadu Bello University
P.M.B 1096, Shika-Zaria,
Kaduna State, Nigeria.
Email:japr@napri.gov.ng Url:journals.napri.gov.ng

EFFECTS OF DIETARY CASSAVA PEEL MEAL INCLUSION AND STORAGE DURATION ON INTERNAL AND EXTERNAL CHARACTERISTICS OF CHICKENS' EGG

[*1]Ogunwole, O. A., [2]Samireddypalle, A., [1]Awoyemi, E. I. and [1]Mosuro, A. O.
[1]Agricultural Biochemistry & Nutrition Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria
[2]International Livestock Research Institute, c/o International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria
[*]Corresponding authors E-mail: droaogunwole@gmail.com

ABSTRACT

Effect of dietary cassava peel meal on internal and external quality of chicken egg during storage was evaluated. Isa Brown layers (n=2400), aged 36 weeks were randomly allotted to two dietary treatments each having 1200 birds each. Control group was fed standard corn-soya diets while treatment group which contained 5% cassava peel mash was fed with water ad libitum. At week 6 of feeding, eggs (n=150) were randomly collected from each treatment, stored at ambient conditions and assessed for internal and external quality characteristics at days 0, 7, 14, 21 and 28 of egg storage The experiment was a 2×5 factorial arrangement in a completely randomised design. Effect of dietary cassava peel was not significant (P>0.05) on all egg external quality indices. There was decreased egg weight (66.90±4.54 to 56.87±5.56), shell thickness (0.58±0.09 to 0.34±0.03), yolk height (17.63±1.50 to 6.68±1.05), albumen height (6.99±1.95 to 3.15±0.35) Haugh unit (70.03±10.48 to 55.73±7.44), yolk index (0.44±0.05 to 0.12±0.03) and yolk diameter (40.19±1.55 to 54.54±2.55) in days of storage (DOS). Interaction of DOS and diets significantly influenced (P<0.05) egg weight, length, shell thickness, yolk height, yolk index and Haugh unit. Most eggs external attributes were not affected by dietary cassava peel mash while most internal qualities reductions during storage were due to dietary CPM.

Keywords: Egg quality indices, Egg weight, Haugh unit, Isa brown, Yolk index

INTRODUCTION

Poultry and products are regarded as one of the most veritable source of animal protein to wit the ever rising future global demand. This assertion stemmed from the ever rising world population and the need for an expansible and highly productive stock (PM note, 2013). Poultry however, requires adequate feed supply. In fact, over 70% of the cost of poultry production is adduced to feed. Maize, being the most important feed ingredient is increasingly becoming unavailable due to food-feed competition between human and animal, seasonal fluctuation and economic instability. These have detrimental effects on poultry production especially egg production in which its expansion in Nigeria has been reported to slow down from 4 percent to 2.5 percent due to high input cost (FAO, 2011). This has further intensified the drive for alternative ingredient to maize in poultry feed.

Cassava has been advocated as an ideal feed ingredient to replace maize because it is a high energy crop available throughout the year in Nigeria (Okoli, 2008) which will go a long way in solving the problem associated with seasonal fluctuation and high cost of maize especially, in Nigeria (Ukachukwu 2005). However, due to

the cassava transformation that is underway in Africa which has transformed the traditional cassava to a high yield cash crop, there is increased demand for cassava for food, starch, livestock feed and ethanol production (FAO 2005). The greater demand for cassava tubers by local industries coupled with high demand for cassava chips outside the country has led to an increment in price from N10, 000 per tonne in 2012 to N25, 000 per tonne in 2013. All these point to the fact that there will be an increase in demand for cassava and its future availability for poultry use at economic price will be threatened. In addition, the explosive use of cassava in industries will increase the tonnes of waste generated which will increasingly pose disposal problem. One of the major wastes in the cassava industries is cassava peel.

Cassava peels constitute a substantial by-product of cassava being about 10-13 % of the total tuber weight. Most of the peels generated during processing are usually left to rot away on farms and homesteads (Akinfala and Tewe, 2004). The use of cassava peel as feed for non-ruminant animals is limited by its high fibre content (10-31.8%) low protein value (4.2-6.5%) and hydro-cyanic acid which are deleterious to their growth and development (Tewe, 2004). However, various processing techniques have reduced the cyanide level to the minimum with ensiling and fermentation reported as the best technique (Tewe and Kasali, 1986). Cassava peel, when fermented causes environmental pollution leading to foul odour, acid soil as a result of hydro cyanide present and sparse vegetation (Ubalua 2007). This can be diverted into poultry feeding thereby reducing its nuisance to the environment. Also, cassava peel is a waste product with little or no economic value therefore its successful incorporation into layers diet will give rise to new feed resource thereby decreasing the food-feed competition for cereal and feed cost reduction.

