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INTERNAL AND EXTERNAL EGG QUALITIES OF LAYERS FED TWO PROPRIETARY FEEDS INTERCHANGEABLY

Onabajo, A. O.[1+]
Awojobi, H. A.[2]
Apata, E. S.[3]

[1]*Rasable Farm Ventures, Ijeun Akoni Village, Odeda Local Government Area, Osiele-Abeokuta, Ogun State, Nigeria.*
[1,2,3]*Department of Animal Production, Faculty of Agricultural Production and Renewable Resource, College of Agricultural Sciences, Olabisi Onabanjo University, Ayetoro Campus, Ayetoro, Ogun State, Nigeria.*
[1]*Email: onabajoadebisi@gmail.com*
[2]*Email: hakeemawojobi@yahoo.com*
[3]*Email: ebunoluapata2008@yahoo.com*

(+ Corresponding author)

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ABSTRACT

Four hundred and eighty, 53 weeks old Isa Brown layers were used for the 8 weeks feeding trial to determine the internal and external egg qualities of layers fed two proprietary feeds (designated Top feed (TF) and Animal Care feed (AC)) in five dynamics and two feeding frequencies. The birds were randomly allocated in a 5 x 2 factorial arrangement to five feeding dynamics (D1 TF only; D2 AC feed only; D3 weekly alternation of TF & AC; D4 Alternation of TF & AC every two weeks; D5 Monthly alternation of TF & AC) and two feeding frequencies (Twice & Thrice daily). Data were collected on external and internal egg qualities and analyzed using Analysis of variance (ANOVA). The results showed that both feeding dynamics and feeding frequencies significantly ($p<0.05$, R2=0.4) contributed to egg length as single factor. However, egg shape index (p=0.002), % yolk (0.00), yolk weight (p=0.004), egg moisture (0.003), egg fat (0.001) and egg carbohydrate (0.001) were influenced by interaction effect of feeding dynamics and feeding frequency. From the findings of this study, alternating brands of feed in the short term (weekly) and feeding laying birds twice daily is recommended.

Contribution/Originality: Sudden change in the brand of feed fed to laying birds affects both the internal and external quality of eggs. However, such changes are not detrimental to egg quality where the nutrient composition of interchanged brands is comparable. Feeding laying hens twice or thrice daily does not affect egg quality.

1. INTRODUCTION

The consumption of poultry products, especially poultry meat and egg, has consistently increased over the years as a result of increase in population, urbanization and income. This has resulted in profound effect on the demand for feed and feed raw materials. Ojewole [1] and Eruvbetine [2] reported that the rate and level of performance in the livestock industry especially poultry production has fallen below expectation due to high feed cost arising from fluctuations in feed supplies, rising prices of feed ingredients, high capital outlay in purchase and storage of ingredients over time, poor feed quality (adulterated feed), increase competitive demand for feed, scarcity of the conventional ingredients and most importantly inefficiency in feed production [3, 4]. In commercial poultry production, the main constraint to successful production is feed cost which accounts for about 75 to 80% of the total cost of production [5].

Fallen trend in commercial feed production in Nigeria according to Bello [6] started around 1998-2000 when feed production figures dropped from 2.4MMt in 1995 to 1.6MMt in 2000 with subsequent decline up to 1.00MMt in the year 2008. This low capacity feed resources utilization could be linked to inadequate information based on location and localization of feed resources, processing, storage, and quality enhancement. The net effect of all these are capacity under-utilization, curtailment of planned expansion programs and in extreme cases liquidation [2]. However, Oyediji [7] reported that there was a rise in the quantity of poultry feed produced in Nigeria from 2.2MMt in 2010 to about 3.3MMt in 2014. This was as a result of the ban imposed on the importation of frozen chicken and other livestock products which made poultry production more attractive. The rise in the number and size of poultry business has led to more demand for feeds and subsequent pressure on feed production ingredients. Thus, the rise in the number of feed mills to meet this demand of most poultry farmers became inevitable and the incessant increase in prices of the feed could be attributed to decrease productivity and inefficiency in the use of resources by the feed industries [8].

Laying chickens require a completely balanced diet to sustain maximum egg production over time and inadequacies can cause hens to stop-laying. To avert this, there has been introduction of feeding dynamism which is characterized by continuous change in feeding practices among poultry farmers due to limited availability of feed and changing feed quality of branded feed [9]. This usually involve shift from one source of commercial feed to another, either in the short, medium or long-run. This study therefore investigated the response of egg-type chickens to simulated dynamics of poultry feeding in practice, with emphasis on egg quality.

2. MATERIALS AND METHODS

2.1. Study Location

The experiment was conducted on a private farm at Ijeun-Akoni Village, Odeda Local Government Area (LGA), Osiele, Abeokuta, Ogun State Nigeria. Odeda LGA shares boundary with Abeokuta North LGA of Ogun State. Geographically, Abeokuta lies on latitude 7^{0}15N and longitude 3^{0}25E. Abeokuta lies on an altitude of about 157m above sea level amidst isolated outcrop of natural formation of granite rocks which give the town landscape its undulating characteristics. The area has rainfall of between 100mm and 200mm [10, 11].

