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Functional attributes of eggs from hens fed different proprietary feeds during storage in Ibadan, Nigeria

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Abstract

Implications of feeding different proprietary feeds to laying hens on stored egg functional properties were assessed in this study. Lohmann Brown layers (n=540) aged 59-week were randomly assigned to six proprietary feed brands: G, H, I, J, K and L. Each treatment was replicated ten times (a replicate had nine hens) for 12 weeks. At week-74 hen-age, 600 eggs were sampled, stored at ambient conditions and assessed at 0, 7, 14, 21 and 28 Egg Storage Days (ESD) using standard procedures. Eggs from J had significantly higher emulsion stability (62.02) and foam stability (67.77) among the group. Effects of interaction of feed brand x ESD were significant ($p<0.05$) for all parameters. The foam capacity (%) declined significantly ($p<0.05$) from 75.60 to 70.67 for G, 80.23 to 73.48 for H, 79.01 to 73.94 for I, 84.34 to 77.67 for J, 82.20 to 76.33 for K, 76.74 to 70.56 for L through the ESD. The relationship between brands LGC (%) of H (R2=0.14), I (R2=0.14), L (R2=0.25) and ESD was similar ($p>0.05$). All eggs collected from hens on different feed brands had diminished functional attributes during storage. Eggs from hens on brand J had overall improved functional properties compared to others. Thus, the quality of commercial feed consumed by the hens could determine the functional characteristics.

Keywords: functional properties; duration of storage; commercial feeds; laying chickens.

1. Introduction

Eggs are a prime source of high-quality protein in human diets due to their peculiar nutritional composition required for the growth and maintenance of life [1]. Chicken eggs are used in the cosmetic, food, and pharmaceutical industries due to their emulsifying and foaming properties, which may be dependent on the feed quality given to the hens. In the food industry, eggs have been used as one of the raw ingredients in the food industry. The proteins in egg white such as ovalbumin, ovotransferrin, ovomucin, ovomucoid and lysozyme are responsible for gel formation, foaming and emulsifying capacities.

Ovalbumin has a major impact on the functional properties of eggs and it is a monomeric phosphoglycoprotein [2]. When whipped, ovalbumin denatures and unfolds forming a network that traps air which helps in foam stability and is imperative in the baking industry and other confectionaries. Globulins in the egg help in the foam formation and ovomucin enhances foam stability which is expedient for baking products like bread, and cake in the food industry [3].

Yolk accounts for 33% of the liquid weight and less of the protein in the egg. The lecithin composition of egg yolks acts as an emulsifier with both hydrophilic and hydrophobic abilities, stabilising mixtures of oil and water which is important in the production of mayonnaise [4]. The quality of eggs including the functional attributes and shelf-life has been linked to the nutrition of the laying chickens [5], thus, the need to ensure the quality of feed is not compromised. The feed contains necessary nutrients which determine egg characteristics and are equally highly imperative for their durability and quality

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attributes [6]. This may clearly explain the reason why the feed industry is becoming increasingly regulated in Nigeria [7]. Relevant government agencies are coming alive with regulations which among others would ensure feed uniformity and standard nutrient composition. However, due to scarcity and high cost of feed ingredients, some manufacturers may reduce the quality of their products. Small, medium and large-scale farmers are largely dependent on commercial feeds for their laying chickens. Hence, compromise on feed quality may have adverse effects on the functional properties of eggs during storage.

The influence of different feed brands on the meat quality of broiler chickens has been documented [8, 9]. Also, the quality attributes of eggs from laying hens on different commercial feeds have been reported [10, 11]. An earlier study [12] ascertained the influence of proprietary vitamin-mineral premixes on egg functional characteristics. However, there is scanty information on the impact of proprietary feeds on the functional properties of eggs.

Understanding the impact of different feed brands on the functional attributes of eggs will help producers in the food industry pay closer attention to the eggs used as ingredients during food processing. Information on the likely effect of feed quality on egg products is also imperative to farmers and nutritionists. This study was, therefore, aimed at ascertaining the impact of feeding different commercial feeds to the laying chickens on the functional attributes of eggs during storage.

2. Materials and method

2.1.Experimental location

This study was carried out at the Poultry Unit, Teaching and Research Farm, University of Ibadan, South-West geopolitical zone of Nigeria. The location is in the derived savanna vegetation belt of Nigeria and lies between longitude 7°27.05 north and 3°53.74 of the Greenwich Meridian east at an altitude of 200m above sea level [13].

