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Performance and Egg Qualities of Isa-Brown Layers Fed Different Quantities of Feed at Varying Feeding Frequencies

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Most poultry farmers in Nigeria feed their laying birds twice a day with one bag of 25 kg to 200 layers which translate to 125g/bird/day, while very few feed once or thrice a day and there has been little or no documentation on how many times laying hens should be fed in a day to optimize profit. Thus, this study was designed to investigate the performance and egg qualities of Isa-Brown layers fed different quantities of feed at varying feeding frequencies. Three hundred and sixty (360) 16-weeks in-lay Isa-Brown layers were used in this trial. The treatment consisted of 95g, 105g, 115g, and 125g of feed per day at varying frequencies of once, twice and thrice per day. The birds were housed in California type cages, 3 birds per cage unit, 5 cage units per replicate, and 6 replicates per treatment. A completely randomized experimental design with a 4x3 factorial was adopted. Results at the end of the trial showed that bird fed 115g of feed twice per day had the highest percentage hen-day production (85.24%), highest egg mass (56.69g) and best feed conversion ratio (1.96) while lowest percentage hen-day production (62.02%) and lowest egg mass (39.22g) were observed in hen fed 95g of feed thrice per day and worst feed conversion ratio (2.50) was recorded in bird fed 125g of feed thrice per day. The bird fed 115g twice per day had the highest net profit (N637.63) while the lowest net profit (N199.33) was recorded in bird fed 125g thrice per day. It could be concluded that for optimum laying performance and to save time and labour expended in feeding birds thrice per day, feeding laying Isa-Brown birds the required feed quantity (115g) twice per day would be most economical.

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Introduction

In a commercial poultry production system, profit can be attained by minimizing feed cost which accounts for about 60 - 70% of the total cost of production under intensive system management (Atteh 2002; Etalem et al., 2009; Adegbenro et al., 2012). The regular supply of feed over and above maintenance requirements is essential to improve productivity in the family of poultry production (FAO, 2004). The increasing cost of feed resources in livestock production has been identified as a serious impediment to meeting the demand for animal protein particularly in developing countries (Adejinmi et al., 2000). This challenge resulted in a research focus that could reduce the cost of feeding without negatively influencing the performance of the birds. The feed is the most important input for poultry production and the availability of low-priced, high-quality feeds are critical for the expansion of the poultry industry and quality (Ismoyowati and Sumarmono, 2011). The high cost of conventional feed ingredients and additives has led researchers worldwide to search for alternatives that will give an optimum performance (meat and egg) and to make these products available to the populace (Oyedeji et al., 2007). Generally, most poultry farmers in Nigeria feed their laying birds twice a day with one bag of 25kg to 200 layers which translate to 125g/bird/day, while very few feed once or thrice a day and there has been little or no documentation on how many times laying hens should be fed in a day to optimize profit. Splitting the daily feed allotment can ensure that a sufficient volume of feed is provided at each feeding time to minimize competition among the hens. However, the effect of feeding more than once a day on the production performance and egg quality is still controversial (Majid et al., 2013). In both developed and developing countries, increased egg production and consumption could significantly improve the nutritional needs of both children and adult. Eggs are an economical source of nutrients for a healthy diet and life, especially important for the mental development of growing children

(Miranda et al., 2015). Eggs, commonly available and low in cost or more affordable, represent a "complete food" required for wellbeing and are recognized by consumers as versatile and wholesome with a balance of essential nutrients to sustain both life and growth (Singh et al., 2012, Iannotti et al., 2014). This study, therefore, focused on feeding management of Isa-Brown laying birds concerning their production performance and economic benefits to maximise the net revenue of the farmers.

Materials and Methods

Experimental layout and feeding trials: Three hundred and sixty (360) 16weeks in-lay Isa-Brown laying birds were procured from a reputable farm for this trial. The laying birds were randomly distributed using a completely randomized experimental design with a 4×3 factorial arrangement, consisting of four different feeding quantities (95, 105, 115 and 125g) which were further divided each into three groups of varying feeding frequencies (once, twice and thrice per day). The birds were housed in a three (3) tiers Califonia type colony cages (43×41cm). Three (3) birds per cage unit, five (5) cage unit per replicate and six (6) replicate per treatment making a total of ninety (90) birds per treatment. The birds were weighed individually in all groups and the average weight was taken at the beginning of the experiment and thereafter at the end of each phase. The feeding trial lasted for twelve (12) weeks. The birds were fed at 8.00 am, 12 noon and 4.00 pm base on the feeding regime for each treatment except those fed once per day. The birds were also provided with fresh and clean water and the varying feed levels (95, 105, 115, and 125g) fed daily throughout the feeding period in all the groups. The weekly feed intake and eggs laid were recorded while feed conversion ratio was calculated from the data obtained from the weekly feed intake and egg mass. The experimental period was further divided into three (3) phases of four weeks per phase. Parameters on both internal and external quality of egg were taken in each group at the end of each phase.

Experimental Diets: A layers mash of 16.5% crude protein and 2500kcal/kg metabolizable energy was formulated for this trial. This was offered to the birds and replicated thrice based on the quantities (95, 105, 115 and 125g) and also on the frequency of feeding (once, twice and thrice daily). Table 1 shows the gross composition of the diet used.

Data Collection: Birds were weighed at the beginning of the experiment and the end of each phase (4^{th}, 8^{th}and12^{th} week) of the experimental period. The live weight changes were calculated by subtracting the initial weight from the weight at the end of the experiment. A weighed quantity of feed was fed every morning and the quantity left over the next morning weighed to account for daily feed intake (DFI). This was calculated as follow:

$$DFI=\frac{\text{Weekly feed consumption by a replicate}}{\text{No of birds in a replicate during that week}}\times\frac{1}{7}$$

Egg collection and production performance: Eggs were collected thrice a day; in the morning (8.00- 8.30 am), afternoon (12.00-12.30pm) and (4.30-5.00pm) for birds fed twice and thrice per day except those fed once a day. The number of eggs laid by birds in each replicate was recorded daily and summed up at the end of each phase to obtain production per phase. Eggs collected from each replicate, two (2) days to the end of each phase were properly labelled using a permanent marker. These eggs were randomly selected and used for the egg quality assessment. No mortality was recorded throughout the experimental period.

