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Influence of Level and Duration of Quantitative Feed Restriction on Post-Restriction Egg-Laying Characteristics and Egg Quality of Pullets

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Abstract: The effects of levels and duration of quantitative feed restriction on post-restriction egg-laying characteristics and egg quality as well as economics of egg production of pullets were investigated in a 2x7 factorial for completely randomized design experiment using 126 point-of-lay (POL) Olympia Brown commercial pullets, which had been subjected to various levels and durations of feed restrictions. The experiment lasted from 20th to 37th week of age but the actual period of data collection was from 30th to 37th week of age (that is, 8 weeks). The feeding regimens (treatments) were AFAF (*ad libitum* feeding from 20th week to 34th week - 14 weeks); AFRF$_1$ (*ad libitum* feeding from 20th to 24th week (POL) – 5 weeks followed by 10% restriction feeding from POL to 34th week - 9 weeks); AFRF$_2$ (*ad libitum* feeding from 20 thto POL – 5 weeks followed by 20% restriction feeding from POL to 34th week - 9 weeks); RF$_1$RF$_1$ (10% restriction feeding from 20th to 34th week - 14 weeks); RF$_1$AF (10% restriction feeding from 20th week to POL – 5 weeks followed by *ad libitum* feeding from POL to 34th week - 9 weeks); RF$_2$RF$_2$ (20% restriction feeding from 20th to 34th week - 14 weeks); and RF$_2$AF (20% restriction feeding from 20th week to POL – 5 weeks followed by *ad libitum* feeding from POL to 34th week - 9 weeks). From 34th to 37th week of age, all the groups were reverted, on treatment basis, to *ad libitum* feeding (post-restriction period). Each treatment was replicated into three with six pullets per replicate. During the data collection period (30th – 37th week of age) one egg per replicate was collected three times per week for egg quality indices. Birds that were under feed restriction laid heavier first eggs but had lower (P<0.05) hen day production (HDP) than their *ad libitum* counterparts. *Ad libitum* fed birds transferred to 20% restricted feeding had the best economic indices. Birds subjected to restriction feeding had higher feed intake, poorer kg feed/dozen eggs, higher cost for dozen eggs (N) and lower gross margin (N) during post-restriction time (P<0.05) than when they were under restriction. On egg quality, birds had higher (P<0.05) haugh unit and albumen height but lower yolk index during restriction time than during post-restriction time. There were no significant differences in all the other quality indices.

Key words: Level of feed restriction, duration of feed restriction, post-restriction period, egg quality

Introduction

Feed restriction had been advocated for both egg-type and broiler breeder growing pullets (Gowe *et al*., 1960, Fuller and Dunahoo, 1962). Commercial pullets have conventionally been fed and watered *ad libitum* in order to enhance their growth and early maturity. Nevertheless, due to recent phenomenal increase and upsurge in feed cost and occasional feed scarcity in Nigeria, many farmers have been forced to engage in indiscriminate restriction of the amount of feed offered to commercial layers. This practice, no doubt, will affect the production potential of such farms. This unwholesome development in our poultry industry has made research into feed restriction for commercial layers imperative.

Balnave (1973, 1974), Christmas *et al*. (1974) and Douglas *et al*. (1973) have reported reduced body weight at laying age and delayed sexual maturity as a result of restrictive feeding. Gowe *et al*. (1960) and Blair (1972) reported that feed restriction during the rearing period reduced body weight, delayed sexual maturity, increased the intensity of egg production once delay in sexual maturity has been overcome, increased egg size and reduced carcass fat content. They also reported that feed restriction during the laying period resulted in reduced body weight gains and lower egg production.

Ezieshi *et al*. (2003) reported that feed restriction in layers depressed egg production, water intake and feed intake, the severity of depression depending on the extent of feed restriction. Egg weights were not affected. However, there is no information on whether the depression is reversed by restoring the birds to unrestricted feeding.