2.2.Experimental animals

Lohmann Brown layers (n=540) at week 59 of age, were allotted randomly to six commercial feeds (G, H, I, J, K, L). The feeds were purposively selected and obtained within 72 hours after they were manufactured. Each treatment consists of ten replicates comprising nine birds each. The hens were housed in a 3-tier battery system and each cubicle measured 50 x 45 x 40cm^3.

2.3.Experimental design

The experimental design was a completely randomised design where the six selected feed brands represented the treatments in the study.

Parameters measured

At week-74 hen age, 600 freshly laid eggs were sampled from layers fed different feed brands and stored between temperatures 24.1-28.9^{o}C and relative humidity of 73-84%. Functional properties such as FC, FS, EC, ES and LGC were determined on days 0, 7, 14, 21 and 28 of eggs storage.

2.4.Functional properties of chickens' eggs

Foam capacity and stability were measured following the methods outlined by [14] with slight adjustments. Firstly, 50 mL of each egg pool was whipped with 100 mL of distilled water for 5 minutes using a Kenwood blender set to speed 1-inch. The resulting mixture was then poured into a 250 mL graduated cylinder to determine its foam capacity and stability. Volume Increase (%) was calculated using the following equation:

$$\boldsymbol{V_{Increase}}\ (\%) =$$

$$= \frac{\boldsymbol{V_{after\ whipping}\ (ml) - V_{before\ whipping}\ (ml)}}{\boldsymbol{V_{before\ whipping}}} \cdot \mathbf{100}$$

$$\boldsymbol{Foam\ stability} = \frac{\boldsymbol{V_s}}{\boldsymbol{V_t}} \cdot \mathbf{100}$$

where:

V_s represents the volume of the liquid albumen separated

V_t the total volume of albumen originating the volume of foam transferred into the conical vessel. This was done on 0, 7, 14, 21 and 28 ESD.

Distilled water was used to prepare suspensions ranging from 2% to 20%. Each of the prepared dispersions was transferred into a test tube, with 10ml in each. The test tubes were then heated in a boiling water bath for one hour, followed by rapid cooling in a bath of cold water. Afterwards, the samples were further cooled at 4°C for 2 hours. The least gelation concentration was then determined by observing when the egg sample from the inverted test tube did not fall or slip.

Emulsion capacity and stability were determined following the methods described by [15] with some adjustments. First, 50ml of egg sample and 100ml of distilled water were blended for 30 seconds in a Philips blender 5000 series, HR2224/00 at 1600 rpm. While blending, vegetable oil was gradually added in 5ml increments from a burette. Blending was continued until the emulsion breakpoint, which is the separation into two layers, was reached. The

determination of emulsification was performed at room temperature. Emulsion capacity was calculated as the quantity of oil emulsified and held per gram of sample. Emulsion stability was determined using the egg sample prepared for emulsion capacity measurement. The sample was heated for 15 minutes at 85°C, the mixture was cooled and evenly distributed into 50ml centrifuge tubes. The tubes were then centrifuged at 1100 rpm for 5 minutes. Emulsion stability was expressed as the percentage of emulsifying activity remaining after heating.

Data were analysed using descriptive statistics and repeated measures ANOVA [16]. Means were separated using Duncan Multiple Range Test of the same software at α0.05.

3. Results and Discussion

The proximate composition of the proprietary feeds is presented in Table 1. The compositions significantly varied ($p<0.05$) from one to another.