Table 1. Gross composition (kg) of the experimental diet

Ingredients	Quantity (kg)
Maize	54.25
Soybean meal (42%)	12.00
Groundnut cake	9.00
Wheat offal	11.00
Brewer dry grain	4.00
Oyster shell	6.00
Bone meal	3.00
Lysine	0.10
Methionine	0.10
Layer premix	0.25
Salt	0.30
Total	100.00
Calculated content	
Crude protein (%)	17.08
Energy (kcal/kg)	2685.00
Calcium (%)	3.44
Av. Phosphorus (%)	0.65
Lysine (%)	0.70
Methionine (%)	0.38

*Contained vitamins A (8,500,000 IU); D3 (1,500,000 IU); E (10,000mg); K3 (1,500mg); B1 (1,600mg); B2 (4,000mg); B6 (1,500mg); B12 (10mg); Niacin (20,000mg); Pantothenic acid (5,000mg); Folic acid (500mg); Biotin H2 (750mg); Choline chloride (175,000mg); Cobalt (200mg); Copper (3,000mg); Iodine (1,000mg); Iron (20,000mg); Manganese (40,000mg); Selenium (200mg); Zinc (30,000mg); and Antioxidant (1,250mg) per 2.5kg

The number of eggs laid by each replicate was recorded daily and the hen-day production (HDP) was calculated as the number of an egg laid divided by the number of hens and multiplied by 100 (Ahmed et al., 2009).

$$HDP=\frac{\text{Total number of eggs produced on each day}}{\text{Number of hen alive on each day}}\times 100$$

Egg mass was calculated by multiplying mean egg weight by egg production percentage.

AEM=HDP × AEW

AEM = Average egg mass
HDP = % Hen-day production (% HDP)
AEW = Average egg weight (gram)

Feed conversion ratio (FCR) was calculated as gram feed consumption per day per hen divided by gram egg mass:

$$FCR=\frac{\text{Feed consumption (g)}}{\text{Egg mass}}$$

Egg quality assessment: On the last two consecutive days of each phase, all eggs collected from each replicate were marked and a total of five (5) fresh eggs per replicate per phase were collected for determination of internal and external egg quality parameters.

Egg weight: Collected eggs were weighed using a sensitive digital balance (g). The weight of the egg was recorded and then the eggs were marked with a permanent marker.

Eggshell weight: After removing the yolk and the albumen from the shell, the shells were oven-dried for one hour at 40°C using laboratory oven, (TT-9053, Technel and Technel, USA) and weighed using a digital sensitive balance scale. Shell weight was determined according to the procedures described by Kul and Seker (2004)

Percentage shell weight: The percentage shell weight was calculated by dividing the shell weight by the weight of the egg and multiplying by 100 (Chowdhury and Smith 2001).

$$\text{Percent shell (\%)}\ \frac{\text{Weight of shell (g)}}{\text{Weight of egg in(g)}} \times 100$$

Eggshell thickness: After weighing the dried shell, part of the shell was cut and the inner layer removed to measure the thickness of the eggshell using micrometer screw gauge. The shell thickness was measured at three different points at the equatorial shell region and the average of the three was used as a trait.

Shell surface area: The shell surface area was calculated using the formula:

$$SSA = W^{0.667} \times 4.67$$

Where W= average egg weight, 0.667 and 4.67 are constant.

Albumen weight: Each egg was gently crack to expose the interior portion. The egg yolk was manually separated from the albumen with use of tablespoon. The albumen weight was then measured using a sensitive digital scale.

Haugh unit: Albumen quality is measured in terms of haugh units (HU) calculated from the albumen height and the weight of the egg

$$\text{Haugh unit} = 100 \log (AH + 7.57 - 1.7 \times EW^{0.35})$$

Where AH= Albumen height, EW= Egg weight, 7.57, 1.7 and 0.35 constant. (Haugh, 1937).

Economic analysis: The economic and cost of producing the experimental diets were estimated based on prevalent market prices for the ingredients as at the time of the experiment, which was used to calculate the total cost of feed, gross return from eggs and net return/profit.

Data Analysis: All data collected were subjected to 4 x 3 factorial analysis using SPSS version 17 package and where significant difference exists, Duncan Multiple Range Test (DMRT) of the same package was used to separate the means.

Results

Table 2 shows the effect of different quantities of feed and frequencies on the production performance of Isa-Brown laying birds. All the parameters measured were significantly (P<0.05) influenced by quantities of feed given. The highest final weight, highest weight gain and highest egg weight (1.80±0.01kg, 129.8±14.12g and 65.15±0.96g, respectively) were recorded in bird fed 125g/day of feed while lowest final weight, lowest weight gained and lowest egg weight (1.68±0.01kg, 54.13±80.00g and 64.03±0.36g, respectively) were recorded in birds fed 95g/day, 95g/day and 105g/day of feed respectively. Also highest %HDP (80.48±1.13%), highest egg mass (51.71±1.14g) and best FCR (2.17±0.05) were recorded in birds fed 115g/day while lowest %HDP (64.29±0.48%), lowest egg mass (41.37±0.42g) and poor FCR (2.38±0.03) were observed in birds fed 95g/day, 95g/day and 125g/day, respectively.

Table 2. Effect of different quantities of feed and feeding frequencies on production performance of Isa-Brown laying birds at 36-48th weeks.