Milby and Sherwood (1956), Davis and Watts (1955) and Blair *et al*. (1976) reported that feed restriction during the rearing period did not affect production but feed restriction during laying did. Aukland and Wilson (1975) observed that during rehabilitation after feed restriction egg production was similar for controls and restricted treatments.

The timing and duration of restriction however, vary between operators, and most certainly, the amount of gain differs.

There appears to be no agreement on when restrictive feeding is best applicable, McDaniel *et al*. (1981) and Yu *et al.* (1992) suggested that it should cover the entire rearing and laying period. Pym and Dillon (1974) agreed that restriction was only necessary during the rearing period. Robbins *et al.* (1986, 1988) concluded that *ad libitum* feeding during part or all laying period increased egg production. Hocking *et al.* (1993) suggested that restriction of breeder pullets after 14 week of age decreases the incidence of multiple ovulations and also increases egg production.

Miles and Jacqueline (2000) contended that feed restriction programmes result in a slight decrease in egg size, which is of less consequence once the majority of the eggs are in the large category. They also said that if a feed restriction programme is used, it is usually not started until the majority of the eggs being produced fall into the large size category. They also asserted that initiation of a feed restriction programme should commence later for layer strains of lower body weight, particularly during periods of hot weather. Bruggeman *et al.* (1988) found out that subjecting pullets to combinations of either *ad libitum* or restriction feeding before sexual maturity influenced body weight at sexual maturation, the development of the reproductive apparatus (oviduct and ovary), reproductive hormone levels, age at first egg, and subsequent number of eggs produced. They concluded that chicken fed *ad libitum* had lowest total egg production, although they reached sexual maturity earliest.

Hocking *et al.* (1993) in his work concluded that feed restriction should be continued until the onset of lay because multiple ovulations are a major source of less production when feeds are not restricted from 15 weeks of age onward.

This study was therefore aimed at verifying the influence of level, timing and duration of restriction feeding on laying characteristics, egg quality and economics of production of commercial egg layers.

Materials and Methods

Experimental procedure and design: One hundred and twenty-six Olympia Brown commercial pullets at 20 weeks of age were reared in floor pens littered with wood shavings and supplied with suspended drinkers. Initial body weights of birds were taken and they were fed a commercial layer's diet (2500 Kcal ME / kg, 16.50% crude protein, 3.30% fat, 6.70% crude fibre, 3.5% calcium and 0.45% available phosphorus). All birds had unrestricted access to water. Standard litter management practice was strictly adhered to. Birds were dewormed using Piperazine® and an antibiotic (Keproceryl)® administered in drinking water to ensure good health.

The birds were previously subjected to different levels and lengths of feed restriction (feeding regimens). The feeding regimens (treatments) were AFAF (a*d libitum* feeding for entire period of 10 weeks preceding the experimental period, that is, 20th week to 50% hen-day-production, HDP), $AFRF_1$ a*d libitum* feeding from 20th week till point-of-lay, POL – 5 weeks followed by 10% restriction feeding till 50% HDP – another 5 weeks), $AFRF_2$ (*ad libitum* feeding from 20th week till POL - 5 weeks followed by 20% restriction feeding till 50% HDP – another 5 weeks), RF_1RF_1 (10% restriction feeding from 20th week till 50% HDP – 10 weeks), RF_1AF (10% restriction feeding from 20th week till POL – 5 weeks followed by *ad libitum* feeding till 50% HDP – another 5 weeks), RF_2RF_2 (20% restriction feeding from 20th week till 50% HDP – 10 weeks), RF_2AF (20% restriction feeding from 20th week till POL – 5 weeks followed *ad libitum* feeding till 50% HDP – another 5 weeks). The 50% HDP corresponded to 29th week of age. The data collection period (30th to 37th week of age) was divided into two time periods, viz: restricted time (Rt, 30th to 33rd week) and post-restriction time (Pt, 34th to 37th week). During the Rt period the birds were left under the feeding regimens they had been, while during the Pt period all the groups were reverted, on treatment basis, to *ad libitum* feeding. Each treatment was replicated into three with 6 birds per replicate. During the entire data collection period one egg per replicate was collected three times per week for egg quality indices.

