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Effects of dietary inclusion of cassava peel meal on functional properties of chicken egg in duration of storage

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Abstract

Effect of dietary inclusion of cassava peel meal on functional properties of chicken eggs in days of storage was evaluated. Issa Brown layers (n=2400), aged 36 weeks were randomly allotted to two dietary treatments of 1200 birds each. Control (T1) was corn-soya diet while T2 had 5% corn replaced with cassava peel mash and were fed *ad libitum* to respective birds for six weeks. Eggs (n=150) were sampled, stored at ambient conditions and functional properties as well as lipid oxidation monitored at days 0, 7, 14, and 21. Bulk density (9.75±0.94-10.00±1.42), emulsion activity (51.83±1.00-52.00±1.41), lipid oxidation (0.91±0.14-0.96±0.06) increased while foaming capacity (15.17±5.78-4.17±4.26), foaming stability (8.00±6.63-3.75±2.72), water absorption capacity (1.53±0.78-1.441±0.89), water retention capacity (1.66±1.06-1.48±0.90), oil absorption capacity (1.39±0.89-1.38±0.93), oil retention capacity (0.99±0.74-1.16±0.73) decreased in days of storage (DOS). Interaction of DOS and diets affected (P<0.05) foaming capacity and stability of eggs. Dietary cassava peel meal enhanced foaming capacity and lipid oxidation in chicken eggs.

Keywords: Foaming capacity, Water retention capacity, Days of storage, Emulsion activity

1. Introduction

Cassava and cassava products could keep pace with increasing poultry production in terms of serving as alternatives to other scarce and often unavailable conventional energy feedstuff like maize and other cereals [9]. Cassava as energy source in poultry diets have been widely reported [1-3,5, 15, 37].

Cassava peels are agro-industrial by product of cassava production which is always abundant where cassava are processed into human foodstuff. They are generated from the two outer coverings of the cassava roots before processing into other products. Cassava peels poses a serious disposal problem particularly due to the increased production of cassava products in Nigeria [30]. Cassava peel is predominantly carbohydrate with low protein content [25] and could constitute an important feed resource if properly harnessed biotechnologically.

Dietary cassava peel when fed to starter and finisher broilers at levels of between 0 and 30 percent replacement of maize increased feed intake, reduced body weight gain, and reduced nutrient utilization [36]. Also, inclusion of up to 27% cassava peels at the expense of maize resulted in satisfactory feed intake, egg production and feed per unit egg produced [36]. It was noted that feed conversion was consistently more efficient with rations based on cassava peel compared with maize control.

Despite researches and emphases on performance of laying chickens when fed cassava based rations [4, 29], not much have been on effects of such diets on eggs characteristics and composition in days of storage. alterable

Internal egg component was reported alterable by poultry feeding practices) [4, 22, 23, 26, 34]. During storage, as the vitelline membrane degenerates,

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water enter the yolk causing mottling afterwards, albumen proteins also enters the yolk increasing the severity of mottling after prolonged storage [21]. Storage time was reported to affect the degree of egg yolk mottling [10]. Storage time is also one of the crucial factors which affect the severity of albumen quality [33]. In most parts of developing countries, table eggs are stored at ambient temperature until they are sold or consumed. Prolonged storage influences internal egg quality if the environment in the storage room is inadequate [38].

There have been reports [1-3,5, 15, 37] on effects of whole cassava meal and by products on performance of laying chickens without emphases on quality characteristics of eggs. Recent attempts at documenting effects of diets of chicken on egg characteristics in days of storage ended with the chemical composition [30] with, very scanty reports [1] on functional properties of egg white. Information on functional properties (emulsification, thickening, foaming and moisturizing) are of primal considerations and cardinal to egg use in industrial production of many human food products [13, 8]. Thus, the present endeavour was aimed at assessing the functional properties of eggs collected from chicken fed cassava peel meal based diets in days of storage

2. Materials and Methods

***Experimental sites and Experimental Birds*:** The study was carried out at the International Livestock Research Institute located inside the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and in Meat Science Laboratory, Department of Animal Science, University of Ibadan, Ibadan, Nigeria. The sites are within the geographical location of longitude 7.25^0 and latitude 53.74^0. Isa Brown layers (n=2,400) aged 36 weeks were randomly allotted to two dietary treatments of 1, 200 birds each.