QF	F	IW(kg)	FW(kg)	WG(g)	FCBD(g)	TFCB(kg)	TEB	HDP(%)	EW(g)	EM(g)	FCR
95		1.62±0.01^{b}	1.68±0.01^{c}	54.13±80.00^{c}	094.40±0.31^{d}	7.93±0.03^{d}	54.00±0.40^{d}	64.29±0.48^{d}	64.33±0.21^{b}	41.37±0.42^{d}	2.28±0.02^{b}
105		1.61±0.01^{b}	1.72±0.02^{bc}	112.2±12.77^{ab}	103.29±0.34^{c}	8.68±0.03^{c}	60.13±0.51^{c}	71.59±0.61^{c}	64.03±0.36^{d}	45.85±0.52^{c}	2.25±0.03^{c}
115		1.64±0.02^{ab}	1.73±0.02^{b}	90.17±13.02^{b}	112.30±0.45^{b}	9.43±0.04^{b}	67.60±0.95^{a}	80.48±1.13^{a}	64.16±0.53^{c}	51.71±1.14^{a}	2.17±0.05^{d}
125		1.67±0.01^{a}	1.80±0.01^{a}	129.8±14.12^{a}	117.86±0.69^{a}	9.90±0.06^{a}	63.93±0.67^{b}	76.11±0.8^{b}	65.15±0.96^{a}	49.57±0.86^{b}	2.38±0.03^{a}
	1	1.63±0.01	1.72±0.02	89.58±13.96	106.59±1.87	8.95±0.16	60.70±0.98^{c}	72.26±1.17^{c}	63.25±0.52^{c}	45.61±0.50^{c}	2.34±0.03^{a}
	2	1.62±0.01	1.73±0.02	107.0±12.79	107.40±2.15	9.02±0.18	62.75±1.45^{a}	74.70±1.73^{a}	65.75±0.54^{a}	49.24±1.43^{a}	2.2±0.04^{c}
	3	1.65±0.02	1.74±0.02	93.15±90.38	106.89±2.22	8.98±0.19	60.80±1.33^{b}	72.38±1.58^{b}	64.25±0.23^{b}	46.53±1.07^{b}	2.3±0.03^{b}
	1	1.63±0.02	1.68±0.03	45.40±21	095.00±0.66	7.98±0.06	54.1±0.00	64.41±0.00	65.03±0.00	41.88±0.00	2.27±0.01
95	2	1.62±0.02	1.65±0.03	35.00±21	094.80±0.66	7.96±0.06	55.8±0.00	66.43±0.00	64.74±0.00	43.01±0.00	2.20±0.01
	3	1.61±0.02	1.70±0.03	82.00±21	093.40±0.66	7.85±0.06	52.1±0.00	62.02±0.00	63.23±0.00	39.22±0.00	2.38±0.01
	1	1.63±0.02	1.74±0.03	113.20±21	103.32±0.66	8.68±0.06	60.1±0.00	71.55±0.00	65.84±0.00	47.11±0.00	2.19±0.01
105	2	1.59±0.02	1.71±0.03	121.40±21	103.78±0.66	8.72±0.06	57.8±0.00	68.81±0.00	62.65±0.00	43.11±0.00	2.41±0.01
	3	1.61±0.02	1.71±0.03	102.00±21	102.76±0.66	8.63±0.06	62.5±0.00	74.41±0.00	63.60±0.00	47.32±0.00	2.17±0.01
	1	1.59±0.02	1.67±0.03	75.30±21	112.83±0.66	9.48±0.06	63.0±0.00	75.00±0.00	61.69±0.00	46.27±0.00	2.44±0.01
115	2	1.64±0.02	1.77±0.03	128.00±21	110.98±0.66	9.32±0.06	71.6±0.00	85.24±0.00	66.51±0.00	56.69±0.00	1.96±0.01
	3	1.70±0.02	1.77±0.03	67.20±21	113.09±0.66	9.50±0.06	68.2±0.00	81.19±0.00	64.28±0.00	52.19±0.00	2.17±0.01
	1	1.69±0.02	1.81±0.03	124.40±21	115.20±0.66	9.68±0.06	65.6±0.00	78.10±0.00	60.43±0.00	47.20±0.00	2.44±0.01
125	2	1.65±0.02	1.79±0.03	143.60±21	120.06±0.66	10.09±0.06	65.8±0.00	78.33±0.00	69.11±0.00	54.14±0.00	2.22±0.01
	3	1.66±0.02	1.79±0.03	121.40±21	118.31±0.66	9.94±0.06	60.4±0.00	71.91±0.00	65.89±0.00	47.38±0.00	2.50±0.01
Q		**	**	**	**	**	*	*	*	*	**
F		NS	NS	NS	NS	NS	*	*	*	*	**
Q×F		*	NS	NS	**	**	*	*	*	*	**

QF: Quantity of feed (g/day), F: Frequency, Q: Quantity, Within column, means followed by different letters are significantly different (P<0.05), NS= None significant, * significant, IW= initial weight, FW=Final weight, WG=Weight gain, FCBD=Feed consumed/bird/day, TFCB=Total feed consume/bird, TEB=Total egg produced/bird, HDP= Hen-day production, EW=Egg weight, EM=Egg mass, FCR=Feed conversion ratio.

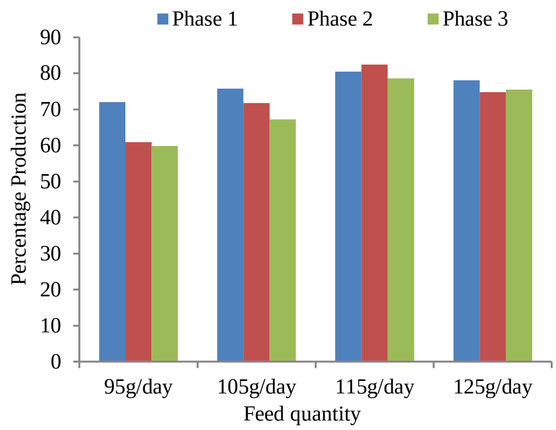

Figure 1. Effect of different quantity of feed at different feeding phases on percentage Hen Day Production (%HDP)

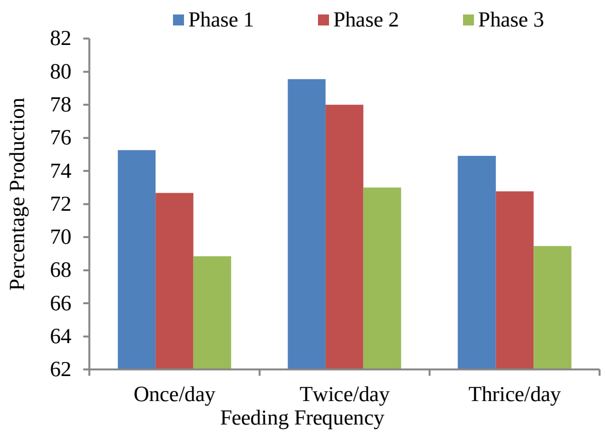

Figure 2. Effect of different feeding frequencies at different feeding phases on percentage Hen Day Production (%HDP)

Table 3. Effect of different quantities of feed and frequencies of feeding on external egg quality of Isa-Brown laying birds at 36-48th week.