2.2. Animal Housing and Management

A total number of four hundred and eighty, 53 weeks old ISA Brown laying hens were used for the experiment. They were housed in battery cages 50x40x40cm/cell (4layers/cell). The experimental feeds were offered at 125g/bird/day and water was provided free-choice. Birds were raised under natural day length.

Table 1. Nutrient composition of experimental feeds.

Nutrients	TF	AC
Crude protein	16.50	16.50
Fat/oil	5.00	3.00
Crude Fibre	6.00	7.00
Calcium	3.60	3.60
Phosphorus	0.45	0.45
Methionine	0.34	-
Lysine	0.80	-
Salt	0.3	-
Metabolizable energy (Kcal/kg)	2500	2650

Source: Proprietary feeds leaflet.

2.3. Feed and Feeding Practices

Two reputable commercial brands (TF and AC) of feeds (Layers mash) of comparative nutritional quality were used for the experiment**.** The nutrient compositions of the experimental feeds are presented in Table 1. The feeding practice was twice feeding daily or thrice feeding daily.

2.4. Experimentation

The experiment was Randomized Complete Block Design (RCBD). The treatment being 5 (five) dynamics of feed change and the block (two feeding times per day).The five treatment groups are

Dynamic 1 (D1): use of TF Layers mash throughout the experiment.

Dynamic 2 (D2): use of AC Layers mash throughout the experiment.

Dynamic 3 (D3): short term (weekly) alternation of AC and TF throughout the experiment.

Dynamic 4 (D4): medium (2 weekly) alternation of AC and TF throughout the experiment.

Dynamic 5 (D5): Long term (monthly) alternation of AC and TF throughout the experiment.

The two blocks were:

Block 1 (B1): Feeding twice daily at 7a.m in the morning and 2pm in the afternoon.

Block 2 (B2): Feeding thrice daily at 7a.m in the morning, 1pm in the afternoon and 5pm in the evening.

2.5. Data Collection

2.5.1. External Egg Quality

Twelve (12) eggs were randomly selected weekly/group of 48 birds for egg quality analysis. The indices determined were as follows:

Egg weight (g): Egg weight was taken for selected egg collected from the hens and the weighing was done for all the selected eggs. Egg weight was taken to the nearest grams for all eggs collected individually.

Egg grade: Egg grades were assigned according to Agmark Standards for market table eggs [12].

Egg length and width: The length and width of the egg were measured with electronic digital vernier caliper sensitive to 0.00mm.

Egg Shape Index: The egg shape index was calculated as the proportion of egg length to diameter.

Egg Shell Thickness (mm): This was determined by pulling off the shell immediately the egg was broken and the shell was air-dried for 24 hours. Thereafter the egg shell thickness was measured with a micrometer screw gauge.

Egg Shell Weight (g): Each egg was carefully broken and dried after which the egg was weighed using a weighing balance.

2.6. Internal Egg Quality

Albumen Height: The eggs after weighing were broken into a flat bottom glass positioned on a flat surface. The albumen height was measured using a tripod micrometer [13].

Albumen Weight: Albumen was placed in a petri-dish on an electronic digital scale and the weight determined by difference.

Percentage Albumen: $= \frac{\text{Albumen weight}}{\text{Egg weight}} \times 100$

Yolk height: The eggs after weighing were broken into a flat bottom glass (beaker) positioned on a flat surface. The Yolk height was measured using a tripod micrometre.

Yolk Weight (g): The yolk was separated from the albumen and placed in weighed petri-dish on an electronic digital scale and the weight of the yolk was determined by difference.

Yolk Percentage: $\frac{\text{Yolk weight}}{\text{Egg weight}} \times 100$

Haugh Unit: This was calculated from the values obtained from the albumen height and egg weight by using the formula according to Williams [14].

Haugh's unit = $100\log10\,(H+7.57-1.7W^{0.37})$.

2.7. Proximate Composition of Egg

2.7.1. Preparation of Egg for Analyses

The samples of various treatment eggs were carefully opened and the contents emptied into a beaker. Egg samples were weighed using electronic balance and recorded. The sample were homogenized and kept in a dry, clean sample bottles and later used for analysis.

2.7.2. Proximate Composition

Moisture, ash, protein, and carbohydrate were determined by the methods described by AOAC [15]. Whereas lipid composition were determined by the method as described by McLean and Drake [16].

2.8. Statistical Analysis

The Statistical Design was RCBD. Data were arranged in a 5 by 2 Factorial Experimental layout. Significant differences were separated using Duncan's Multiple Range Test. All data analysis was done using [17].

$$Y_{ijk}=\mu+Di+Fj+(DF)ij+\sum ijk$$

Where:

Yijk = observed value of dependent variable.

μ= overall mean.

Di = Effect of the i^{th} feeding dynamic (1, 2, 3, 4, 5).