Experimental diets: Cassava peels were sourced from villages and Gari processing unit in Oyo State. The fresh peels were collected and grated. The grated peel was de-watered using a hydraulic press, and left overnight. The fermented cake was sieved and dried. Two diets were formulated, the control diet which was a maize-soy based diet and the experimental diet which contained 5% cassava peel meal. The gross composition of diets is shown in Table 1

Birds' Management and Eggs collection: Experimental birds were in cages and were maintained under standard management practices with free access to experimental diets and water for 6 weeks. The control group was fed standard corn-soya diets while treatment group had its corn content replaced with 5% cassava peel meal At week 42, 150 eggs were randomly collected from each treatment and were kept in ambient condition until analysed.

***Functional Properties determination*:** At the day of egg sampling (which corresponds to 0 day of storage) a total of 15 eggs per treatment were randomly selected from sampled eggs and analysed. Eggs were homogenized and oven dried at 60^0C for 48 hours. The process was repeated at days 7, 14, and 21. The foaming capacity and stability were determined using the method of Coofman and Garcia (1977) [41]. Emulsion activity was determined with the method of Damodaran S. (2005) [12]. Bulk density was according to Narayana and Narasinga (1984) [42] while water and oil absorption/retention capacities were determined using the method of Sefa-Dedeh *et al*. (2004) [40].

Statistical Analysis: Data were subjected to descriptive statistics, regression and T-test using by SAS (2000) software.

3. Results

***Effect of dietary inclusion of cassava peel on functional properties of chicken eggs*:** The effect of partial replacement of maize with cassava peel meal (CPM) in diets for layers on functional properties of chicken eggs is shown in Table 2. There was no significant difference (P>0.05) in bulk density and emulsion activity of the control (maize-based) and experimental (cassava peel meal based) diets. Foaming capacity however, differed significantly (P<0.05) with treatments. Eggs collected from layers fed experimental diet had significantly higher (P<0.05) foaming capacity (%) (14.92) compared with those on control diet (12.50). Foaming stability of eggs from layers on control (maize-based) and experimental (cassava peel based) diets was similar (p>0.05). Also, there was no significant difference in water absorption capacity and water retention capacity (P>0.05) between the control (maize-based) and experimental (cassava peel meal based) diets. Oil absorption capacity and oil retention capacity of eggs were not affected significantly (P>0.05) by treatments.

Table 1. Gross composition of the Experimental diet (%) fed to layers

Ingredients	**Control**	**Experiment (CPM)**
Maize	55.50	50.50
Soya oil	1.70	1.70
Wheat middling	0.25	0.45
Soybean meal extraction	29.3	29.00
Cassava peel meal	0.00	5.00
Limestone	9.94	10.04
Salt	0.35	0.35
Vitamin-mineral premix and amino acid (lysine and methionine)	1.06	1.06
Dicalcium phosphate	1.90	1.90
Total	100	100
Calculated composition		
Crude Protein (%)	17.50	17.10
Metabolizable Energy (MJ/Kg)	2753	2707

*Premix composition: Vitamin A, 200 000.00 IU, Vit. D3, 40 000.00 IU, Vitamin E (mg) 460, Vitamin K3 (kg) 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.