Quantity	Frequency	EW(g)	EL(cm)	EWD(cm)	SW(g)	ST(mm)	%SW	SSA(cm^2)
95		64.57±0.80	4.72±0.50	3.50±0.33	6.45±0.09	0.37±0.01	10.03±0.14^b	75.14±0.62
105		63.93±0.85	4.71±0.28	3.48±0.28	6.56±0.12	0.36±0.01	10.30±0.17^{ab}	74.70±0.67
115		63.69±0.69	4.73±0.35	3.44±0.17	6.67±0.09	0.35±0.02	10.49±0.13^a	74.54±0.53
125		63.24±0.78	4.73±0.35	3.43±0.2	6.63±0.12	0.35±0.02	10.51±0.17^a	74.17±0.61
	1	62.77±0.66	4.71±0.40	3.45±0.28	6.64±0.11	0.36±0.01	10.60±0.16^a	73.76±0.51
	2	64.38±0.73	4.78±0.28	3.46±0.19	6.60±0.08	0.37±0.02	10.28±0.11^{ab}	75.06±0.56
	3	64.41±0.62	4.73±0.30	3.47±0.16	6.50±0.08	0.34±0.01	10.11±0.12^b	75.10±0.49
	1	64.41±1.35	4.73±0.65	3.56±0.43	6.57±0.17	0.37±0.03	10.25±0.26	74.90±1.05
95	2	64.44±1.35	4.76±0.65	3.50±0.43	6.41±0.17	0.37±0.03	09.97±0.26	75.08±1.05
	3	64.86±1.35	4.78±0.65	3.45±0.43	6.39±0.17	0.36±0.03	09.88±0.26	75.45±1.05
	1	64.49±1.35	4.68±0.65	3.49±0.43	7.14±0.17	0.39±0.03	11.10±0.26	75.11±1.05
105	2	62.88±1.35	4.77±0.65	3.42±0.43	6.31±0.17	0.37±0.03	10.07±0.26	73.90±1.05
	3	64.41±1.35	4.68±0.65	3.52±0.43	6.24±0.17	0.33±0.03	09.72±0.26	75.09±1.05
	1	61.46±1.35	4.64±0.65	3.40±0.43	6.63±0.17	0.36±0.03	10.81±0.26	72.80±1.05
115	2	64.93±1.35	4.78±0.65	3.46±0.43	6.82±0.17	0.36±0.03	10.52±0.26	75.51±1.05
	3	64.67±1.35	4.77±0.65	3.46±0.43	6.55±0.17	0.34±0.03	10.14±0.26	75.30±1.05
	1	60.73±1.35	4.68±0.65	3.36±0.43	6.22±0.17	0.32±0.03	10.25±0.26	72.24±1.05
125	2	65.29±1.35	4.82±0.65	3.48±0.43	6.87±0.17	0.39±0.03	10.57±0.26	75.74±1.05
	3	63.70±1.35	4.68±0.65	3.45±0.43	6.80±0.17	0.35±0.03	10.71±0.26	74.53±1.05
Quantity		NS	NS	NS	NS	NS	NS	NS
Frequency		NS	NS	NS	NS	NS	*	NS
Quantity×Frequency		NS	NS	NS	*	NS	*	NS

Within column, means followed by different letters are significantly different (P<0.05), NS= None significant, * significant, EW=Egg weight, EL=Egg length, EWD=Egg width, SW=Shell weight, ST=Shell thickness, %SW=Percentage shell weight, SSA= Shell surface area.

For the frequency, only the total egg produced per bird, % HDP, egg weight and egg mass were significantly (P<0.05) influenced. Nevertheless, highest weight gained (107.0±12.79g), highest HDP (74.70±1.73%), highest egg weight (65.75±0.54g), highest egg mass (949.24±1.43g) and best FCR 92.2±0.04) were observed in bird fed twice/day while the lowest weight gained (989.58±13.96g), lowest HDP (72.26±1.17%), lowest egg weight (63.25±0.52g), lowest egg mass (45.61±61±0.50g) and poor FCR (2.34±0.03) were recorded in bird fed once/day. In term of interaction, all the parameters measured were not significantly (P>0.05) influenced. However, the highest final weight (1.81±0.03kg) was recorded in bird fed 125g once/day while the lowest final weight (1.65±0.03kg) was observed in bird fed 95g twice/day. Highest %HDP (85.24±0.00%) and best FCR (1.96±0.01) were recorded in bird fed 115g twice/day while lowest %HDP (62.02±0.00%) and poor FCR (2.50±0.01) were recorded in bird fed 95g of feed thrice/day and 125g of feed thrice/day, respectively.

Figure 1 shows the effect of different feeding quantities at different feeding phases on percentage hen-day production. From the figure, it shows that bird fed 115g/day had the percentage highest percentage hen-day-production (%HDP) compared to other feeding quantities. Also, all other feeding levels except 115g/day had their highest percentage hen-day-production (%HDP) at the first phases of the feeding trial. A chap reduction was observed at the second and third feeding phases for bird fed 95g/day. Also, reduction in the percentage hen-day-production (HDP) was recorded in bird fed 105g/day and 125g/day of feed. In all, birds fed 115g/day had the best percentage hen-day-production (%HDP) at the second feeding phase. Figure 2 shows the effect of different feeding regime on the percentage hen day production at different feeding phases. It was observed that bird fed twice/day had the best %HDP performance compared to other feeding regimes. A gradual reduction in %HDP performance was observed in the three feeding regimes from phase one to phase three, however, bird fed twice/day still performed better.