The experimental design used was a 2 x 7 factorial in completely randomized design (CRD) with feeding regimen as factor A (at seven levels, and time period as factor B (at two levels, Restriction and Post-restriction periods).

Determination of egg quality: A total of 63 eggs were collected per week during restriction and post restriction periods; at 1 egg per replicate 3 times a week. Determination of the egg quality was carried out not later than a day after collection.

Eggs were weighed using Sartorius electric balance (of 0.01g sensitivity). Egg length and width were measured to the nearest 0.1cm using 13cm monostat vernier calipers and shape index was calculated as the proportion of the maximum width to the length. Studies on yolk and albumen were done after the eggs were broken with a small sharp knife and the content poured on a piece of flat glass plate placed on a flat surface. The albumen and yolk height were then measured using sliding type steel vernier caliper. The widths of albumen and yolk were measured using a pair of dividers. Haugh unit was calculated following the method proposed by Haugh (1937). Shell thickness was measured to the nearest 0.001mm using micrometer screw gauge with a ball anvil.

Data analysis: Data collected on production performance, laying characteristics, economics of egg production and egg quality were subjected to analysis of variance (ANOVA) in a 2x7 factorial for completely

Table 1: Outline/design of the feeding regimens

Pre-experimental Period		Experimental Period	
Week 20 - 24	POL – Week 29	Restriction 30^{th} – 33^{rd} week	Post-restriction 34^{th} – 37^{th}
Ad lib feeding	*Ad lib* feeding	*Ad lib* feeding	*Ad lib* feeding
Ad lib feeding	10% Restriction	10% Restriction	*Ad lib* feeding
Ad lib feeding	20% Restriction	20% Restriction	*Ad lib* feeding
10% Restriction	*Ad lib* feeding	*Ad lib* feeding	*Ad lib* feeding
10% Restriction	10% Restriction	10% Restriction	*Ad lib* feeding
20% Restriction	*Ad lib* feeding	*Ad lib* feeding	*Ad lib* feeding
20% Restriction	20% Restriction	20% Restriction	*Ad lib* feeding

randomized design layout (Mead and Currow, 1983), and significant differences between means were separated using Duncan's multiple range tests (Duncan, 1955) as packaged in the SPSS computer package (SPSS Inc, 2001).

Results and Discussion

Production performance and egg-laying characteristics during restriction time (30^{th}-33^{rd} week) versus post-restriction time (34^{th}-37^{th} week)

Results of production performance, laying characteristics and economics of egg production of birds under restriction (30^{th}-33^{rd} week) and post-restriction (34^{th}-37 thweek) time periods are shown in Table 2. There were significant (P<0.05) feeding regimens (FR) main effects on average feed intake, quantity (kg) of feed consumed per dozen egg laid, cost of feed per dozen egg, and gross margin from dozen egg laid, whereas time period (TP) main effects were significant (P<0.05) for average daily feed intake only. There were significant (P<0.05) TP x FR interaction effects on feed intake, kg feed per dozen egg, HDP, cost of feed per dozen egg, and gross margin from a dozen egg.

All the birds subjected to feed restriction immediately before the post-restriction time ($AFRF_1$, $AFRF_2$, RF_1RF_1 and RF_2RF_2) had higher (P<0.05) feed intake and HDP during the post-restriction time than during the restriction time. The same effect was observed in kg feed/dozen egg and cost of feed/dozen egg of $AFRF_2$ and RF_2RF_2, and gross margin from a dozen egg of RF_2RF_2. Also, RF_1AF showed the same effect in cost of feed/dozen eggs and gross margin while only RF_2AF showed similar effect in gross margin. All the groups had similar (P>0.05) feed intake during the post-restriction time.