Studies (Tewe and Egbunike, 1992; Salami and Odunsi, 2003; Aderemi et al., 2006; Anaeto and Adighibe, 2011) have been on cassava root, cassava leaves, cassava sievate and cassava peels incorporated into poultry diets with various effects on performance and haematological indices with very scanty documentation on the effect on eggs produced by such chickens, particularly, when stored. This study was therefore conducted to evaluate and to provide more information on the physical quality of chicken eggs due to dietary cassava peel inclusion in layers diet during egg storage.

MATERIALS AND METHOD

Experimental location and animal allotment

The study was carried out at the International Institute of Tropical Agriculture (IITA) Farm, Ibadan, South West Nigeria and also at the Nutrition Unit, Department of Animal Science, University of Ibadan, Ibadan, Nigeria; within the geographical location of longitude 7.25º and latitude 53.4º. Isa Brown layers (n=2400), aged 36 weeks were randomly allotted to two dietary treatments of 1200 birds each. The control group was fed standard maize-soya based diets using conventional ingredients while treatment group which contained 5 % cassava peel mash was fed for six weeks to respective experimental birds.

Experimental diets

Two diets were compounded in this study. Diet 1 which had 55.5% maize was the control. However, in diet 2, the test ingredient which was the cassava peel meal was incorporated at 5% inclusion level to replace part of the dietary maize.

The fresh cassava peels sourced from neighbouring villages and Garri Processing Centres in Oyo State were collected and grated as described (Okike *et al*., 2015). They were then dewatered using hydraulic press and left overnight to ferment. The fermented cake was loosened, sieved and dried. Dried cassava peels were then used in the formulation of experimental diet. The composition of the

experimental diets has been earlier documented (Ogunwole et al., 2018) and details are shown in Table 1 below.

T1: Basal diet (No CPM)

T2: Basal diet + 5% cassava peel meal (5% CPM)

Table 1: Gross composition (%) of the experimental diets fed to pullets

Ingredient	Diet I (Control diet)	Diet II (Cassava peel meal-based diet)
Maize	55.5	50.5
Soya oil	1.70	1.70
Wheat middling	0.25	0.45
Soybean meal extraction	29.3	29.0
Cassava peels	-	5.00
Limestone	9.94	10.04
Salt	0.35	0.35
*Vitamin mineral premixToxin binder	0.300.09	0.300.09
DL Methionine	0.37	0.37
LysineAcidifier	0.100.20	0.100.20
Di calcium phosphate	1.90	1.90
Calculated nutrient	100	100
Crude protein (%)	17.5	17.1
Metabolizable Energy(MJ/Kg)	2753	2707

Source: Ogunwole *et al.* (2018)

* Vitamin and mineral Premix composition: Vitamin A, 200 000.00 IU, Vit. D3, 40 000.00 IU, Vitamin E (mg) 460, Vitamin K3 (mg) 40, Vitamin B1 (mg) 60, Vitamin B2 (mg) 120, Niacin (mg) 1 000, Calcium pantothenate (mg) 200, Vitamin B6 (mg) 100, Vitamin B12 (mg) 05, Folic acid (mg), 20, Biotin (mg) 1, Chlorine chloride (mg) 8 000, Manganese (mg) 2 400, Iron (mg) 2 000, Zinc (mg) 1 600 Copper (mg) 170, Iodine (mg) 30, Cobalt (mg) 6, Selenium (mg) 24, Anti-oxidant (mg) 2 400

Diet I: control diet (without cassava peel meal)

Diet II: cassava peel meal-based diet at inclusion level of 5%

Laying chickens management and egg sampling

Experimental birds were housed in cages and maintained under standard management practices with free access to feed and water. Also routine medication, vaccination and husbandry practices were administered according to Oluyemi and Roberts (2000). The design of the experiment was a completely randomized design in a 2 x 5 factorial arrangement.

At week 6 of feeding the experimental diet, a total of 150 eggs were randomly collected from each treatment group for analysis. The sampled eggs were stored at room temperature and the internal and external quality characteristics were determined at days 0, 7, 14, 21 and 28. Sampled eggs were properly labelled during storage. Analysis was carried out each week for the four weeks. A total of 15 eggs were randomly selected from each tray and analysed.

External egg quality determination

The egg weight is the weight of the whole egg and it was measured with Amput High Precision weighing balance. The length and width were measured using the digital Venier calliper. The egg shells were air dried for 24 hours after careful breaking and their weight were measured using the Amput High Precision weighing balance. Egg thickness was then measured with the micrometer screw guage. This was done by measuring the thickness at three point of the egg shell and their average determined.

Internal egg quality determination

Each egg was broken on a flat plate. The albumen height was measured using the tripod micrometer. The yolk was then separated from the albumen and the yolk weight was measured using the Amput High Precision weighing balance. Albumen weight was determined by deducting the egg weight from the yolk and shell weight. Yolk height and width were measured with the digital Venier calliper. Yolk colour was determined using the DSM colour fan. The egg yolk that was already separated from the albumen were placed on a plain white surface and examined under normal daylight. The DSM Colour fan was placed beside it and the intensity yolk colour that matched the yolk colour number was recorded.