Table 4. Effect of different quantities of feed and frequencies of feeding on internal egg quality of Isa-Brown laying birds at 36-48th week

Quantity	Frequency	YW(g)	YH(mm)	YWD(mm)	AW(g)	AH(mm)	YI	HU	%YW
95		15.90±0.24	13.36±0.26	43.22±0.31[ab]	39.44±0.67	7.69±0.39	0.31±0.01	83.80±2.39	24.76±0.43
105		15.85±0.20	12.84±0.28	42.49±0.28[b]	39.83±0.72	7.72±0.24	0.30±0.01	85.91±1.48	24.90±0.35
115		15.84±0.16	13.09±0.27	42.96±0.24[b]	39.12±0.56	7.51±0.31	0.30±0.01	84.12±1.83	24.94±0.27
125		15.73±0.40	12.76±0.28	43.93±0.37[a]	38.62±0.61	7.11±0.33	0.29±0.01	81.34±2.01	24.92±0.60
	1	15.61±0.17	13.15±0.22	42.48±0.23[b]	38.87±0.50	7.77±0.27	0.31±0.01	86.00±1.53	24.93±0.23
	2	16.08±0.17	13.00±0.26	43.47±0.29[a]	39.49±0.60	7.57±0.29	0.30±0.01	83.92±1.72	25.10±0.31
	3	15.80±0.32	12.88±0.23	43.50±0.26[a]	39.40±0.56	7.19±0.28	0.30±0.01	81.46±1.80	24.61±0.51
	1	15.81±0.46	13.20±0.46	42.47±0.50	40.51±1.11	8.47±0.54	0.31±0.01	89.41±3.29	24.58±0.75
95	2	16.38±0.46	13.13±0.46	43.93±0.50	38.74±1.11	8.33±0.54	0.30±0.01	86.98±3.29	25.66±0.75
	3	15.52±0.46	13.73±0.46	43.27±0.50	39.07±1.11	6.27±0.54	0.32±0.01	74.99±3.29	24.05±0.75
	1	15.94±0.46	13.33±0.46	42.40±0.50	39.77±1.11	8.27±0.54	0.32±0.01	89.24±3.29	24.80±0.75
105	2	15.44±0.46	11.80±0.46	41.67±0.50	39.06±1.11	7.13±0.54	0.28±0.01	82.49±3.29	24.72±0.75
	3	16.15±0.46	13.40±0.46	43.40±0.50	40.65±1.11	7.76±0.54	0.31±0.01	86.01±3.29	25.19±0.75
	1	15.22±0.46	13.13±0.46	42.67±0.50	38.31±1.11	6.73±0.54	0.31±0.01	80.40±3.29	24.84±0.75
115	2	16.09±0.46	13.60±0.46	42.87±0.50	40.12±1.11	8.20±0.54	0.32±0.01	88.15±3.29	24.83±0.75
	3	16.22±0.46	12.53±0.46	43.33±0.50	38.93±1.11	7.60±0.54	0.29±0.01	83.80±3.29	25.17±0.75
	1	15.49±0.46	12.93±0.46	42.40±0.50	36.90±1.11	7.60±0.54	0.31±0.01	84.92±3.29	25.52±0.75
125	2	16.40±0.46	13.47±0.46	45.40±0.50	40.03±1.11	6.60±0.54	0.30±0.01	78.06±3.29	25.20±0.75
	3	15.30±0.46	11.87±0.46	44.00±0.50	38.95±1.11	7.13±0.54	0.27±0.01	81.04±3.29	24.05±0.75
Quantity		NS	NS	*	NS	NS	NS	NS	NS
Frequency		NS	NS	*	NS	NS	NS	NS	NS
Quantity×Frequency		NS	*	*	NS	*	*	NS	NS

Within column, means followed by different letters are significantly different (P<0.05), NS= None significant, * significant, YW=Yolk weight. YH=Yolk height, YWD=Yolk width, AW=Albumen weight, AH=Albumen height, YI=Yolk index, HU=Haugh unit, %YW= percentage yolk weight.

Table 3 shows the effect of different quantities of feed and frequencies of feeding on the external egg qualities of Isa-Brown laying birds. Among all the parameters measured for quantity, frequency and interaction, only the shell weight was significantly (P<0.05) influenced by quantities of feed and frequencies of feeding. Considering the quantity of feed, highest egg weight (64.70g), highest egg length (4.80cm) and highest egg width (3.50cm) were observed in bird fed 95g/day while lowest egg weight (63.24g), lowest egg length (4.71cm) and lowest egg width (3.50cm) were observed in birds fed 125g/day,105g/day and 125g/day respectively. For frequency of feeding, highest egg weight (64.41g), highest egg width (3.47cm) and highest egg length (4.78cm) were recorded in birds fed thrice/day, thrice/day and twice/day respectively. Lowest egg weight (62.77g), lowest egg length (4.71cm) and lowest egg width (34.51cm) were observed in bird fed once/day. Looking at the interaction, highest egg weight (65.29g) was observed in birds fed 125g twice/day, highest egg length (4.86cm) and highest egg width (3.56cm) in birds fed 95g once/day. Lowest egg weight (61.46g) was recorded in bird fed 115g once/day, while lowest egg length (4.68cm) and lowest egg width (3.59cm) were recorded in birds fed 105g once/day and 125g once/day, respectively. Base on the quantity of feed, the highest shell weight (6.67±0.09g), highest shell thickness (0.37±0.01mm), highest percent shell weight (10.51±0.17%) and highest shell surface area (74.17±0.61cm^2) were recorded for birds fed 115, 95, 125 and 95g/day of feed, respectively, while the lowest shell weight (6.45±0.09g) and lowest percent shell weight (10.03±0.14%) were observed in birds fed 95g/day of feed. Lowest shell thickness (0.35±0.02mm) and lowest shell surface area (74.17±0.61cm$^{2)}$ were also recorded in birds fed 125g/day. For frequency of feeding, highest shell weight (6.64±0.11g) highest percent shell weight (10.60±0.16%) and lowest shell surface area (73.76±0.51cm^2) were observed in bird fed once/day while the highest shell thickness (0.37±0.02mm) was recorded for bird fed twice/day. Highest shell surface area (75.10±0.49cm^2), lowest shell weight (6.50±0.08g), lowest shell thickness (0.34±0.01mm) and lowest % shell weight were observed in bird fed thrice/day. For the interaction, highest shell weight (7.14±0.17g), highest shell thickness (0.39±0.03mm) and highest % shell weight (11.10±0.26%) were recorded in bird fed 105g once/day while the lowest shell weight (6.22±017g), lowest shell thickness (0.32±0.03mm), and lowest shell surface area (72.24±1.05cm^2) area were observed in birds fed 125g once/day. Lowest % shell thickness (09.72±0.26%) and highest shell surface area (75.74±1.05cm^2) were recorded in birds fed 105g thrice/day and 125g twice/day, respectively.