Table 2. Effect of dietary inclusion of cassava peel for layers on functional properties of eggs

Parameter	**Control**	**Experiment**	**SEM**
Bulk density (g/mL)	9.125	10.127	0.315
Emulsion activity (%)	52.500	52.833	0.398
Foaming capacity (%)	12.500^{b}	14.917^{a}	1.447
Foaming stability	7.542	7.833	1.197
Water absorption capacity (g)	1.360	1.348	0.146
Water retention capacity (g)	1.300	1.320	0.177
Oil absorption capacity (g)	1.467	1.264	0.166
Oil retention capacity (g)	1.096	1.154	0.155

Means along the same rows with different superscripts are significantly different (p<0.05)

Effect of duration of storage on the functional properties of chicken eggs: **Ef**fect of feeding cassava peel meal based diets to layers on eggs functional properties in days of storage is shown in Table 2. At day 7 of storage, bulk density was significantly lowered (P<0.05) (8.253g/ml) compared with those at days 0, 14 and 21. The bulk density of eggs at day 14 was significantly higher (10.500g/mL) (P>0.05) compared with days 0 and 21. Emulsion activity (%) was higher (P<0.05) at 14 (54.833) compared with 0 (51.83), 7 (52.00) and 21(52.00) DOS. Emulsion activity (%) of egg at day 0 was lower (51.833) and similar (P>0.05) to values at 7 and 21 DOS.

Foaming capacity was not affected significantly (P>0.05) in DOS of chicken eggs. Foaming stability was higher (P<0.05) (10.00) at 14 DOS, compared with 0 and 21 DOS. Egg foaming stability at day 21 was lower (3.750) and differed (P<0.05) from values obtained at 0, 7 and 21 DOS. Water absorption, water retention capacity, oil absorption and retention capacity of chicken eggs were not affected in DOS**.**

Table 3. Effects of duration of storage on the functional properties of chicken eggs

Parameter	**0 Day**	**7 days**	**14 days**	**21 days**	**SEM**
Bulk density (g/mL)	9.750[a]	8.253[b]	10.500[a]	10.000[a]	0.315
Emulsion activity (%)	51.833[b]	52.000[b]	54.833[a]	52.000[b]	0.398
Foaming capacity (%)	15.167	20.000	15.500	4.167	1.447
Foaming stability	8.000[b]	9.000[ab]	10.000[a]	3.750[c]	1.197
Water absorption capacity (g)	1.527	1.242	1.206	1.441	0.146
Water retention capacity (g)	1.660	1.292	0.805	1.483	0.177
Oil absorption capacity (g)	1.385	1.335	1.361	1.382	0.166
Oil retention capacity (g)	0.991	1.405	0.946	1.159	0.155

Means along the same rows with different superscripts are significantly different ($p<0.05$)

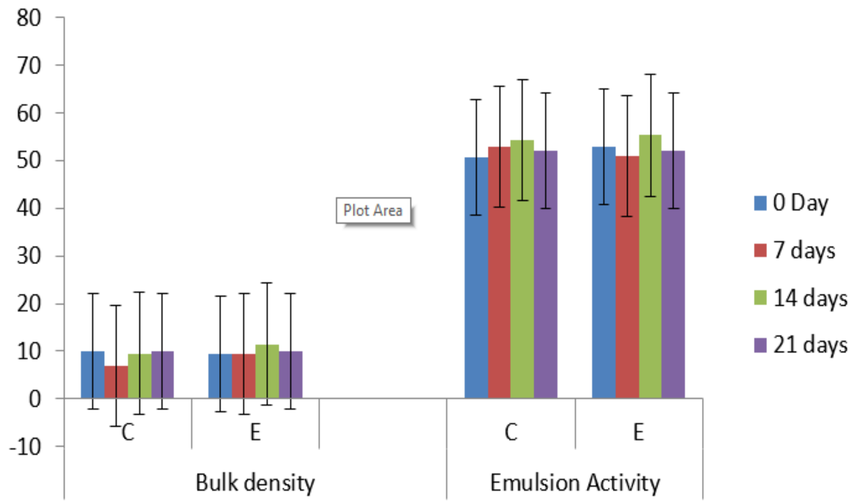

Figure 1. Effects of interaction of diets based on cassava peal meal and duration of storage on bulk density and emulsion activity chicken eggs