Table 1 Proximate Composition of Different Commercial Layers' Feeds in Ibadan

Brand	%CP	%EE	%CF	%Ash	%Moisture	%Dry Matter	%NFE
G	16.43±0.39^{c}	3.74±0.10^{c}	4.27±0.16^{e}	6.13±0.15^{d}	9.55±0.19^{c}	90.45±0.19^{c}	59.88±0.61^{a}
H	16.30±0.44^{d}	3.65±0.11^{d}	4.40±0.13^{d}	6.02±0.15^{f}	9.67±0.19^{b}	90.33±0.19^{d}	59.96±0.64^{a}
I	16.46±0.28^{c}	3.51±0.11^{f}	4.42±0.12^{d}	6.09±0.15^{e}	9.73±0.17^{a}	90.28±0.17^{e}	59.79±0.49^{a}
J	16.80±0.32^{b}	3.56±0.11^{e}	4.67±0.17^{a}	6.44±0.14^{c}	9.64±0.14^{b}	90.36±0.14^{d}	58.90±0.57^{b}
K	16.93±0.31^{a}	3.92±0.14^{b}	4.56±0.14^{b}	8.16±0.12^{b}	9.28±0.16^{d}	90.72±0.16^{b}	57.15±0.56^{c}
L	17.03±0.30^{a}	4.06±0.14^{a}	4.46±0.18^{c}	8.47±0.14^{a}	9.19±0.15^{e}	90.81±0.15^{a}	56.80±0.59^{d}
SEM	0.06	0.01	0.01	0.02	0.16	0.02	0.08

^{abc} Means with different superscripts along the column differed significantly ($P<0.05$), CP: Crude Protein, EE: Ether Extract, CF: Crude Fibre, NFE: Nitrogen Free Extract, SEM: Standard Error of Mean, G, H, I, J, K, L: Brands of feed.

Both feeds K and L contained similar ($p>0.05$) crude protein of 16.93 and 17.03%, respectively which were significantly higher ($p<0.05$) than others with trends similar to reported values.

Report [17] revealed significant disparities in the crude protein of the layers feed, however, some feeds contained up to 27.00% which was higher than required by the laying chickens. Another study [18] on the crude protein of different poultry layers feed revealed a range of 15.89 to 20.22%. Significant variations ($p<0.05$) were observed in the crude fibre compositions of brands G (4.27%), H (4.40%), I (4.42%), J (4.67%), K (4.56%) and L (4.46%).

The impact of feed brands on crude protein content of chicken eggs in days of storage is shown in Table 2.

Table 2 Effect of Feed Brands on Crude Protein Composition of Chicken Eggs in Days of Storage

		BRANDS					
Parameters	**Days of storage**	**G**	**H**	**I**	**J**	**K**	**L**
%CP	0	8.48±0.31^{c}	8.97±0.03^{b}	7.78±0.02^{b}	9.22±0.02^{b}	10.22±0.02^{a}	9.98±0.02^{b}
	7	9.03±0.01^{b}	8.85±0.01^{c}	8.53±0.01^{ab}	9.14±0.01^{b}	10.11±0.01^{a}	10.33±0.01^{ab}
	14	9.53±0.02^{a}	8.65±0.02^{d}	9.30±0.03^{ab}	9.53±0.04^{a}	10.30±0.02^{a}	10.43±0.06^{a}
	21	9.19±0.03^{ab}	9.63±0.03^{a}	10.82±1.72^{a}	9.57±0.03^{a}	10.04±0.24^{a}	10.46±0.01^{a}
	28	8.49±0.03^{c}	8.52±0.03^{e}	8.20±0.13^{ab}	8.73±0.02^{c}	9.57±0.03^{b}	10.29±0.03^{ab}
	SEM	0.13	0.12	0.43	0.10	0.08	0.06

a,b,c Means with different superscripts on the same column differed significantly ($p<0.05$); G, H, I, J, K, L: Brands of feed, CP: Crude protein

The % CP of eggs declined significantly ($p<0.05$) in storage days. Layers on brands K and L produced eggs with higher CP of 10.22±0.02 and 9.98±0.02%, respectively amongst the group. This observation aligned to the earlier values that K and L contained more %CP than G, H, and J. The %CP of eggs from layers on K were relatively more stable ($p>0.05$) on 0 (10.22±0.02%), 7 (10.11±0.01%), 14 (10.3±0.02%), 21 (10.04±0.24%) days but declined significantly ($p<0.05$) on day 28 (9.57±0.03%). Conversely, the %CP of G, H, I, J and L variec irregularly during storage. During the egg storage period, the pH of egg increases which activates enzymes such as the proteases and cathepsins and these enzymes breaks down the protein which then, reduced the egg crude protein content [19].

The influence of proprietary feeds on the functional properties of eggs is shown in Table 3. The foaming capacity (FC) of proprietary feed J (80.84%) was appreciably higher than K (79.34%), H (76.58%), I (76.40%), G (73.30%) and (73.36%).