Table 4 shows the qualities of the internal egg of Isa-Brown laying birds fed different quantities of feed at different feeding frequencies. Among all the parameters measured for the quantity, frequency and interaction, only the yolk width was significantly (P<0.05) influenced at the quantity and frequency levels. For the quantity of feed, highest yolk weight (15.09±0.24g), highest yolk height (13.36±0.26mm) and highest yolk width (43.93±0.37mm) were observed in birds fed 95g/day,95g/day and 125g/day, respectively while lowest yolk weight (15.73±0.40g) and lowest yolk height (12.76±0.28mm) were observed in bird fed 125g/day. Considering the frequency of feeding, highest yolk weight (16.08±0.17g) and lowest yolk weight (15.61±0.17g) were recorded in birds fed twice/day and once/day respectively. Highest yolk height (13.15±0.22mm) and lowest yolk width (42.48±0.23mm) were recorded in birds fed once/day while lowest yolk height and highest yolk width (12.88±0.23mm and 43.50±0.26mm) were observed in bird fed thrice/day. For interaction, highest yolk weight (16.40±0.46g) and highest yolk width (45.40±0.50mm) were observed in birds fed 125g twice/day while lowest yolk weight (15.22±0.46g) and lowest yolk width (41.67±0.50mm) were recorded in bird fed115g once/day and 105g twice/day. Highest yolk height (13.73±0.46mm) and lowest yolk height (11.80±0.46mm) were recorded in bird fed 95g thrice/day. For the quantity of feed, highest albumen weight (39.83±0.72g) and highest albumen height (7.72±0.24mm) were observed in bird fed 105g/day while the lowest albumen weight (38.62±0.61g) and lowest albumen height (7.11±0.33) were recorded in bird fed125g/day. For frequency of feeding, highest albumen weight (39.49±0.60g) and highest albumen height (7.77±0.27mm) were observed in bird fed twice/day and once/day respectively. Lowest albumen weight (38.87±0.50g) and lowest albumen height (7.19±0.28mm) were observed in bird fed once/day and thrice/day respectively. For interaction, highest albumen weight (40,65±1.11g) and highest albumen height (8.47±0.54mm) were recorded in bird fed 105g thrice/day and 95g once/day respectively while the lowest albumen weight (38.31±1.11g) and lowest albumen height (6.27v0.54mm) were observed in bird fed 115g thrice/day. For quantity of feed, highest yolk index (0.31±0.01), highest haugh unit (85.91±1.48) and highest % yolk weight (24.94±0.27%) were recorded in birds fed 95g/day, 105g/day and 115g/day respectively. For frequency of feeding, highest yolk index (0.31±0.01), highest haugh unit (86.00±1.53) and highest %yolk weight (25.10±0.31%) were observed in birds fed once/day and twice/ day, respectively while the lowest yolk index (0.30±0.01), lowest haugh unit (81.46±1.80) and lowest %yolk weight (24.61±0.51%) were recorded in bird fed thrice/day. For the interaction, highest yolk index (0.32±0.01)was recorded in birds fed 95g thrice/day,105g once/day and 115g twice/day while the lowest yolk index was observed in bird fed 125g thrice/day. Highest haugh unit (89.41±3.29) and highest percentage yolk weight (25.66±0.75) were recorded in bird fed 95g once/day and 95g twice/day, respectively while the lowest haugh unit (74.99±3.29) and lowest percentage yolk weight (24.05±0.75) was observed in bird fed 95g thrice/day.

Table 5 shows the feed cost, gross return and net return/profit from birds fed different quantities of feed at varying feeding frequencies. All the parameters measured under the quantities of feed given were significantly (P<0.05) influenced while the total egg produced per bird (TEB), crates of egg produced per bird (CRTB), gross return from eggs (GRT) and net profit (NETPFT) were significantly influenced (P<0.05) by the frequency of feeding. For all parameters measured under the interaction, they were not significantly influenced (P >0.05). For quantity of feed given, highest total egg produced per bird (67.60±1.07 eggs), highest crate of egg/bird (2.25±0.04) and the highest gross return atN850/crate of egg(N1915.33±30.21) were recorded in bird fed 115g/day while the lowest total egg production per bird (54.00±0.46 eggs), lowest crate of egg/bird(1.80±0.02) and lowest gross return N850/crate of egg (N1539.00±12.92) were observed in bird fed 95g/day. For frequency, highest total egg produced per bird (62.75±1.64), highest crate of egg/bird (2.09±0.05) and highest gross return N850/crate of egg (N1777.92±46.33) were recorded in bird fed twice/day while the lowest total egg production per bird (60.70±1.10), lowest crate of egg/bird (2.02±0.04) and lowest gross return N850/crate of egg (N1719.83±31.30)were observed in bird fed once/day. For the interaction, highest total egg produced per bird (71.60±0.00), highest crate of egg/bird (2.39±0.00) and highest gross return N850/crate of egg (N2028.67±0.00) were recorded in bird fed 115g twice/day, while the lowest total egg production per bird (52.10±0.00), lowest crate of egg/bird (1.74±0.00) and lowest gross return N850/crate of egg (N1476.17±0.00) were observed in 95g thrice/day. In term of quantity, highest net profit (N524.29±30.21) was recorded in bird fed 115g/day while the bird fed 125g/day had the lowest net profit. For the frequency, highest net profit (N447.36±29.39) were recorded in bird fed twice/day while the lowest net profit (N389.27±70.97) was recorded in bird fed once/day.

Table 5. Economic effect of different quantities of feed and frequencies of feeding on the production of Isa-Brown laying birds at 36-48th week.