The Haugh unit (Haugh 1937) is a measure of egg quality based on the height of albumen and egg weight and is calculated by using the formula given below:

$$HU = 100 \log (h+7.6-1.7w^{0.37})$$

Where, h = observed albumen height in mm

w = observed weight of the egg in g

Egg shape Index

The egg shape index was measured for each egg by using the egg width and length in the formula described by Reddy *et al.* (1979).

$$\text{Shape index} = \frac{\text{egg width}}{\text{egg length}}$$

Yolk index was determined using yolk height and width

$$\text{Yolk index} = \frac{\text{height of the yolk (cm)}}{\text{Diameter of the yolk (cm)}}$$

Statistical Analysis

Data were subjected to descriptive statistics, regression, T-test and the analysis of variance using SAS (2000). Means were separated by Duncan option of the same software at $\alpha_{0.05}$.

RESULTS AND DISCUSSION

Effect of cassava peel based diet on external and internal characteristics of egg collected from layers fed diets containing cassava peel

Effect of feeding cassava peel based diet on external and internal characteristics of chicken egg is shown in Table 2. Weight and width of eggs collected from laying hens on control (maize-based) diet were significantly higher ($P<0.05$) than those from cassava peel based diet. This was attributed to lower feed intake of layers on CPM-based diet. This conformed with the findings of Salami and Odunsi (2003) that birds have aversion to dietary CPM. Hammershog and Stenfeldt (2005) reported that decreased feed intake may lead to inadequate supply of amino acids, especially, if methionine intake was below requirement, the egg weight may drop.

Egg shell quality is an important egg quality parameter. This is because weak egg shell increases breakage which contributes to economic loss (Mazzuco and Bertechini, 2014). The thickness of the egg shell has been found to be related to egg shell strength (Roberts, 2004). Since the shell on a single egg contains up to 3 grams of calcium, adequate calcium supply in the feed is necessary. Egg shell weight and shell thickness was not significantly affected ($P<0.05$) by feeding

layer diets containing CPM. The similarity in shell thickness implied that the two dietary treatments were adequate in calcium and that dietary cassava peel at 5% inclusion did not interfere with calcium metabolism in the laying hens which confirmed earlier observations (Lawal 1992, Aderemi *et al.*, 2011). Shell thickness is also a function of the specific gravity as both are positively correlated (Oluyemi and Robberts 1979; Aderemi 2012); therefore dietary cassava peel had no depressing effect on the specific gravity of the egg.

The Haugh unit determines the quality of egg, calculated from albumen height. No significant difference (P<0.05) was observed in albumen height and the Haugh unit of eggs from hens fed both treatments. This contradicted the report of Oladunjoye *et al*. (2010) that Haugh unit was significantly affected (P<0.05) by feeding cassava peel meal. The insignificant difference (P<0.05) in values could be attributed to lower inclusion level of 5%, compared to 50% used by Oladunjoye *et al.* (2010). Yolk index is a measure of the spherical nature of yolk and is calculated from the yolk height. No significant difference (P<0.05) was observed for the yolk height and the yolk index of eggs collected from hens fed maize-based diet and the CPM diet. This conformed to earlier study of Oladunjoye *et al*. (2010) that cassava peel meal did not affect yolk index.

Table 2: Effect of cassava peel based diet on the external and internal quality of egg collected from layers

Parameter	**Diet**		**SEM**
	Control diet	**Cassava peel meal-based diet**	
Egg weight	61.8[a]	58.8[b]	0.496
Egg length	57.4	56.7	0.200
Egg width	44.6[a]	43.9[b]	0.117
Shell weight	6.39	6.37	0.005
Shell thickness	0.454	0.444	0.008
Yolk weight	17.6	17.2	0.123
Albumen weight	34.9[a]	32.4[b]	0.459
Yolk height	11.9	11.5	0.325
Albumen height	4.60	4.50	0.136
Yolk diameter	48.7	48.0	0.466
Yolk colour	5.87	6.19	0.125
Yolk index	0.255	0.254	0.009
Haugh unit	61.3	62.5	1.27

[a b] Means with different superscripts along the same row are significantly different (p<0.05)
SEM = Standard Error of Mean

Effect of storage duration on external and internal characteristics of eggs collected from layers fed diets containing cassava peel meal

Effect of duration of storage on external and internal qualities of egg collected from layers fed diets containing cassava peel are shown in Tables 3. There was also a noted significant decrease ($P<0.05$) in egg weight as the week of storage increases. This is in line with the studies of Jin *et al.* (2011) and Ogunwole *et al.* (2015; 2017) who reported egg weight losses with increasing days of storage. This was attributed to loss of humidity, water, carbon dioxide, ammonia and hydrogen sulphide from inside the egg due to evaporation effect. Shell weight significantly decreased ($P<0.05$) during egg storage. Weight of the shell is a constituent of the egg weight, therefore decrease in egg weight will reflect on the shell weight because moisture is lost from the shell first before the effect is transferred to the content (Jones *et al.*, 2002). This is because the shell is in contact with the atmosphere and so become drier and lighter.