Table 3 Effects of feed brands on egg functional attributes of laying chickens

Brand	EC	ES	FC	FS	LGC
G	20.51±1.23^{c}	57.81±1.98^{d}	73.30±1.76^{d}	66.00±1.61^{c}	67.56±9.81^{c}
H	20.06±1.22^{d}	57.39±1.67^{e}	76.58±2.31^{c}	63.06±1.91^{f}	73.33±9.54^{b}
I	21.37±1.04^{b}	58.16±2.03^{c}	76.40±1.77^{c}	66.68±2.02^{b}	78.44±5.20^{a}
J	21.69±1.02^{a}	62.02±1.93^{a}	80.84±2.40^{a}	67.77±1.83^{a}	74.22±9.17^{ab}
K	20.12±0.88^{d}	60.30±1.42^{b}	79.34±2.24^{b}	65.73±1.81^{d}	63.56±16.12^{c}
L	19.89±1.02^{e}	56.23±1.90^{f}	73.36±2.23^{d}	63.69±2.22^{e}	74.67±8.94^{ab}
SEM	0.04	0.06	0.05	0.05	1.25

$^{a, b, c}$ Means with different superscripts differed significantly ($p<0.05$), EC: Emulsion capacity, ES: Emulsion stability, FC: Foam Capacity, FS: Foam Stability, LGC: Least Gelation Concentration, G, H, I, J, K, L: Brands of feed

The FC of eggs ranged from 73.30±1.76 in brand G to 80.84±2.40 in J. The values were lower than 128.00±1.20 to 143.80±2.00 for chicken and 134.80±1.20 to 151.30±1.60 for quail eggs when dried to powdery form (20). A significant variation was found in the foaming stability (FS) of the proprietary feeds. Feed J (67.77±1.83) had higher stability ($p<0.05$) than I (66.68±2.02), G (66.00±1.61), K (65.73±1.81), L (63.69±2.22) and H (63.06±1.91). An earlier report (21) revealed higher FS values of 115.30±0.40 to 130.20±1.00 in powdery chicken whole eggs and 121.30±0.90 to 134.20±0.70 in powdery quail eggs. This could be due to partial denaturation of protein during the drying process which invariably, increased the molecular flexibility that enhances the formation of viscoelastic films in the oil-water interphase [20].

The protein content of the feed ought to have a considerable impact on the foaming ability of eggs which conversely was contrary to findings in this study; as higher crude protein was in K and L but did not translate to any higher foaming attributes.

Brand L had lower EC and ES values of 19.89±0.02 and 56.23±1.90, respectively, while layers fed brand J produced eggs with higher EC (21.69±1.02) and ES (62.02±1.93) amongst the group. This could be attributed to the brand having ingredients with more emulsifiers like lecithin which was ultimately deposited in the eggs, thereby enhancing the emulsifying ability of the eggs.

Effect of different proprietary feed brands on rheological properties of eggs from hens during storage is shown in Table 4. Within the ESD of 0 to 28, there was a significant decrease ($p<0.05$) in the FC of eggs from hens fed G, H, I, J, K, and L. The FC reduced from 75.60 to 70.67; G, from 80.23 to 73.48; H, from 79.01 to 73.94; I, from 84.34 to 77.67; J, from 82.20 to 76.33; K, and 76.74 to 70.56 for L. This finding was contrary to the earlier assertions [21], that DoS would not lower the FC.

During ESD, the FS of the eggs decreased significantly ($p<0.05$) for all treatments. Earlier study [22] where the foaming stability of fresh chicken egg white, coated and non-coated with whey protein-based concentrate (WPC) film stored for 28 days was assessed. The WPC coating had better FS in the ESD due to its more efficient barrier against carbon dioxide losses which could occur when eggs were stored over a period of time. The EC and ES of the whole eggs ranged from 21.26±0.17, 58.82±0.28 to 22.92±0.23, 64.61±0.17, respectively. A higher EC of 25.54% was similar to the reported [23] EC values of 26.64±0.13 in quail eggs.

On day 28, the FS on day 0 (75.60±0.22, 66.16±0.25, 69.51±0.15, 70.23±0.22, 68.64±0.17, 66.61±0.15) decreased to 63.78±0.33, 60.70±0.26, 64.23±0.23, 65.48±0.25, 63.65±0.18, and 60.45±0.20, respectively. However, storage duration did not affect ($p>0.05$) the LGC of eggs of hens on Brands H, I, and L.