Quantity	Frequency	FCB(g)	TFCB(kg)	P/Kg(N)	TCFB	TEB	CRTB	GRT@N850	NETPFT
95		95±0.00[d]	7.98±0.00[d]	144	1149.12±00[a]	54.00±0.46[d]	1.80±0.02[d]	1530.00±12.92[d]	380.88±12.92[c]
105		105±0.00[c]	8.82±0.00[c]	144	1270.08±00[c]	60.13±0.58[c]	2.00±0.02[c]	1703.78±16.39[c]	433.70±16.39[b]
115		115±0.00[b]	9.66±0.00[b]	144	1391.04±00[b]	67.60±1.07[a]	2.25±0.04[a]	1915.33±30.21[a]	524.29±30.21[a]
125		125±0.00[a]	10.5±0.00[a]	144	1512±00.00[a]	63.93±0.75[b]	2.13±0.03[b]	1811.44±21.36[b]	299.44±21.36[d]
	1	110±2.89	9.24±0.24	144	1330.56±34.92	60.70±1.10[c]	2.02±0.04[c]	1719.83±31.30[c]	389.27±70.91[c]
	2	110±2.89	9.24±0.24	144	1330.56±34.92	62.75±1.64[a]	2.09±0.05[a]	1777.92±46.33[a]	447.36±29.39[a]
	3	110±2.89	9.24±0.24	144	1330.56±34.92	60.80±1.49[b]	2.03±0.05[b]	1722.67±42.26[b]	392.11±35.46[b]
95	1	95±0.00	7.98±0.00	144	1149.12±0.00	54.10±0.00	1.80±0.00	1532.83±0.00	383.71±0.00
	2	95±0.00	7.98±0.00	144	1149.12±0.00	55.80±0.00	1.86±0.00	1581.00±0.00	431.88±0.00
	3	95±0.00	7.98±0.00	144	1149.12±0.00	52.10±0.00	1.74±0.00	1476.17±0.00	327.05±0.00
105	1	105±0.00	8.82±0.00	144	1270.08±0.00	60.10±0.00	2.00±0.00	1702.83±0.00	432.75±0.00
	2	105±0.00	8.82±0.00	144	1270.08±0.00	57.80±0.00	1.93±0.00	1637.67±0.00	367.59±0.00
	3	105±0.00	8.82±0.00	144	1270.08±0.00	62.50±0.00	2.08±0.00	1770.83±0.00	500.75±0.00
115	1	115±0.00	9.66±0.00	144	1391.04±0.00	63.00±0.00	2.10±0.00	1785.00±0.00	393.96±0.00
	2	115±0.00	9.66±0.00	144	1391.04±0.00	71.60±0.00	2.39±0.00	2028.67±0.00	637.63±0.00
	3	115±0.00	9.66±0.00	144	1391.04±0.00	68.20±0.00	2.27±0.00	1932.33±0.00	541.29±0.00
125	1	125±0.00	10.5±0.00	144	1512.00±0.00	65.60±0.00	2.19±0.00	1858.67±0.00	346.67±0.00
	2	125±0.00	10.5±0.00	144	1512.00±0.00	65.80±0.00	2.19±0.00	1864.33±0.00	352.33±0.00
	3	125±0.00	10.5±0.00	144	1512.00±0.00	60.40±0.00	2.01±0.00	1711.33±0.00	199.33±0.00
Quantity		*	*	NS	*	*	*	*	*
Frequency		NS	NS	NS	NS	*	*	*	*
Quantity×Frequency		NS	NS	NS	NS	*	*	*	*

Within column, means followed by different letters are significantly different (P<0.05), NS= None significant, * significant ,FCB= Feed consume/bird, TFCB=Total feed consume/bird, P/Kg= Price per kilogram of feed, TCFB=Total cost of feed consume/bird, TEB=Total egg produced/bird, CRTB=Crate of egg/bird, GRT= Gross return at #850/crate, NETPFT=Net profit.

For the interaction, highest net gain ((N637.63±0.00) was observed in bird fed 115g twice/day while the lowest net gain (N199.33±0.00) was recorded for bird fed 125g thrice/day.