Fj = Effect of the j^{th} feeding time (1, 2).

(DF)ij = Effect of interaction between feed dynamics and feeding times.

∑ijk = Residual Error.

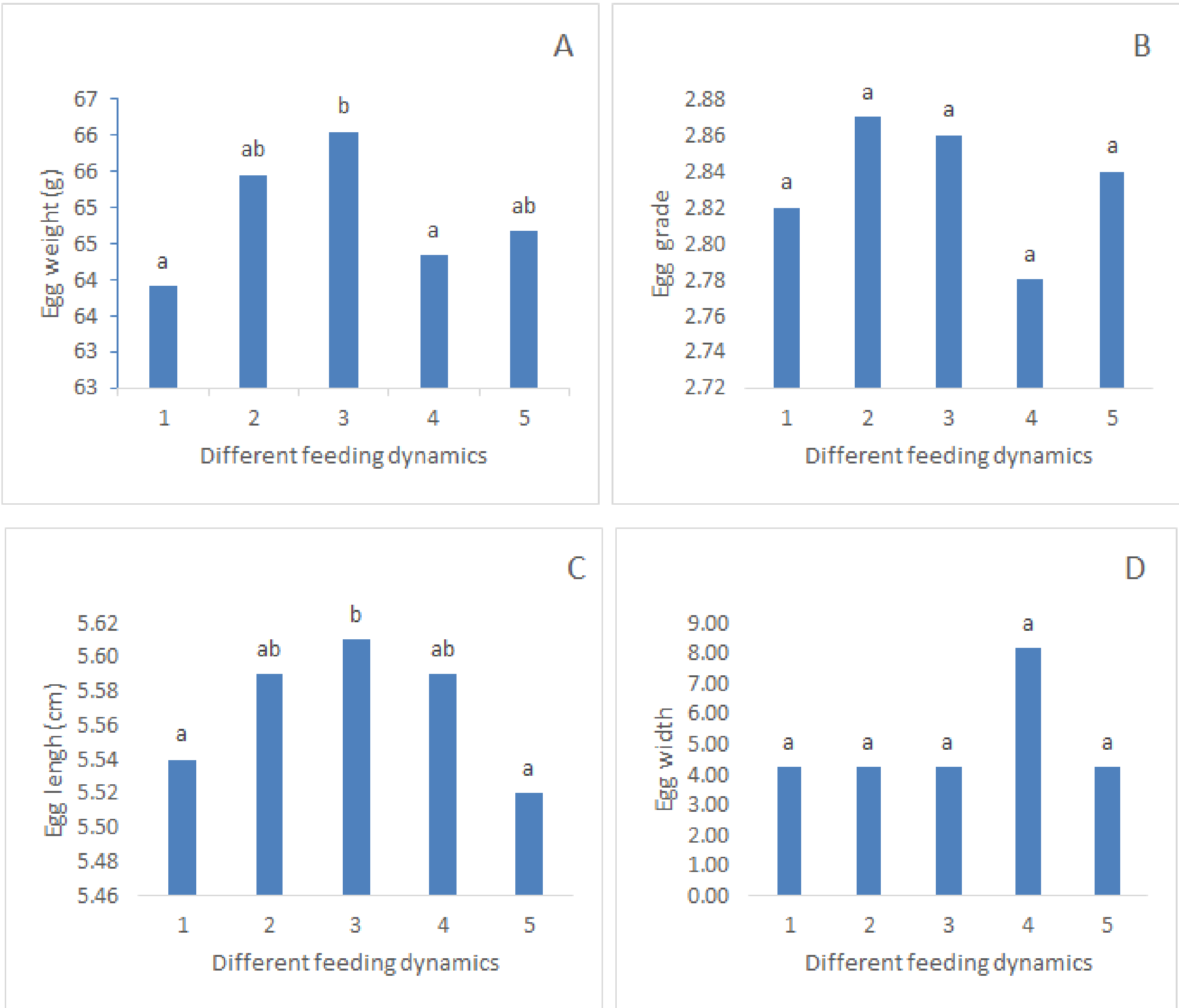
3. RESULTS AND DISCUSSIONS

3.1. Effects of Simulated Feeding Dynamics on External Egg Quality of Poultry Birds

The effects of simulated feeding dynamics on egg weight, grade, length, width, shape index, shell thickness and shell weight are presented in Figure 1(A-G). The result showed that different simulated feeding dynamics significantly contributed ($P<0.05$) to only egg weight (Figure A) and egg length (Figure C). High values were recorded for egg weight and egg length from birds on feeding dynamics D3 (short term weekly alternation of feed brands). Shell thickness (Figure F) was highest in birds on dynamics D5 being significantly ($P<0.05$) higher than that of birds on dynamics D1, D2, D3. Birds on dynamics 4 have intermediate value for shell thickness comparable ($P>0.05$) to that of other treatments. Similarly, birds in dynamics D5 have the highest shell weight (Figure G) which was higher ($P<0.05$) than that of other dynamics. The interactive effect is presented in Table 2. The highest value for egg grade was recorded in dynamics D2 with thrice feeding, followed by dynamics 4 with twice feeding while the least value was observed dynamics D4 with thrice feeding. However, both feeding dynamics and feeding frequencies significantly ($p<.05$, $R^2 = 0.41$) contribute to length as single factors. The two factors did not jointly interact to significantly affect the egg length.