The LGC of the eggs from hens during ESD are shown in Figure 1. Regardless of the feed brand, the increase in the LGC may not be due to DoS. This could be seen from the low regression coefficients of the various feeds [G (0.39), H (0.08), I (0.14), J (0.25), K (0.67), L (0.14)]. The nutritional composition of feed could help to sustain the shelf-life of eggs including the functional properties when there is an inclusion of antioxidants in layers feed. Earlier submission [24], opined that supplemental selenium improved the gelation of eggs in storage. Gelation of eggs entails the coagulation, denaturation and formation of a gel-like structure when they are heated. During heating, there is a

partial unfolding of the egg white protein which forms complexes resulting in the creation of a coagulum. The closeness of the egg pH value to the isoelectric point minimizes gel strength and cohesiveness [25]. Eggs stored at ambient temperature may increase in pH due to loss of carbon dioxide from shell pores.

Table 4 Effect of feed brand on the rheological properties of eggs in days of storage

Parameters	Days of storage	BRANDS					
		G	H	I	J	K	L
EC	0	22.32±0.19^{a}	21.82±0.29^{a}	22.62±0.17^{a}	22.92±0.23^{a}	21.38±0.15^{a}	21.26±0.17^{a}
	7	21.34±0.20^{b}	20.94±0.40^{b}	22.13±0.15^{b}	22.38±0.24^{b}	20.61±0.16^{b}	20.50±0.20^{b}
	14	20.35±0.17^{c}	19.80±0.32^{c}	21.51±0.25^{c}	22.04±0.36^{c}	20.17±0.13^{c}	20.07±0.22^{c}
	21	19.60±0.18^{d}	19.08±0.21^{d}	20.73±0.26^{d}	20.83±0.22^{d}	19.33±0.19^{d}	19.02±0.43^{d}
	28	18.93±0.21^{e}	18.64±0.19^{e}	19.85±0.17^{e}	20.30±0.17^{e}	19.11±0.14^{d}	18.61±0.31^{e}
	SEM	0.18	0.14	0.15	0.15	0.13	0.15
ES	0	60.43±0.20^{a}	59.84±0.28^{a}	60.90±0.15^{a}	64.61±0.17^{a}	62.28±0.19^{a}	58.82±0.28^{a}
	7	59.02±0.31^{b}	58.27±0.17^{b}	59.67±0.34^{b}	63.35±0.17^{b}	61.22±0.21^{b}	57.44±0.28^{b}
	14	58.26±0.28^{c}	57.60±0.18^{c}	57.54±0.58^{c}	62.34±0.22^{c}	60.28±0.18^{c}	56.46±0.16^{c}
	21	56.35±0.18^{d}	55.95±0.17^{d}	56.76±0.50^{c}	60.42±0.28^{d}	59.34±0.14^{d}	54.88±0.24^{d}
	28	54.96±0.11^{e}	55.26±0.20^{e}	55.92±0.22^{d}	59.38±0.23^{e}	58.35±0.20^{e}	53.52±0.24^{e}
	SEM	0.29	0.19	0.30	0.28	0.21	0.28
FC	0	75.60±0.22^{a}	80.23±0.30^{a}	79.01±0.23^{a}	84.34±0.25^{a}	82.20±0.28^{a}	76.74±0.22^{a}
	7	74.46±0.18^{b}	77.35±0.20^{b}	77.32±0.21^{b}	82.43±0.25^{b}	81.17±0.27^{b}	74.77±0.26^{b}
	14	73.55±0.35^{c}	76.76±0.25^{c}	76.44±0.20^{c}	80.51±0.20^{c}	79.31±0.23^{c}	72.93±0.25^{c}
	21	72.21±0.37^{d}	75.06±0.25^{d}	75.27±0.28^{d}	79.23±0.20^{d}	77.67±0.30^{d}	71.77±0.28^{d}
	28	70.67±0.31^{e}	73.48±0.25^{e}	73.94±0.31^{e}	77.67±0.33^{e}	76.33±0.20^{e}	70.56±0.25^{e}
	SEM	0.26	0.27	0.26	0.35	0.33	0.33
FS	0	68.40±0.30^{a}	66.16±0.25^{a}	69.51±0.15^{a}	70.23±0.22^{a}	68.64±0.17^{a}	66.61±0.15^{a}
	7	66.55±0.24^{b}	63.68±0.38^{b}	68.32±0.20^{b}	69.33±0.21^{b}	66.47±0.26^{b}	65.40±0.15^{b}
	14	66.33±0.45^{b}	62.97±0.37^{c}	65.87±0.02^{c}	67.57±0.13^{c}	65.52±0.18^{c}	63.76±0.17^{c}
	21	64.93±0.33^{c}	61.74±0.27^{d}	65.46±0.36^{c}	66.23±0.30^{d}	64.34±0.16^{d}	62.23±0.22^{d}
	28	63.78±0.33^{d}	60.70±0.26^{e}	64.23±0.23^{d}	65.48±0.25^{e}	63.65±0.18^{e}	60.45±0.20^{e}
	SEM	0.24	0.22	0.30	0.27	0.26	0.33
LGC	0	62.22±0.66^{c}	71.11±0.51	80.00±0.00	68.88±0.54^{b}	46.66±3.33^{b}	75.55±2.93
	7	60.00±0.00^{c}	68.88±0.54	75.55±0.81	68.88±0.54^{b}	48.88±3.51^{b}	68.88±3.51
	14	66.66±0.10^{bc}	75.55±0.81	76.66±0.07	75.55±0.81^{ab}	71.11±3.51^{a}	73.33±3.33
	21	73.33±0.10^{ab}	75.55±0.81	80.00±0.00	80.00±0.00^{a}	73.33±3.33^{a}	77.77±2.22
	28	75.55±0.81^{a}	75.55±0.43	80.00±0.00	77.77±0.66^{a}	77.77±2.22^{a}	77.77±2.22
	SEM	1.46	1.07	0.77	1.36	2.40	1.33