The albumen height and the Haugh unit decreased significantly ($P<0.05$) with increased egg storage duration. The Haugh unit (52.51) was observed to fall in the grade of B (59-30) on day 21 of storage (Table 3). The desired standard grade AA is 100-72 or A 71-60. This was also observed for eggs of hens on dietary cassava peel meal (Table 5). These changes were results of the physical and chemical modification in the albumen which includes the thinning of the albumen thickness (Zemková *et al*., 2007), increase of albumen pH caused by loss of carbon dioxide from the egg through the pores in the shell and changes occurring in ovomucin (Toussant and Latshaw 1999). Walsh *et al*. (1995) also postulated that gaseous diffusion of CO_2 and O_2 from thick albumen storage resulted in reduced albumen height thereby corroborating observations in this study.

The Haugh unit was related to storage duration of eggs in Figure 1. The regression equation was

$y = 0.0051x^3 - 0.1303x^2 - 0.44x + 76.823$ ($R^2 = 0.75$)…… (1)

Yolk index and height was observed to reduce significantly ($P<0.05$) with increased duration of egg storage in both treatments. This conformed with observations that yolk index and yolk height reduced as the storage duration increased (Tabidi 2011; Ogunwole *et al*., 2015; 2017). The increased water content as a result of osmotic migration from the albumen to the yolk caused the flattening of the yolk thereby reducing the yolk height.

The yolk index was related to the duration of eggs storage in Figure 2. The graph clearly indicates a strong negative relationship which revealed that yolk index reduced with the storage duration.

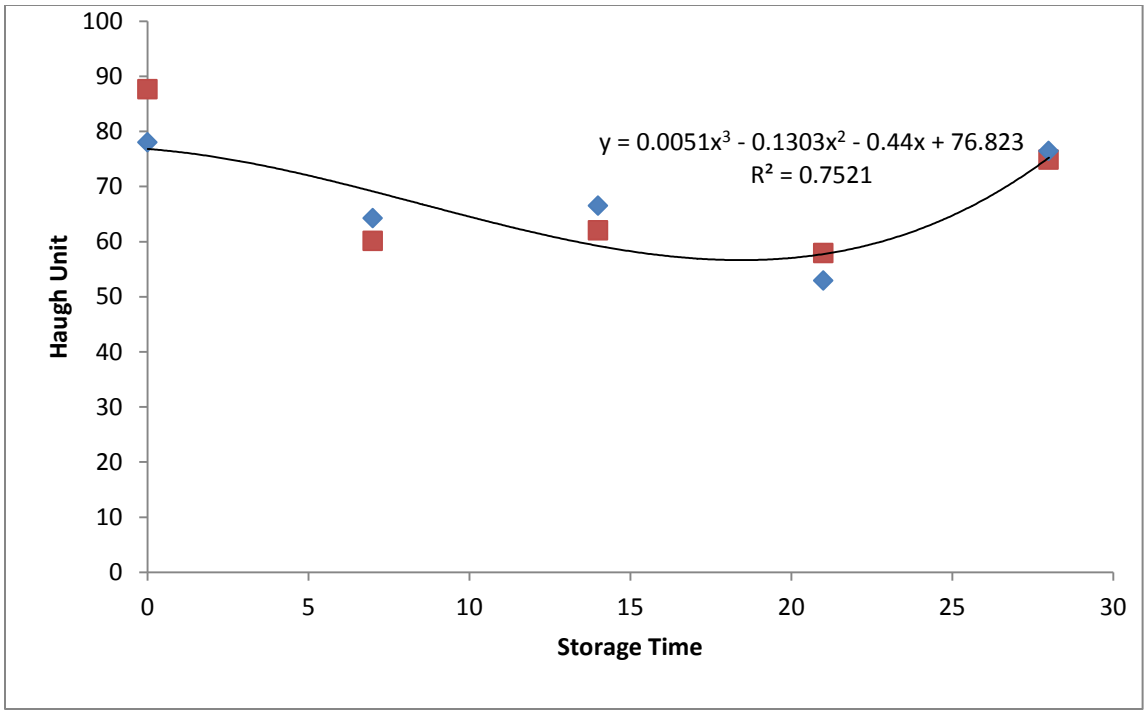
$y = -2E\text{-}05x^3 + 0.0012x^2 - 0.0266x + 0.4292$ ($R^2 = 0.99$)…… (2)

The yolk colour score of eggs from hens fed diets with CPM diets reduced significantly ($P<0.05$) during storage. Oladunjoye *et al.* (2010) earlier observed a reduction in yolk colour score which was attributed to less pigmentation of cassava peel.