In this study, different feeding dynamics significantly affected the egg weight and egg length. The highest values for these two important egg production factors were recorded in birds fed with short term (weekly) alternation of AC and TF throughout the experiment. This implied that weekly alternation of AC and TF will ensure better egg weight and length of egg-type chickens. This finding was similar to the report of Molnár, et al. [18], who reported improvement in egg characteristics of laying hens whose feeds were alternated on daily basis. However, alternation of feed in the longer course seems to increase shell thickness and shell weight of the eggs. The highest values for both shell thickness and weight were recorded in birds fed with TF and AC feed alternatively for one month. The organization of egg shell microstructure is determined by genetic, physiological and external factors [19]. Egg shell thickness, firmness and weight are very important factors to consider in eggs because it conditions the biological and market value of eggs [19].

To further explain this, hen forming thick egg shells had significantly higher egg shell weight, average egg shell thickness and lower rate of breakage (cracked, broken or shell-less eggs) in comparison with hens forming thin egg shells [19, 20]. The fact that long term alternation of feed resulted in better egg shell weight and thickness suggests that Ca, P and Mg metabolism for egg shell formation is not amenable to frequent change of feed brand. In this study, different feeding dynamics significantly affected the egg weight and egg length. The highest values for these two important egg production factors were recorded in birds fed with short term (weekly) alternation of AC and TF throughout the experiment. This implied that weekly alternation of AC care and TF will ensure better egg weight and length of egg-type chickens. This finding was similar to the report of Molnár, et al. [18], who reported improvement in egg characteristics of laying hens whose feeds were alternated on daily basis.