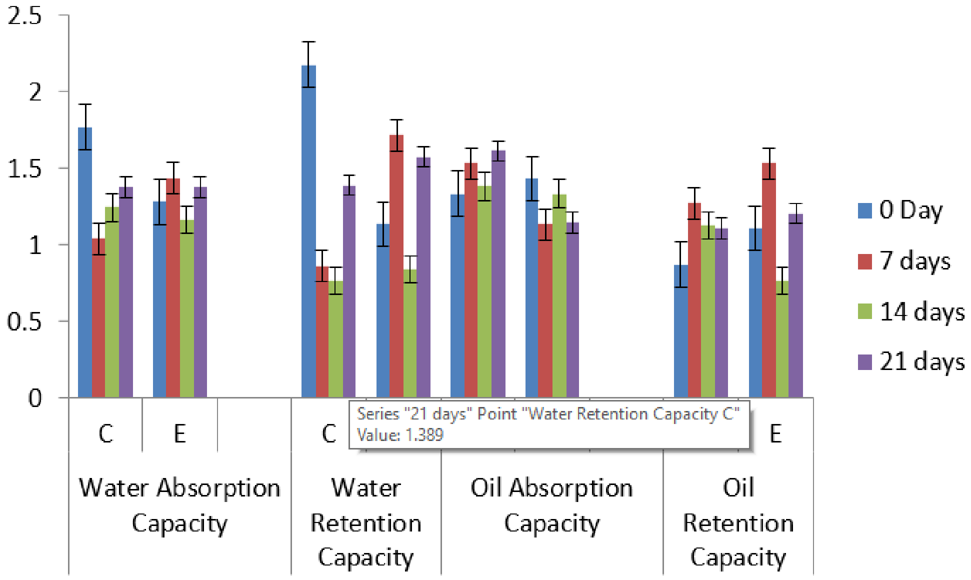

Figure 2. Effects of interaction of diets based on cassava peal meal and duration of storage on water/oil absorption and retention capacity of chicken eggs

Table 4. Effects of interaction of diets based on cassava peal meal and duration of storage on foaming capacity and stability of chicken eggs

Parameters	Duration of Storage	Diets	
		Control	Experiment
Foaming Capacity	0	10.00bC	20.33aA
	7	20.00aA	20.00 aA
	14	12.00bB	19.00 aA
	21	08.00aD	00.33 bB
	SEM	1.395	2.557
Foaming stability	0	02.00bC	14.00 aA
	7	16.00aA	02.00 bB
	14	06.00bB	14.00 aA
	21	06.17aB	01.33 bB
	SEM	1.573	1.874

Effects of interaction of cassava peal meal based diets and duration of storage on functional properties of chicken eggs: Effect of interaction of diets based on cassava peel meal and duration of storage on bulk density and emulsion activity of chicken eggs is shown in Figure 1. There was no significant effect (P>0.05) of interaction on bulk density and emulsion activity of chicken eggs.

Effect of interaction of diets based on cassava peel meal and duration of storage on water absorption and retention capacity of chicken eggs is shown in Figure 2. There was no significant (P>0.05) effects of interaction of diets in DOS on water absorption and retention capacities of chicken eggs. There was also, no significant effects (P>0.05) of interaction of diets and duration of storage on oil absorption and retention capacities of chicken eggs.

Effect of interaction of diets and DOS on foaming capacity and foaming stability of chicken eggs is shown in Table 4. In DOS, effects of interaction with diets on foaming capacity of eggs varied significantly (p<0.05). However, at seven DOS, there was no significant difference (P>0.05) in foaming capacity of eggs from hens on control diet (20.00) and those from experimental diet (20.00) (p>0.05). There was significantly lower (P<0.05) foaming capacity of stored eggs from hens on control diet at 21 (8.00%) DOS compared with those from experimental diets (0.33%).

There were significant differences (p<0.05) in foaming stability of eggs from the control and those of experimental diets in DOS. Also, there were significant differences (P<0.05) in foaming stability of eggs at 0 (2.00, 14.00) and 7 (16.00, 2.00) DOS for both eggs from control and experimental diets, respectively. Lower foaming stability of eggs was observed on 14 (6.00) and 21 (1.33) DOS, for hens fed control and experimental diets, respectively.