$^{a, b, c}$ Means with different superscripts differed significantly ($p<0.05$), EC: Emulsion capacity, ES: Emulsion stability, FC: Foaming Capacity, FS: Foaming Stability, LGC: Least Gelation Concentration, G, H, I, J, K, L: Brands of feed.

In Figure 2, a quartic polynomial relationship was observed between ESD and FS of eggs. The reduction in the FS conforms to report (12) that FS of eggs from hens fed different commercial vitamin-mineral premixes declined with increased ESD. The yolk inclusion might reduce foaming ability of the albumen (26) as a result of its lipid content which could stem from inclusion level in the feed. The foaming stability of G, I and K was intercepted at various points during storage while H and L were intercepted on day 28. Duration of storage highly affected the FS which could be seen from the regression coefficients of 0.95 (G), 0.97 (H), 0.94 (I), 0.98 (J), 0.96 (K), and 0.99 (L).

The equation for the quartic polynomial regression of ESD and FC is shown below:

$y=7E-05x^4-0.0044x^3+0.0847x^2-0.6639x+68.4$……Feed G
$y=5E-05x^4-0.0033x^3+0.0694x^2-0.6963x+66.167$…Feed H
$y=-0.0001x^4+0.0061x^3-0.1038x^2+0.2959x+69.511$…..Feed I
$y=-2E-05x^4+0.0014x^3-0.0317x^2+0.0313x+70.233$…...Feed J
$y=4E-05x^4-0.0023x^3+0.047x^2-0.5409x+68.644$…..Feed K
$y=-2E-05x^4+0.0009x^3-0.0177x^2-0.087x+66.611$….Feed L

From the above equations, there was a negative relationship between the FC and ESD for feeds I, J and K.