Table 3: Effect of duration of storage on the external qualities of egg collected from layers fed diets containing cassava peel meal

	Days of Egg Storage					
Egg quality Indices	**0**	**7**	**14**	**21**	**28**	**SEM**
External quality						
Egg weight	66.9^{a}	61.0^{b}	59.2^{bc}	57.50^{c}	56.9^{c}	0.50
Egg length	58.3^{a}	56.6^{b}	56.9^{b}	57.03^{b}	56.4^{b}	0.19
Egg width	44.7^{a}	44.1^{ab}	44.2^{ab}	43.91^{b}	44.3^{ab}	0.12
Shell weight	6.83^{a}	6.13^{b}	6.37^{b}	6.20^{b}	6.37^{b}	0.05
Shell thickness	0.58^{a}	0.44^{b}	0.46^{b}	0.42^{c}	0.34^{d}	0.01
Egg shape index	0.77	0.78	0.78	0.78	0.79	0.003
Internal quality						
Albumen weight	39.4^{a}	35.0^{b}	31.9	30.9^{c}	31.0^{c}	0.46
Albumen height	6.99 ^{a}	4.19^{b}	4.39^{b}	3.77^{bc}	3.15^{c}	0.14
Haugh unit	70.0^{a}	70.3^{a}	61.1^{b}	52.5^{c}	55.7^{c}	1.27
Yolk weight	16.8^{c}	17.1^{bc}	17.4^{abc}	17.9^{a}	17.7^{ab}	0.12
Yolk height	17.6^{a}	13.9^{b}	10.8^{c}	9.56^{d}	6.68^{e}	0.46
Yolk diameter	40.2^{e}	45.7^{d}	49.7^{c}	51.8^{b}	54.5^{a}	0.14
Yolk colour	7.10^{a}	5.63^{b}	5.63^{b}	5.93^{b}	5.83^{b}	0.13
Yolk index	0.44^{a}	0.30^{b}	0.21^{c}	0.19^{d}	0.12^{e}	0.001

$^{a, b, c,}$ Means with different superscripts along the same row are significantly different ($p<0.05$)
DOS: Days of storage; SEM: Standard error of mean



A.

Figure 1: Effect of duration of storage on the Haugh unit of eggs from hens fed diets containing cassava peel

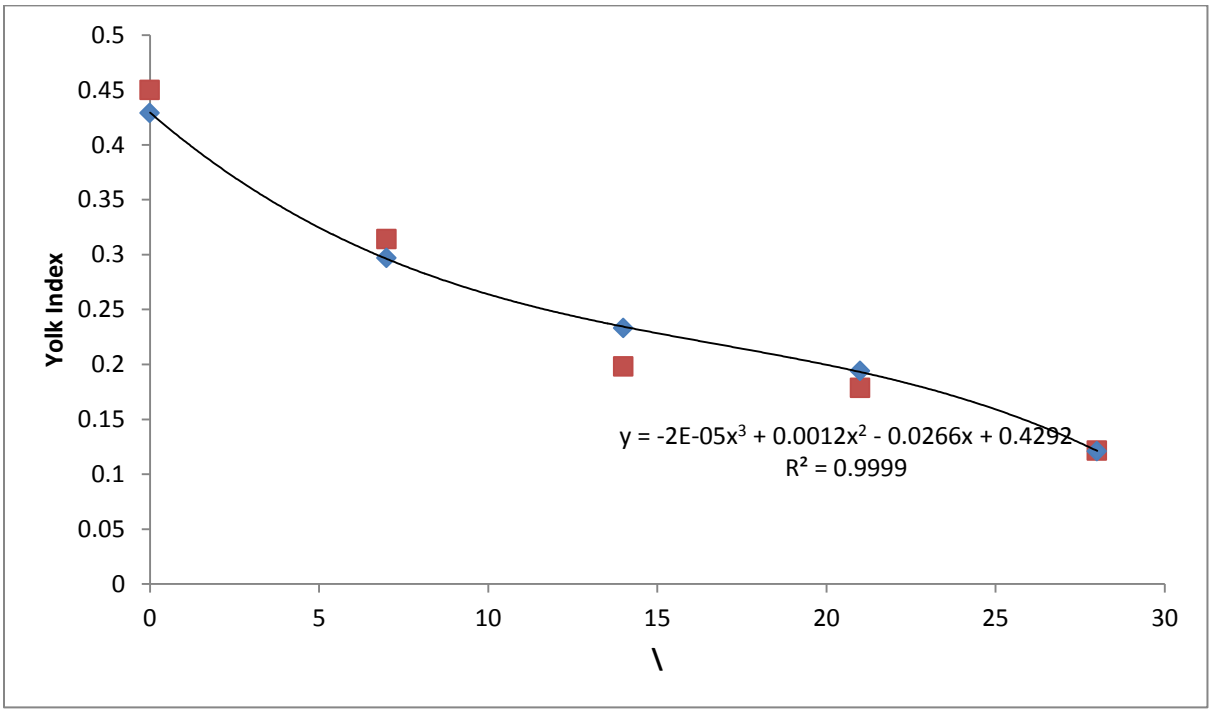


Figure 2: Effect of duration of storage on the yolk index of eggs collected from chickens fed dietary cassava peel