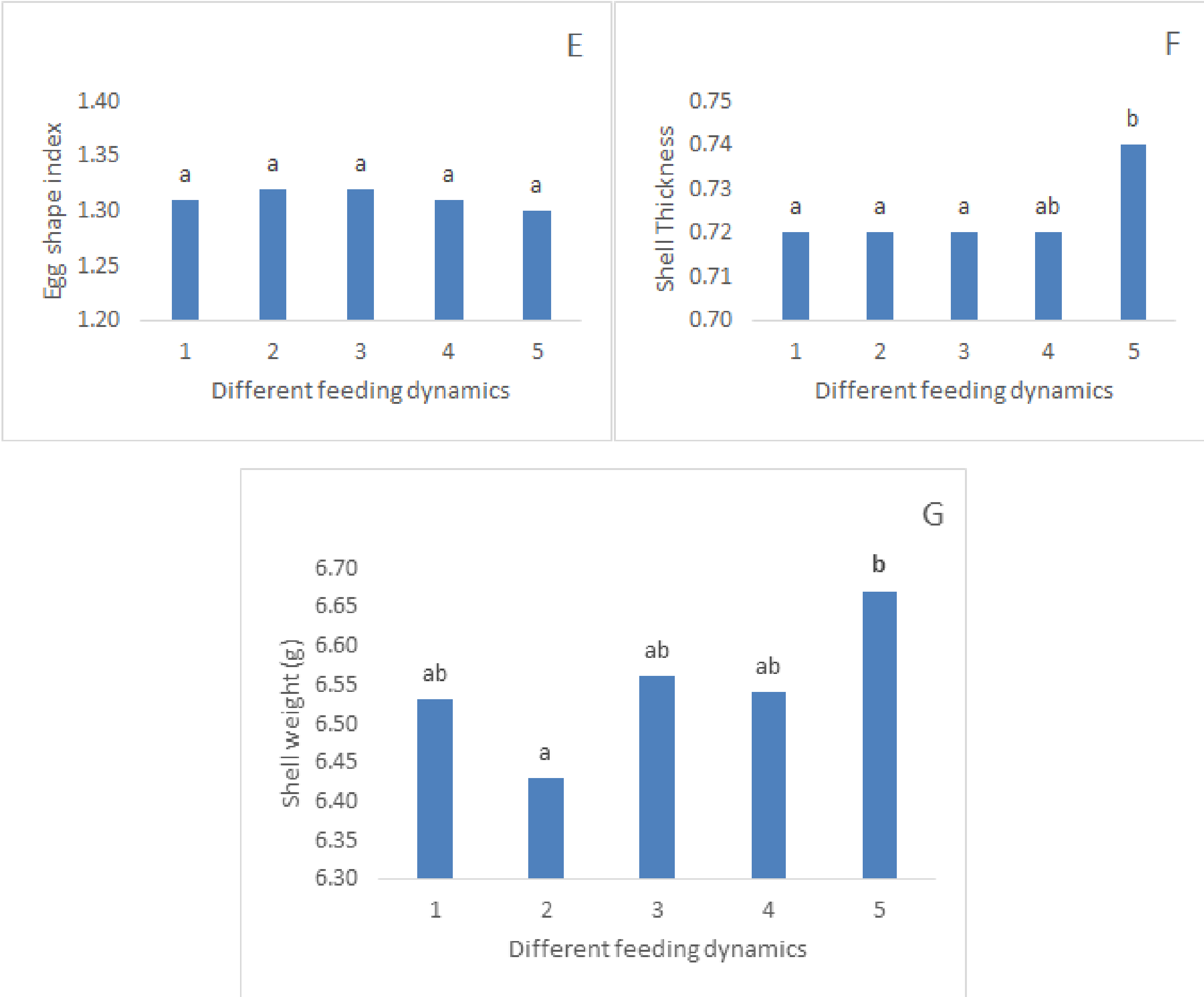


Figure 1. Effects of simulated feeding dynamics on Egg weight (A) grade (B) length (C) width (D) shape index (E) Shell thickness (F) and shell weight (G). Bars with different superscripts (alphabet) on a chart are significantly different (P<0.05).

Table 2. Interactive effects of stimulated feeding dynamics and feeding frequency on external egg quality of chicken's egg

Dynamics	Feeding frequency	Egg weight	Egg Grade	Egg Length	Egg width	Egg shape index	Shell thickness	Shell weight
Dynamics 1	Twice feeding	64.52±0.89	2.79±0.06[ab]	5.53±0.03[ab]	4.25±0.02[a]	1.30±0.01[ab]	0.72±0.01[ab]	6.66±0.11[ab]
	Thrice feeding	63.29±0.66[a]	2.85±0.05[b]	5.54±0.03[ab]	4.20±0.01[a]	1.31±0.01[b]	0.72±0.01[ab]	6.40±0.01[a]
Dynamics 2	Twice feeding	64.49±0.87[ab]	2.80±0.07[ab]	5.52±0.05[ab]	4.24±0.02[a]	1.31±0.01[b]	0.73±0.01[ab]	6.47±0.12a
	Thrice feeding	66.44±0.71[b]	2.94±0.04[b]	5.65±0.03[c]	4.26±0.02[a]	1.32±0.01[b]	0.70±0.01[a]	6.39±0.01[a]
Dynamics 3	Twice feeding	66.44±0.83[b]	2.90±0.05[b]	5.60±0.03[abc]	4.28±0.02[a]	1.31±0.01[b]	0.72±0.01[ab]	6.54±0.11[ab]
	Thrice feeding	65.67±0.94[ab]	2.83±0.05[b]	5.63±0.03[bc]	4.24±0.02[a]	1.32±0.01[b]	0.72±0.01[ab]	6.58±0.10[ab]
Dynamics 4	Twice feeding	64.83±0.58[ab]	2.92±0.04[b]	5.57±0.03[abc]	4.27±0.02[a]	1.30±0.01[ab]	0.73±0.01[ab]	6.65±0.08[ab]
	Thrice feeding	63.88±0.95[a]	2.65±0.08[a]	5.61±0.04[abc]	12.09±7.85[a]	1.32±0.01[b]	0.72±0.01[ab]	6.43±0.12[a]
Dynamics 5	Twice feeding	64.96±0.63[ab]	2.85±0.05[b]	5.51±0.02[a]	4.29±0.02[a]	1.29±0.01[a]	0.74±0.01[b]	6.57±0.01[ab]
	Thrice feeding	64.38±0.63[ab]	2.83±0.05[b]	5.53±0.03[ab]	4.24±0.02[a]	1.32±0.01[b]	0.74±0.01[b]	6.77±0.09[b]
Interactions		p-values	p-values	p-values	p-values	p-values	p-values	p-values
Dynamics		0.046	0.529	0.021*	0.404	0.463	0.071	0.245
Feeding freq.		0.519	0.397	0.038*	0.326	0.002*	0.213	0.328
Dynamics + Feeding freq.		0.243	0.004*	0.365	0.405	0.350	0.384	0.132
R^2 Values		0.032	0.39	0.41	0.019	0.36	0.30	0.28

Note: Values with the same superscript (alphabet) in a column are not significantly different ($p>0.05$). *p-values with asterisk connotes significant interactions ($p<0.05$)