This shows that the lower feed during restriction time was reversed at the post-restriction time. In other words, birds previously on restricted feeding and subsequently transferred to *ad libitum* feeding tended to eat more. This observation could be attributed to increase in appetite of these birds. This is in agreement with the observation of Wilson and Osbourn (1960) who discovered birds to have increased appetite during post-restricted feeding and which they attributed to improvement in growth and feed utilization associated with compensatory growth. The similarity of feed intakes observed for all the groups at the post-restriction time shows that the birds formerly under feed restriction quickly increased their feed intake and got to what the intake level would have been if they were not restricted. The stabilized feed intake at post-restriction time reflects on the kg feed/dozen egg laid and cost of feed/dozen egg produced (N), except for RF_1AF, RF_2RF_2 and RF_2AF whose values were similar but higher than others. This means higher cost implication for them and this explains their lowest gross margin (N). $AFRF_2$ had the highest gross margin, which was similar to that of the control (AFAF). This appears to confirm the superiority of the $AFRF_2$ feeding regimen over the other feeding regimens involving restriction. This regimen encouraged maximization of feed consumed in egg production.

The similarity in kg feed/dozen egg laid during the two time periods in this trial suggests that birds are as efficient in feed utilization immediately after restriction time as during restriction time. Snetsinger and Zimmerman (1974) compared restricted and unrestricted feeding and concluded that restricted birds are more efficient converters of feed into eggs than the unrestricted ones. Our trials compared restricted feeding time and post-restricted feeding time. The higher hen day production (HDP) figures of restricted birds at post-restriction time than at the restriction time are in agreement with those of Schneider *et al.* (1955); Hollands and Gowe (1961); Fattori *et al.* (1991) and Hocking *et al.* (1993) who reported that restricted birds came into egg production and laid at higher rate.

Egg quality indices of birds during the restriction and post-restriction periods: Table 3 shows the quality indices of egg laid by the experimental birds. There were no significant (P>0.05) feeding regimens (FR) main effects and FR by Time period (TP) (FR x TP) interaction effects in all the egg quality indices measured. However, there were significant TP main effects only in Haugh unit, albumen height and yolk index. Haugh unit and albumen height were higher (P<0.05) during restriction time (Rt, 85.46 and 0.33cm) than during post-restriction time (Pt, 85.20 and 0.28cm). Yolk index was significantly (P<0.05) higher during post-restriction time (0.34) than during restriction time. The non-significant feeding regimens

Table 2: Production performance, laying characteristics and economics of egg production of birds during restriction (30th-33rd week of age) and post-restriction (34th - 37th weeks of age) periods

Feeding Regimen (FR)	(a) Body Weight		
	30th week	33rd week	37th week
AFAF	1728	1738	1750
$AFRF_1$	1693	1704	1721
$AFRF_2$	1690	1695	1700
RF_1RF_1	1688	1698	1703
RF_1AF	1676	1688	1705
RF_2RF_2	1605	1649	1692
RF_2AF	1686	1697	1720
Mean	1681	1696	1713

(b) Average Feed intake (g)

FR	Time period: Rt	Pt	Mean
AFAF	132.4^{a}	136.0^{a}	134.2^{a}
$AFRF_1$	117.5^{b}	135.4^{a}	126.4^{b}
$AFRF_2$	108.6^{c}	135.8^{a}	122.2^{b}
RF_1RF_1	104.8^{cd}	135.2^{a}	120.0^{b}
RF_1AF	135.2^{a}	135.8^{a}	135.5^{a}
RF_2RF_2	96.2^{d}	135.9^{a}	116.1^{c}
RF_2AF	130.3^{a}	135.6^{a}	133.2^{a}
Mean	117.9^{b}	135.7^{a}	