Effect of Interaction of dietary cassava peels and eggs storage duration on external and internal quality of eggs

Effects of interaction of dietary cassava peels and duration of eggs storage on external quality of eggs from layers on diets containing cassava peel is shown in Tables 4. Effect of interaction of diets and the duration of eggs storage on egg diameter, shell weight and egg shape index during storage were not significantly different (P>0.05). There was also no significant difference (P>0.05) due to interaction of days of storage and diets on shell weight. This implied that dietary CPM did not affect the shell weight as the duration of storage increased.

Effect of interaction of diets and storage duration on internal egg quality attributes is shown in Table 5. The yolk weight, yolk colour, albumen weight and albumen height were not significantly affected (P>0.05) by the interaction of diets and storage duration. However, yolk index and Haugh unit which are measures of egg freshness both diminished significantly (P<0.05) due to interaction of diets and storage duration. This observation was analogous to those earlier documented for egg (Tabidi, 2011; Ogunwole et al., 2015; Ogunwole et al., 2017)

Table 4: Effect of interaction of dietary cassava peel and duration of egg storage on external quality characteristics of eggs

		Parameters					
	Days of egg storage	**Egg weight**	**Egg length**	**Egg diameter**	**Shell weight**	**Shell thickness**	**Egg shape Index**
Diet I	0	67.4^{ap}	58.1^{ap}	45.1	7.00	0.608^{ap}	0.773
	7	62.4^{aq}	57.8^{apq}	44.2	6.13	0.441^{aq}	0.764
	14	59.3^{aq}	56.5^{apq}	44.2	6.27	0.447^{aq}	0.779
	21	59.7^{aq}	56.8^{apq}	44.3	6.27	0.441^{aq}	0.774
	28	60.3^{aq}	57.5^{apq}	45.1	6.27	0.333^{ar}	0.785
	SEM	0.613	0.251	0.148	0.08	0.012	0.004
	0	66.4^{ap}	58.5^{ap}	44.3	6.67	0.553^{ap}	0.757
Diet II	7	59.6^{aq}	57.4^{apq}	44.0	6.13	0.449^{aq}	0.797
	14	59.1^{aq}	57.2^{apq}	43.5	6.47	0.469^{aq}	0.775
	21	55.3^{br}	57.2^{apq}	43.6	6.13	0.469^{aq}	0.790
	28	53.4^{br}	55.4^{br}	44.3	6.15	0.351^{ar}	0.757
	SEM	0.743	0.310	0.173	0.073	0.01	0.005
Source of Variation (P-value)	Diets	0.096	0.0002	0.004	<0.001	0.024	<0.001
	Diet I × Storage	0.036	0.0002	0.015	<0.001	<0.001	<0.001
	Diet II × storage	0.096	0.002	0.004	<0.001	<0.001	<0.001
	Diets I, II × Storage	0.0036	0.002	0.015	<0.001	<0.001	<0.001

a, b,c,p,q,r… Means with different superscripts along the same row are significantly different ($p < 0.05$)
Diet I: Maize-soybean diet
Diet II: Cassava Peel Mash
SEM: Standard error of mean

Table 5: Effect of interaction of diets and duration of egg storage on internal egg quality characteristics

	Duration of storage	Yolk weight	Yolk height	Yolk diameter	Yolk colour	Yolk index	Albumen weight	Albumen height	Haugh unit
Diet I	0	16.9	17.3^{ap}	40.66	6.60	0.429^{ap}	40.0	6.67	78.0^{bp}
	7	17.6	13.8^{aq}	40.6	5.27	0.297^{aq}	35.7	4.75	64.2^{aq}
	14	17.0	11.4^{ar}	49.3	5.87	0.233^{ar}	33.4	4.80	66.5^{aq}
	21	18.1	9.96^{as}	51.8	5.87	0.194^{bs}	32.2	3.56	52.9^{ar}
	28	18.1	6.84^{at}	55.4	5.77	0.121^{bt}	33.2	3.28	44.9^{as}
	SEM	0.183	0.441	0.647	0.160	0.013	0.635	0.171	1.65
Diet II	0	16.6	17.9^{ap}	39.7	7.60	0.450^{ap}	38.87	7.00	87.9^{ap}
	7	16.6	14.0^{aq}	44.7	6.00	0.314^{aq}	34.3	4.20	60.10^{aq}
	14	18.1	10.1^{ar}	50.6	5.40	0.198^{bs}	30.4	4.39	62.0^{aq}
	21	17.7	9.17^{as}	51.8	6.00	0.179^{bs}	29.5	3.77	57.9^{aq}
	28	17.7	6.52^{at}	53.6	5.93	0.121^{bt}	28.7	3.48	44.9^{as}
	SEM	0.163	0.481	0.671	0.191	0.014	0.634	0.213	1.94
Source of variation (p-value)	Diet	<0.0001	0.0002	0.0001	<0.0001	<0.0001	0.0204	0.0001	0.065
	Diet I× storage	<0.0001	0.0002	0.0001	<0.0001	0.646	0.0204	<0.0001	0.065
	Diet II× storage	0.0046	0.0019	0.0017	0.0024	<0.0001	0.326	0.0040	0.062
	Diet I×II ×Storage	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.020	0.0001	<0.0001