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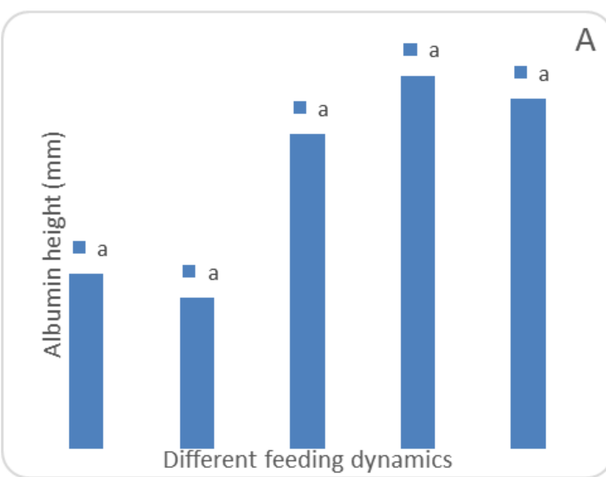
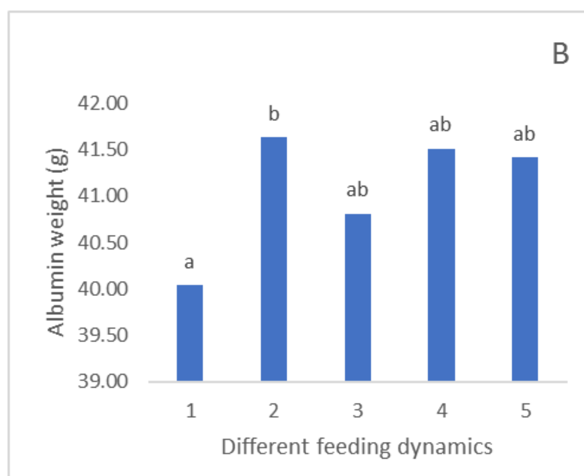
3.2. Effects of Simulated Feeding Dynamics on Internal Egg Quality of Poultry Birds

The effects of simulated feeding dynamics on egg albumen height, weight and percentage, yolk height, yolk weight, percentage yolk and haught unit are presented in Figure 2(A-G). The result showed that different stimulated feeding dynamics significantly contributed ($P<0.05$) to albumen weight (Figure A), yolk weight (Figure E) and percentage yolk (Figure F). The highest value for egg albumen weight was recorded in birds from feeding dynamics D2 while the least was recorded in birds from feeding dynamics D1. Furthermore, the highest value for yolk weight and percentage yolk was recorded in birds from feeding dynamics D4 while the least was recorded in birds from feeding dynamics D2. The interactive effect is presented in Table 3. It was recorded that all parameters on internal egg quality were not significantly ($P>0.05$) influenced by feed pattern. The results showed that both feeding dynamics and feeding frequencies did not significantly contribute to egg albumen height ($P>0.05$, R^2 = 0.24), egg albumen weight ($P>0.05$, R^2 = 0.35) and percentage albumen (0.05, R^2 = 0.19) width either as single or joint factors. Contrastingly, only feeding dynamics significantly contributed to yolk weight and percentage yolk as a single factor. However, no joint interaction effects of feeding dynamics and feeding frequency on yolk weight and percentage yolk was observed. The highest values for both yolk weight and percentage yolk were recorded in birds on feeding dynamics D4.

The result from this study revealed that egg weight, comprises of the cumulative weight of its components such as albumen, haught unit, yolk, etc. The only variability observed with respect to albumin properties of the egg with respect to the different feeding dynamics observed in this study was observed in egg albumen weight. The different feeding dynamics significantly affected the yolk weight and percentage yolk, but did not significantly affect the yolk height and haught unit. Studies have reported that egg quality characteristics such as yolk weight, percentage yolk, yolk height and colour have been of great interest to the egg industry [21-23]. Hence determining feeding practices that best suit these properties is very important. This current study revealed that medium alternation (two weekly) of AC and TF throughout the experiment produced the best results for yolk weight and yolk percentage.

To further understand the best feeding practices that will mostly influence these eggs qualities, we employed factorial analysis to study interactions between different feeding dynamics Simulated Feeding Dynamics (SFD) and feeding (FQ) frequencies using general linear model for univariate analysis of variance and this revealed that interaction between SFD and FQ only significantly affected egg grade. This implied that the role of the feed in quality egg production might be more important than the feeding frequency employed in this study. This is in contrast with earlier report of Molnár, et al. [18] who reported significant differences in some egg quality parameters with respect to different feeding frequencies. The reason for this disparity might be due to the differences in feeding frequency employed in this study and theirs. This study employed twice and thrice feeding a day, while their own study employed twice feeding and uncontrolled feeding (throughout the day).