SEM FR 1.41*, TP = 2.21*, FRxTP 2.55*

(C) Kg feed/dozen egg

FR	Time period: Rt	Pt	Mean
AFAF	2.16^{c}	2.18^{c}	2.17^{c}
$AFRF_1$	2.27^{c}	2.24^{c}	2.26^{c}
$AFRF_2$	1.86^{d}	2.19^{c}	2.03^{c}
RF_1RF_1	2.27^{c}	2.38^{bc}	2.33^{b}
RF_1AF	2.95^{a}	2.61^{b}	2.78^{a}
RF_2RF_2	2.30^{bc}	2.89^{a}	2.60^{ab}
RF_2AF	3.21^{a}	2.81^{a}	3.01^{a}
Mean	2.43	2.47	122

SEM FR = O.15*. TP = O.008^{ns}. FR xTP = 0.183*

(d) Cost of feed per dozen egg

FR	Time period: Rt	Pt	Mean
AFAF	108^{c}	108^{c}	108^{c}
$AFRF_1$	114^{c}	112^{bc}	113^{bc}
$AFRF_2$	93^{d}	110^{c}	102^{c}
RF_1RF_1	114^{c}	119^{bc}	117^{b}
RF_1AF	148^{a}	131^{b}	140^{a}
RF_2RF_2	115^{c}	145^{a}	130^{ab}
RF_2AF	161^{a}	141^{ab}	151^{a}
Mean	122	124	

SEM FR= 2.079*. TP=1.111^{ns}. FR x TP =2.941*

(e) Gross margin of a dozen egg (N)

FR	Time period: Rt	Pt	Mean
AFAF	72.0^{a}	72.0^{a}	72.0^{a}
$AFRF_1$	66.5^{b}	68.0^{b}	67.3^{b}
$AFRF_2$	87.0^{a}	70.5^{ab}	78.8^{a}
RF_1RF_1	66.5^{b}	61.0^{b}	63.8^{b}
RF_1AF	32.5^{d}	49.5^{c}	41.0^{c}
RF_2RF_2	65.0^{b}	35.5^{d}	50.3^{bc}
RF_2AF	19.5^{e}	39.5^{c}	29.5^{d}
Mean	58.4	56.6	

SEM FR =2.083*. TP=1.114^{ns}. FR x TP =2.946*

Table 2 Continued

(f) HHA

FR	Time period: Rt	Pt	Mean
AFAF	19.01	19.4	19.21
AFRF	16.3	18.7	17.5
AFRF	17.7	19.2	18.5
RF_1RF	16.6	18.8	17.7
RF_1AF	19.0	20.4	19.7
RF_2RF	15.3	17.3	16.3
RF_2AF	16.6	17.0	16.8
Mean	17.22	18.69	

SEM FR = 0.707ns. TP = 0.378ns. FR x TP = 1.00ns

(g) HDP (n=28)

	Time period: Rt	Pt	Mean
AFAF	4.76^{a}	4.87^{a}	4.82
AFRF	4.07^{c}	4.67^{a}	4.37
AFRF	4.43^{b}	4.81^{a}	4.62
RF_1RF	3.55^{d}	4.04^{c}	3.79
RF_1AF	4.07^{c}	4.37^{bc}	4.22
RF_2RF	3.27^{e}	3.70^{d}	3.49
RF_2AF	3.55^{d}	3.64^{d}	3.59
Mean	3.96	4.30	51.9

SEM FR = 1.630^{ns}. TP= 0.087^{ns}. FR xTP = 0.230*

(h) Average Egg wt (g)

FR	Time period: Rt	Pt	Mean
AFAF	52.4	50.9	51.7
AFRF	53.6	50.6	52.1
AFRF	52.1	50.6	51.4
RF_1RF	52.7	51.8	52.3
RF_1AF	50.4	51.1	50.8
RF_2RF	51.9	51.1	51.5
RF_2AF	50.0	51.1	50.6
Mean	51.9	51.0	

SEM FR = 0.420^{ns}. TP = 0.220^{ns}. FR xTP =0.582^{ns}

Abcd – means on the column not follow by the same superscript as significantly different from each other at ($P<0.05$)

FR = Feeding regimen; TP = Time period; Price /doz egg = (N) 180; Rt = Restriction time; Pt = Post-restriction

main effects suggest that feeding regimens do not have effects on quality of eggs.