Discussion

A profitable egg production business can be achieved through effective management of the feeding programme. In this trial, the final body weight observed showed a relative increase in weight in comparison to the feed consumed. Bird fed 125g/day with highest body weight produced the highest egg weight. This agreed with the findings of Kirikç et al., (2007) who reported a direct correlation between body weight and egg weight. However, there is no direct correlation between the hen-day production and bodyweight which contradict the findings of Olawumi (2014) who reported that egg production at whatever age depends on body weight of hens and that whatever affects the latter will have a concomitant effect on the former. The weight gain observed in this study showed that the bird fed 125g/day had the highest weight gain. This could be explained as a result of the excess feed consumed by this bird was used to develop the body muscle which justifies for the increase in the body weight. Bird fed 105g/day that consume less compared to bird fed 115g/day had a better weight increase.This could be explained that the excess feed consumed by bird fed 115g/day was used for egg production to justify for the lesser increase in `weight gain and this could also be attributed to increasing demand for nutrients from physiological reserve to meet the demand for egg production as reported by (Olawumi , 2014). Also from the result, bird fed 115g/day had the best %HDP compared to the rest of the treatment. This could be attributed to better feed conversion and efficient feed utilization observed in this treatment. This corroborates the report of Renema et al., (2008) who stated that small degrees of over or underfeeding have been shown to negatively impact egg production. However, this report contradicted the findings of Sekoni et al., (2002) who concluded that quantitative feed restriction did not have any significance on feed consumption and efficiency of feed for egg production. Differences in total egg production observed in this study shows that bird fed two times a day (morning and noon) had better egg production compared with those fed once and thrice a day. This result was consistent with previous reports related to feeding regime performance reported by Majid et al. ,(2013). Also, allocation of restricted feed two times a day improve reproductive performance in broiler breeder hens as reported by (Spradley et al., (2008), Taherkhani et al., (2010) and Moradi et al. ,(2013). Better performance in bird fed twice/day may be partly due to a shortened fasting period as reported by (Spradly et al., 2008). However, this contradicted the report of Oyedeji et al., (2007) who reported that feeding laying birds the required quantity of feed once in a day as against the usual practice of either feeding twice or thrice in the day generally resulted in a better laying performance. It was further stated that birds fed weighed quantities of feed once a day based on the nutrient requirement, compared favourably with that fed *ad libitum* in terms of percentage hen–day-production and egg weight despite not having access to feed all the time. The best performance recorded for bird fed 115g twice/day under the interactive influence of the quantity of feed and frequency of feeding could be attributed to better feed utilization and efficiency. From Figure 1, the best performance recorded for 115g/day of feed to other feeding quantities at all the three phases of production could be attributed to better feed utilization. The increase in percentage hen-day production at the second phase of feeding trial in bird fed 115g/day of feed over the other three feeding quantities further showed better feed utilization and efficiency. There were reductions in egg production from phase one to phase three irrespective of the feeding frequencies. This might be attributed to any other factors (such as environmental temperature, lighting regime and diseases) affecting production other than frequency of feeding as reported by different researchers (Oguntunji and Alabi, 2010, Tumowa and Gous ,2012). It is also significant to note that hen under twice feeding regime had the best production performance. This could be attributed to better hen day production and feed efficiency recorded for twice/day. This agreed with the report of Moradi et al., (2013) who observed that total day egg production in hens fed twice and thrice a day was greater than in those in a once a day feeding programme. The significant difference in percentage shell weight among the treatment showed that bird fed 125g/day and 115g/day were significantly higher than those fed 95g/day and 105g/day. This difference could be attributed to different quantities of feed consumed because bird fed 125g/day and 115g/day consumed a higher quantity of feed which might result in more availability of calcium and phosphorus (that form the larger percentage of the eggshell) from the diet given. Then one effect of feed quantity on shell thickness observed in this study could be as a result of limestone and bone in the feed that influenced shell thickness were provided uniformly for all treatments. This also agreed with the report of (Geleta and Leta, 2015). More so, the shell thickness recorded under this research falls within the range of normal eggshell thickness according to Rath et al., (2015) who reported that an eggshell thickness of 0.33mm has been estimated to be necessary for the eggs to have at least 50% chance to withstand normal handling condition without breakage. The effect of frequency of feeding on the percentage shell which shows that bird fed once/day were better influence could be attributed to the fact that calcium which forms the larger percentage of the shell was better absorbed from the dietary calcium supplied in the feed and mobilized for shell formation. This agreed with the report of Hall, (2005) who reported that the medullary bone calcium can be deposited and released in response to changes in calcium supply and demand during eggshell formation and that only an average of 4grams of calcium is required in a diet to maintain good shell quality. However, the report in this study contradicted the report of Londero et al., (2016) who reported that the practice of feeding only once a day cannot supply the nutritional need of hen, particularly for eggshell formation. The contradiction might be as a result of the different breed used for the trials. The result on egg internal quality characteristics demonstrated that in spite of some variation in the amount of feed given and different frequency level, it did not in any way affect the quality of albumen. This report agrees with the finding of Etalem et al., (2009) who reported that feed restriction did not affect albumen height, albumen diameter and haugh unit. The bird fed 125g/day and twice/day for quantity and frequency respectively were better influenced in terms of yolk width which might imply an improvement in the subsequent performance of the laying house in term of egg weight for the group. It could also be noted that yolk width associated more with the large egg size as reported by Etalem et al., (2009)

The target of an average poultry farmer is to maximize profit. Feed costs are the major costs that influenced the profitability of laying bird rearing in this current study. From Table 4.4, N 524.29, N 433.70, N 380.88 and N 299.44were obtained as the net profits from birds fed 115, 105, 95 and 125g/day respectively from the sale of eggs. Although bird fed 125g/day had higher production percentage than 95g/day and 105g/day, the cost of extra feed/bird (2.52 and 1.22kg) which resulted in an additional cost of N362.88 and N175.68 respectively has reduced the net return.

Feed quantity has a highly significant effect on total feed intake, total feed cost, a total egg produced, gross return and net profit. The reduction in feed cost represented about 24%, 16% and 8% for95g, 105gand 115g, respectively compared to bird fed 125g/day. The reduction in total feed cost as a result of feed restriction could be attributed to the positive effect of quantitative feed restriction on total feed consumption. The better performance observed in bird fed115g/day on net revenue and economic efficiency over other three treatments could be attributed to the better feed conversion, higher percentage hen-day production, higher feed efficiency, total egg number per hen and the total egg price recorded. The result agrees with the report of Hasnath, (2002) and Olawumi, (2014). These researchers opined that net egg income over feed cost increased significantly by quantitative feed restriction.

The effect of feeding frequency in this research also showed that birds fed twice/day were the best in term of total egg produced, crates of egg produced per bird, gross return and net profit. This could be attributed to better hen day production and feed efficiency recorded for bird fed twice/day. This agreed with the report of Moradi et al., (2013) who observed that total day egg production in hens fed twice and thrice a day was greater than in those in a once a day feeding program. On the contrary, Osman et al., (2010) reported no significant differences in net revenue between the different feeding regimens imposed on laying birds.

Conclusion

The study has shown that feeding Isa-Brown laying birds the required quantity of feed twice in a day as against feeding once or thrice a day generally resulted in a better laying performance and net profit returns. The study also showed that feeding a hen 115g/day of feed twice in a day could help farmers reduce feed wastage that may occur through the norm of feeding hen 125g of feed/day or *ad libitum* feeding. The excess 5.56g of feed consumed by each hen fed 125g/bird/day did not produce any significant results in laying performance. Also, this excess feed intake may become commercially significant as farmers could save N 800.64 per day by feeding the birds with 115g/bird/day against feeding 125g/bird/day. Furthermore, time and labour used in feeding hens thrice in a day can be saved for other farm operations if hens are fed twice daily with 115g/bird/ daily. Feeding less than 115g per day or 115g per day once to save feeding cost and maximize time usage did not give optimum performance. Therefore, for optimum laying performance, and reducing feed wastage as well as save time and labour expended in feeding hen three times daily, feeding laying hens 115g/bird/day twice a day is ideal for Isa-Brown laying bird.

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