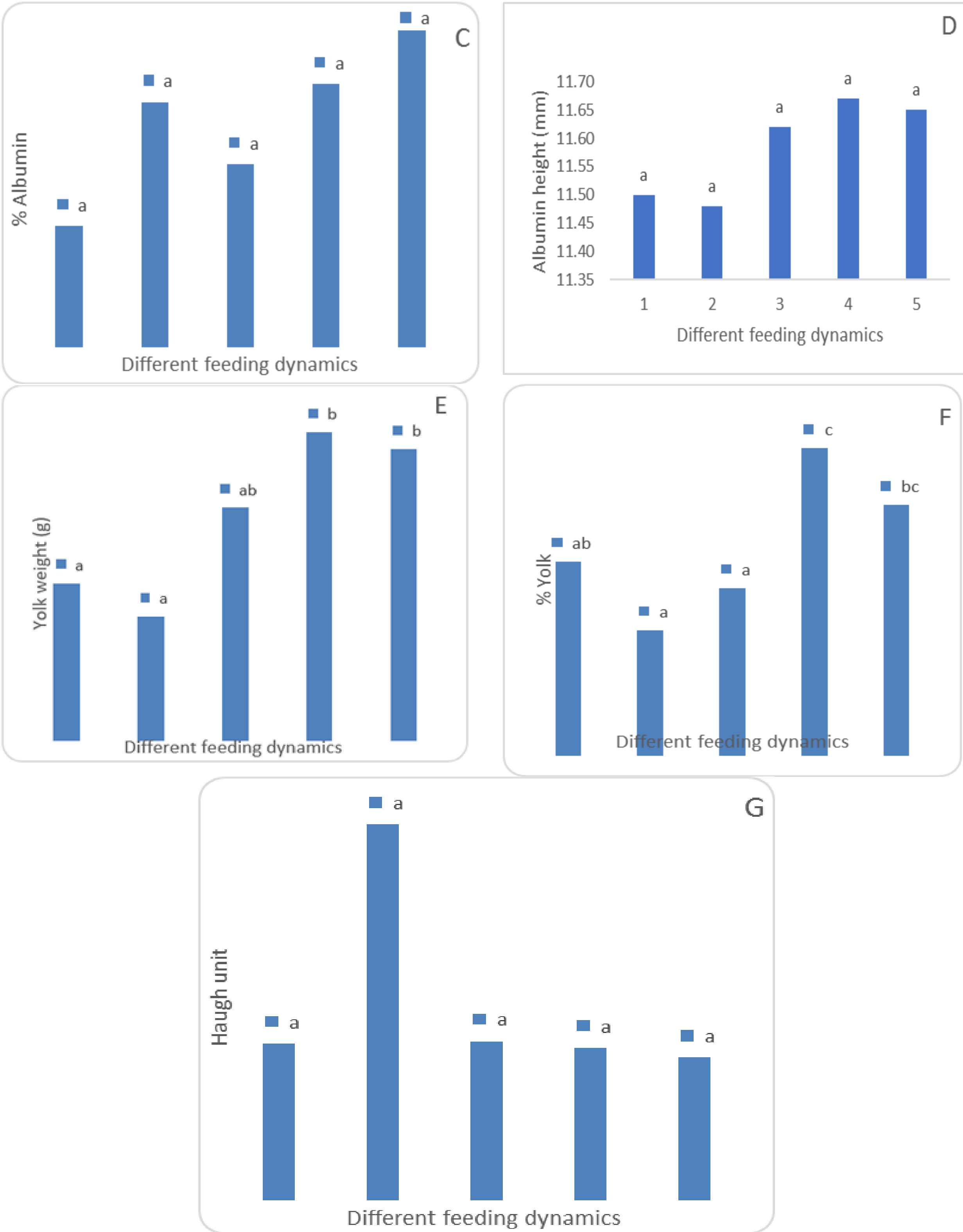


Figure 2. Effects of simulated feeding dynamics on Egg albumin height (A) weight (B) percentage albumin (C) Yolk height (D) Yolk weight € percentage yolk (F) and Haugh unit (G). Bars with different superscripts (alphabet) on a chart are significantly different (P<0.05).

Table 3. Interactive effects of stimulated feeding dynamics and feeding frequency on internal egg quality of chicken's egg

Dynamics	Feeding frequency	Albumin height	Albumin weight	% Albumin	Yolk height	Yolk weight	% Yolk	Haught Unit
Dynamics 1	Twice feeding	11.64±0.03[a]	41.15±0.86[ab]	63.23±0.99[a]	4.52±0.03[ab]	19.83±0.41[bcd]	30.81±0.71[abc]	105.08±0.13[ab]
	Thrice feeding	11.36±0.22[a]	38.94±0.56[a]	61.32±0.57[a]	4.42±0.02[a]	19.25±0.36[ab]	30.73±0.48[abc]	104.77±0.18[ab]
Dynamics 2	Twice feeding	11.39±0.21[a]	40.96±0.72[ab]	63.39±0.57[a]	5.29±0.81[b]	19.08±0.36[a]	29.97±0.50[ab]	123.74±18.95[b]
	Thrice feeding	11.57±0.04[a]	42.31±0.69[b]	63.75±0.85[a]	4.44±0.03[ab]	19.60±0.30[bc]	29.60±0.45[a]	105.26±0.13[ab]
Dynamics 3	Twice feeding	11.63±0.03[a]	40.79±0.66[ab]	61.58±0.93[a]	4.52±0.03[ab]	20.29±0.34[cd]	30.67±0.55[abc]	105.08±0.13[ab]
	Thrice feeding	11.62±0.03[a]	40.83±0.66[ab]	64.26±0.52[a]	4.45±0.03[ab]	19.69±0.25[bc]	30.10±0.41[ab]	105.01±0.17[ab]
Dynamics 4	Twice feeding	11.69±0.04[a]	42.25±0.70[b]	62.74±0.96[a]	4.57±0.03[ab]	20.90±0.35[d]	32.83±0.88[d]	104.62±0.15[ab]
	Thrice feeding	11.64±0.03[a]	40.77±0.72[ab]	64.79±1.02[a]	4.53±0.03[ab]	19.98±0.48[bcd]	31.95±0.53[cd]	104.85±0.13[ab]
Dynamics 5	Twice feeding	11.64±0.03[a]	42.06±0.55[b]	64.31±0.76[a]	4.53±0.03[ab]	20.44±0.30[cd]	31.51±0.50[bcd]	103.31±1.99[a]
	Thrice feeding	11.66±0.03[a]	40.77±0.94[ab]	64.34±0.76[a]	4.49±0.03[ab]	20.25±0.23[bcd]	31.66±0.43[bcd]	105.28±0.14[ab]
Interactions		p-values	p-values	p-values	p-values	p-values	p-values	p-values
Dynamics		0.217	0.145	0.384	0.537	0.004*	0.000*	0.397
Feeding freq.		0.681	0.114	0.304	0.181	0.105	0.324	0.392
Dynamics + Feeding freq.		0.253	0.100	0.410	0.452	0.269	0.906	0.425
R^2 Values		0.24	0.35	0.19	0.18	0.48	0.57	0.18