a,b,c,p,q,r… Means with different superscripts along the same row are significantly different ($p < 0.05$)
Diet I: Maize-soybean diet
Diet II: Cassava
Peel Mash
DOS: Duration of storage

CONCLUSION AND RECOMMENDATION

Most egg external attributes were not affected by dietary cassava peel mash. Conversely, there were reduced egg and albumen weights. Therefore cassava peel meal could successfully replace maize at 5% in layers diet without compromising the internal quality of eggs. The quality of chicken eggs from layers fed 5% CPM fell below desired grade AA after day 7 of storage at room temperature. Alternative methods should therefore be considered for storing excess eggs produced to enhance freshness retention.

REFERENCES

Aderemi, F. A., O. M. Alabi and Lawal, T. E. (2006). Utilization of whole cassava meal by egg laying type chicken. Proceedings of the 11th Annual Conference Animal Science Association Nigeria, September 18-21, 2006, IAR and T, Ibadan, Nigeria, pp: 73-75.

Aderemi, F. A., Adenowo, T. K., Oguntunji, A. O. (2012). Effect of whole cassava meal on performance and egg quality characteristics of layers. *Journal of Agricultural Science* 4(2):195-200. doi:10.5539/jas.v4n2p195 URL:http://dx.doi.org/10.5539/jas.v4n2p195

Akinfala, E. O. and Tewe, O. O. (2004). Supplemental effects of feed additives on the utilization of whole cassava plant by growing pigs in the tropics; *Livestock Research for Rural Development.* Vol. 16, Art. #82. Retrieved August 24, 2016. http://www.lrrd.org/lrrd16/10/akin16082.htm

Anaeto, M. and Adighibe, L. C. (2011). Cassava Root Meal as Substitute for Maize in Layers Ration. *Brazilian Journal of Poultry Science.* 13(2):153-156 http://dx.doi.org/10.1590/s1516-635X2011000200010

FAO (Food and Agriculture Organization) (2005): A review of cassava in Africa with country case studies on Nigeria, Ghana, the United Republic of Tanzania, Uganda and Benin. Proceedings of the validation forum on the global cassava development strategy, volume 2. Food and Agriculture Organization of the United Nations Rome, Italy. Pp 1-66

FAO (2011) Food and Agriculture Organisation Statistics FAOstat. Food and Agricultural Commodities Production; Available online: http://faostat.fao.org/site/339/default.aspx

Hammershoj, M. and S. Stenfeldt (2005) Effect of blue lupin (*Lupinus angustifolius*) in organic layer diets and supplementation with foraging material on layer performance and some egg quality parameters. *Journal of Poultry Science*, 84 (5): 723-733. Doi:10.1093/ps/84.5.723

Haugh RR (1937) The Haugh units for measuring egg quality. U.S. Egg Poultry Management, 43: 552-555

Jin, Y. H., Lee K. T., Lee, W. I. and Han, Y. K. (2011). Effect of storage temperature and time on the quality of eggs from laying hens at peak of production. *Asian-Australian Journal of Animal Science.* Vol 24(2): 279-284 doi: http://dx.doi.org/10.5713/ajas.2011.10210

Jones, D. R., J. B. Tharrington, P. A. Curtis, K. E. Anderson, K. M. Keener and F. T. Jones (2002). Effects of cryogenic cooling of shell eggs on egg quality. *Journal of Poultry Science* 81:727–733.

Mazzuco, H. and Bertechini, A. G. (2014). Critical points on egg production: causes, importance and incidence of egg shell breakage and defects. (A review). *Ciência e Agrotecnologia* vol. 38(1)

Ogunwole, O. A., Ojelade, A. Y. P., Oyewo, M. O. and Essien, E. A. (2015). Proximate Composition and Physical Characteristics of Eggs from Laying Chickens Fed Different Proprietary Vitamin-Mineral Premixes Under Two Rearing Systems During Storage, *International Journal of*

Food Science and Nutrition Engineering, Vol. 5 No. 1, pp. 59-67. doi: 10.5923/j.food.20150501.08.