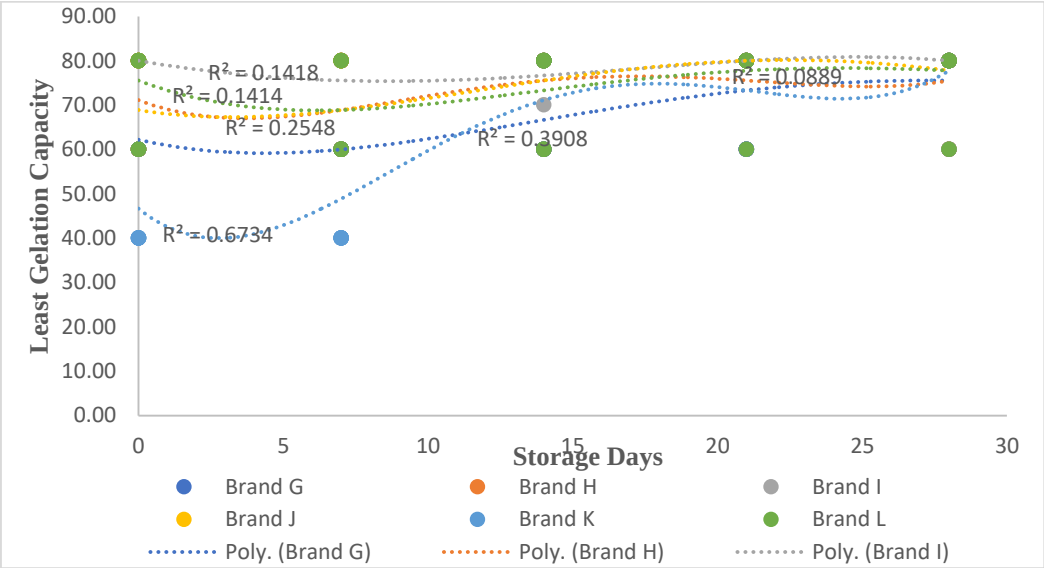

Figure 1 Relationship between the Least Gelation Capacity and storage duration of eggs collected from laying hens fed different commercial feeds

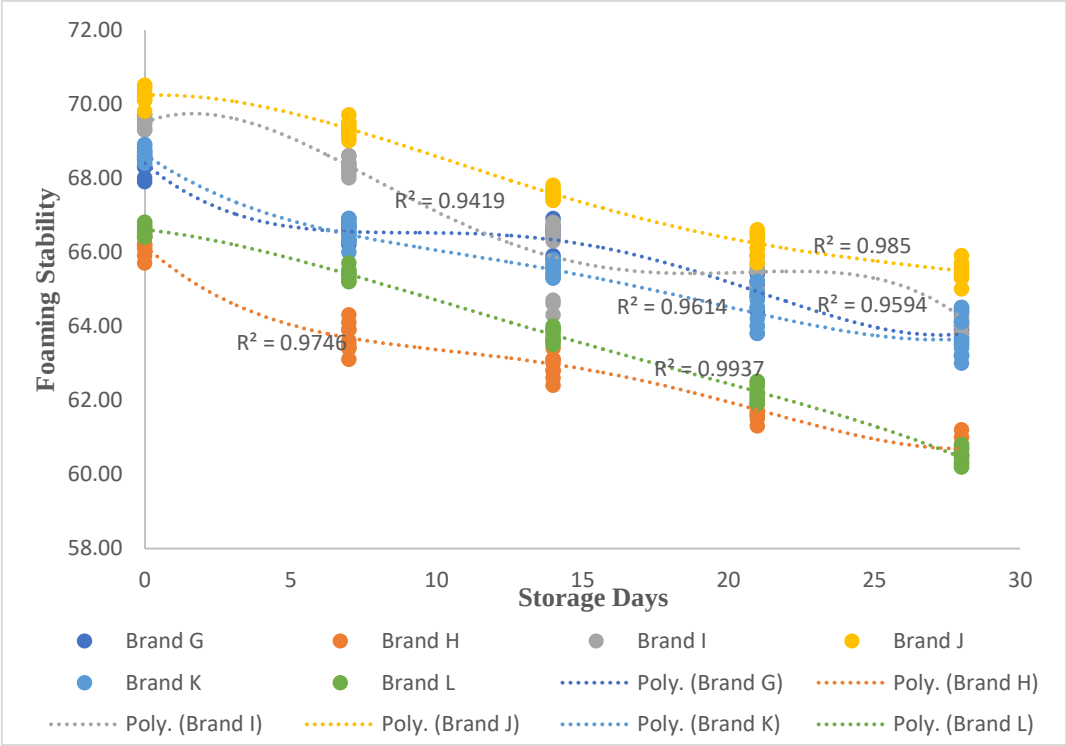

Figure 2 Relationship between the duration of storage and foaming stability of eggs from laying chickens fed different commercial feeds

4. Conclusion

All eggs collected from hens on different feed brands had diminished functional attributes during storage. Eggs from hens on brand J were of overall improved functional properties compared to others. Thus, the quality of commercial feed consumed by the hens could determine the functional characteristics..

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Conflict of interest

This research was carried out without any bias or conflict of interest to any organisation.

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