Note: Values with the same superscript (alphabet) in a column are not significantly different (p>0.05). * p-values with asterisk connotes significant interactions (P<0.05).

3.3. Interactive Effects of Simulated Feeding Dynamics and Feeding Frequency on Proximate Content of Eggs

The interactions effects of simulated feeding dynamics and feeding frequency on proximate contents of the eggs were presented in Table 4. The results showed that feeding dynamics and feeding frequency significantly ($P<0.05$) contributed (both singly and jointly) to ash, and crude protein contents of the egg. These interactions accounted for over 90% of the variations observed in the parameters. Feeding dynamics 4 and 5 significantly ($P<0.05$) decreased ash Crude protein (CP) and Carbohydrate (CHO) constituents of the egg. Feeding dynamics 4 and 5 also increased as well thrice feeding daily increased ($P<0.05$) the fat content of the egg.

Table 4. Interactive effect of stimulated feeding dynamics and feeding frequency on proximate content of eggs.

Dynamics	Feeding frequency	Ash	Fat	Crude protein	Moisture	CHO
Dynamics 1	Twice feeding	1.14^{cd}	19.25^{c}	12.48^{de}	23.25^{c}	43.87^{d}
	Thrice feeding	0.98^{bc}	11.12^{a}	13.49^{e}	21.87^{bc}	53.17^{g}
Dynamics 2	Twice feeding	1.48^{d}	19.70^{c}	11.82^{cd}	21.96^{bc}	45.29^{e}
	Thrice feeding	0.86^{b}	21.50^{d}	11.09^{bc}	23.04^{c}	43.51^{cd}
Dynamics 3	Twice feeding	1.04^{bc}	16.70^{b}	12.60^{de}	20.77^{ab}	48.91^{f}
	Thrice feeding	1.30^{cd}	23.12^{e}	10.29^{ab}	22.00^{bc}	43.92^{d}
Dynamics 4	Twice feeding	0.88^{b}	27.18^{g}	11.06^{bc}	22.68^{c}	38.75^{a}
	Thrice feeding	1.34^{cd}	25.70^{f}	9.67^{a}	23.43^{c}	39.87^{b}
Dynamics 5	Twice feeding	0.21^{a}	26.70^{g}	10.46^{ab}	20.00^{a}	42.65^{c}
	Thrice feeding	1.19^{cd}	29.25^{h}	9.74^{a}	20.94^{ab}	38.87^{ab}
Interactions		p-values	p-values	p-values	p-values	p-values
Dynamics		0.006*	0.001*	0.001*	0.003*	0.001*
Feeding freq.		0.019*	0.223	0.007*	0.130	0.900
Dynamics + Feeding freq.		0.001*	0.001*	0.018*	0.129	0.001*
R^2 Values		*0.913*	*0.997*	*0.910*	*0.824*	*0.994*

Note: Values with the same superscript (alphabet) in a column are not significantly different ($P>0.05$).* p-values with asterisk connotes significant interactions ($P<0.05$)

4. CONCLUSION

The results of this study showed that different feeding dynamics have influence on the external egg quality for weight and length in birds fed with short term (weekly) alternation of AC and TF throughout the experiment. Similarly the short term (Dynamic 3) option gave better balance of nutrient composition of the egg than dynamics 4 and 5. Alternation of feed in the longer course seems to favour increased shell thickness and shell weight of the eggs. From this study, it can be concluded that switching over to a feed of comparative quality not detrimental to egg quality however interchanging feeds on a short term basis (weekly) is recommended from the findings of this study. The study also observed that dividing daily feed allowance into three offers no advantage over feeding twice. Feeding laying birds twice daily is therefore recommended.

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