Ogunwole, O. A., Adesope, A. I., A. A. Raji and O. D. Oshibanjo (2017). Effect of partial replacement of dietary maize with cassava peel meal on egg quality characteristics of chicken during storage. *Nigerian Journal of Animal Science*, 19 (2): 140-152

Ogunwole, O. A., Samireddypalle, A., Daramola, T. B. Mosuro, O. A. and O. D. Oshibanjo (2018). Effects of dietary inclusion of cassava peel meal on functional properties of chicken egg in duration of storage. *Journal of Agroalimentary Processes and Technologies*, 24(3): 177-184

Okike, I., Samireddypalle, A., Kaptoge, L. Fauquet, C., Atehnkeng, J. Bandyopadhyay, R., Kulakow, P., Duncan, A., Alabi, T. and Blummel, M. (2015). Technical innovations for small-scale producers and households to process wet cassava peels into high quality animal feed ingredients and aflasafe™ substrate. *Food Chain* 5:1-2. http://*www.developmentbookshelf.com/doi/pdf/10.3362/2046-1887.2015.005*

Okoli, A. (2008). Nigeria now world's highest producer of cassava [cited 2008]. Available from: www.vanguardngr.com

Oladunjoye I O O Ojebiyi and O A Amao (2010) Effect of feeding processed cassava (*Manihot esculenta crantz*) peel meal based diet on the performance characteristics, egg quality and blood profile of laying chicken. *Agricultura tropica et subtropica* 43: 119-126. ISSN: 0231-5742

Oluyemi, J. A., Roberts, F. A. (1979). Poultry Production in Warm Wet Climate Macmillan Tropical Agriculture, *Horticulture and Applied Ecology series*, pg: 13-15

Oluyemi, J. A. and Roberts, F. A. 2000. Poultry Production in Warm Wet Climates. 2nd Edition. Spectrum Books Ltd, Ibadan, Nigeria. 244p.

PM note (2013). Poultry Production and Management: Veterinary & Nutritional Aspects-Protein Enhancement to Help Combat Hunger at the Hebrew University of Jerusalem, Israel (HUJI) 8 April to 2 May.

Reddy, P. M., V. R. Reddy, C. V. Reddy, S. P. Rap (1979). Egg weight, shape index and hatchability in khaki Campbell duck egg. I*ndian Journal of Poultry* Science 14**,** 26-31.

Roberts Juliet, R. (2004). Factors affecting egg internal quality and egg shell quality in laying hens (A review). *Journal of Poultry Science*, 41 (3):161-177 http:doi.org/10.2141/jpsa.41.161

Salami, R. I. and Odunsi, A. A. (2003). Evaluation of Processed Cassava Peel Meals as substitutes for maize in the diets of Layers. *International Journal of Poultry Science* 2 (2): 112-116. Doi: 10.3923/ijps.2003.112.116 URL:http://scialert.net/abstract/?doi=ijps.2003.112.116

SAS (2000). SAS User's Guide: Statistics. 8th Edn., SAS Institute Inc., Cary, NC., USA.

Tabidi, M. H. (2011) Impact of storage period and quality on composition of table egg. *Advanced Environmental Biology*, 5:856-861.

Tewe O O (2004). Cassava for livestock feed in sub-saharan Africa. Global cassava development strategy. Plant Production and Protection Division, Food and Agricultural Organization and International Fund for Agricultural Development Rome, Italy.

Tewe O O and Egbunike G N (1992) Utilization of Cassava in non-ruminant livestock feeds.

Cassava as livestock feed in Africa: Proceedings of the IITA/ILCA University. Workshop on the Potential Utilization of Cassava as Livestock Feed in Africa: 14-18 November 1988, Ibadan, Nigeria

Tewe O O Kasali O B N (1986) Effect of cassava peel processing on the nutrient utilization and physiopathology of the African giant rat (*Cricetomus gambianus*.

Water house). *Tropical. Agriculture. Trinidad*, 63 (2): 125–128.

Toussant, M. J., and J. D. Latshaw, 1999. Ovomucin content and composition in chicken eggs with different interior quality. *J. Sci. Food Agric*. 79:1666–1670.

Ubalua A O (2007) Cassava waste: treatment options and value addition alternatives. *African Journal of Biotechnology* vol. 6 (18): 2065-2073. ISSN 1684–5315 © 2007 Academic Journals. URL: http://www.academicjournals.org/AJB

Ukachukwu S N (2005) Studies on the nutritive value of composite cassava pellets for poultry: chemical composition and metabolizable energy. *Livestock Research for Rural Development;* 17(11) article # 125 http://www.lrrd.org/lrrd17/11/ukac17125.htm

Walsh T J, Rizk R E and Brake J **(**1995). Effects of temperature and carbon dioxide on albumen characteristics, weight loss and early embryonic mortality of long stored hatching eggs. *Poultry Science* 74: 1403-1410.

Zemková, L., M. Simeonovová, M. Lichovníková, K. Somerliková (2007): The effects of housing systems and age of hens on the weight and cholesterol concentration of the egg. *Czech Journal of Animal Science* 52, 110-11