4. Discussion

Functional properties of chicken eggs: Eggs from hens fed the experimental diet (14.92) had higher foaming capacity (%) compared with those on control diet (12.50). Johnson and Zabik (1981) [21] showed that egg white globulins were responsible for egg foam formation. Egg white has good foaming properties due to the fact that all of its protein components; ovalbumin, ovotransferrin, lysozym, ovomucoid, and ovomucin as well as their interactions have different roles in foaming formation and stabilisation [6]. The ability of protein to form and stabilize foam is related to its ampiphilic behaviour (polar/non polar) [14]. Changes in nutritional properties of these egg proteins may result in detrimental changes in functional properties of egg white products [31]. In this study, foaming property was higher in experimental diet which obviously was due to inclusion of cassava peal meal in layers diet.

Cassava is reportedly high in carbohydrate, particularly, in the level of glucose [35-37]. It was documented ([16] that nutritional component of egg could be influenced by diet. Sucrose is known to have a positive effect on foaming attributes [12, 26, 32].

Foam stabilisation of proteins occurs due to their amphilic behaviour (polar/non-polar) [14]. Albumen has been identified as the egg protein based foaming or whipping agent in food industry [24]. The foaming properties of albumen are affected by several factors, such as protein concentration [7], composition [22], pH [18], heating, presence of salts, and composition of the liquid phase [14], which affects the formation of film and its properties on the interface, the behaviour of proteins on air-water interfaces influences the formation and stability of foam [14]. During storage, ovalbumin is altered to s-ovalbumin, an extra heat-stable form (denaturation at 92.5°C) in comparison to ovalbumin (denaturation at 84.0°C); pH and temperature also affect the s-albumin formation [43]. The conversion of ovalbumin to the extra stable form s-ovalbumin results from differences in the structure of covalent bonding [39].

As the pH increases, part of the egg white ovalbumin is transformed into s-ovalbumin. In view of this, the amount of ovalbumin in the egg white decreases, and this could interfere with the formation of a cohesive film on the air-water interface, causing a decrease in foam stability. The volume of drained liquid increased and the foam stability decreased with increasing s-ovalbumin contents. From this study, foaming stability increased in DOS 0, 7 and 14 but reduced at day 21; which corroborates earlier study [6] on evaluation of effects of storage periods and two temperatures on poultry eggs. The increase in foaming stability does not fully prove the explanation regarding the properties of s-ovalbumin, but properly illustrated how little changes in a given protein could significantly affect its properties.

Also, the foaming properties reduced in DOS, this can be due to the films become progressively thinner and ruptured, and the fluid loss by lamellar water drainage, resulting in a foam collapse during storage period [20].

The emulsification properties of food materials are necessary for the stability of the suspension of one liquid in another.

The yolk portion of an egg contains high lecithin and lipid contents which impart a tenderising and emulsifying effect to the product. When the egg was beaten, lecithin is a protein which encircles the peripheries of the air bubbles formed and so protects them from bursting during baking process [8,29]. In this study, emulsion activity increased in DOS. This may be due to the presence of proteins and lipids (lecithin) found mostly in the yolk which must have contributed to the higher emulsification properties.

Yolks are generally recognized for the role of lipoproteins in forming and stabilizing emulsion potentials) [27]. These properties are useful in foods such as shortened cakes and mayonnaise. However, the emulsion activity declined at 21 DOS. This may be due to decline in the quality of the vitelline membrane during egg storage, making the yolk more susceptible to breaking) [28] and also during storage, moisture from egg is lost through evaporation at a rate that is influenced by temperature of the storage environment [28]. Methods for preparing these emulsions and testing their stability have varied greatly [11, 19, 20].

4. Conclusion

Eggs from layers fed 5% cassava peel meal had increased foaming capacity and lipid oxidation compared with those collected from corn-soya diet. The lipid oxidation was increased by the interaction of diet and duration of storage. This indicates that cassava peel meal contributed positively to the foaming properties of chicken eggs and accompanying lipid oxidation which enhanced egg rancidity.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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