However, our egg shape index results agree with those reported by Olurede and Longe (2002) and Chineke (2001), who had 0.76 and 0.763, respectively. Chineke (2001) also reported shell thickness, egg length and egg width of 0.31mm, 6.24cm and 4.98cm respectively for Olympia Black layers. These values are very close to those obtained in this study.

Conclusion: During restriction period birds had a lower feed intake, but there were no differences between restriction and post-restriction periods in kg feed/dozen eggs, cost of feed/dozen eggs as well as gross margin. On egg quality parameters, birds had higher haugh unit and albumen height during restriction period than during post-restriction period. From this study, it is observed that substantial amount of feeds were conserved by the

Table 3: Egg quality indices of birds during the restriction and post-restriction periods

Feeding Regimen	(a) Haugh Unit Time period			(b) Egg shape index Time period			(C) Shell thickness (mm) Time period		
FR	Rt	Pt	Mean	Rt	Pt	Mean	Rt	Pt	Mean
AFAF	85.49	84.98	85.24	0.85	0.77	0.81	0.27	0.27	0.27
AFRF$_1$	85.51	85.30	85.41	0.79	0.77	0.78	0.28	0.27	0.28
AFRF$_2$	85.52	85.24	85.38	0.76	0.78	0.77	0.27	0.29	0.28
RF$_1$RF$_1$	85.27	85.10	85.19	0.77	0.74	0.76	0.29	0.28	0.29
RF$_1$AF	85.58	85.30	85.44	0.77	0.77	0.77	0.27	0.28	0.28
RF$_2$RF$_2$	85.31	85.39	85.21	0.74	0.78	0.76	0.28	0.28	0.28
RF$_2$AF	85.51	85.39	85.45	0.81	0.76	0.78	0.29	0.28	0.28
Mean	85.46^a	85.20^b		0.78	0.77			0.28	0.28
	SEM FR = 0.098 ^{ns}			SEM FR = 0.016^{ns}			SEM FR = 0.004^{ns}		
	TP =0.049*			TP= 0.009^{ns}			TP = O.002^{ns}		
	FR xTP = 0.131^{ns}			FR x TP = 0.023^{ns}			FR x TP = 0.005^{ns}		

	(d) Egg length (cm) Time period			(e) Egg width (cm) Time period			(f) Albumen height (cm) Time period		
FR	Rt	Pt	Mean	Rt	Pt	Mean	Rt	Pt	Mean
AFAF	5.11	5.18	5.15	4.07	4.0	4.04	0.34	0.25	0.29
AFRF$_1$	5.16	5.11	5.14	4.08	3.97	4.03	0.35	0.30	0.33
AFRF$_2$	5.19	5.10	5.15	3.97	3.97	3.97	0.34	0.29	0.32
RF$_1$RF$_1$	5.18	5.34	5.26	4.01	3.98	3.99	0.30	0.27	0.29
RF$_1$AF	5.16	5.18	5.17	3.98	3.98	3.98	0.33	0.30	0.32
RF$_2$RF$_2$	5.19	5.15	5.17	3.85	3.99	3.92	0.30	0.27	0.29
RF$_2$AF	4.96	5.36	5.14	4.01	4.0	4.01	0.33	0.29	0.31
Mean	5.14	5.20		3.99	3.98		0.33^a	0.28^b	
	SEM FR = 0.083^{ns}			SEM FR = 0.040 ^{ns}			SEM FR= 0.015^{ns}		
	TP = 0.045^{ns}			TP = O.022^{ns}			TP = O.008*		
	FR xTP = 0.118^{ns}			FR x TP = 0.057^{ns}			FR x TP = 0.021^{ns}		

	(g) Yolk index Time period		
FR	Rt	Pt	Mean
AFAF	0.33	0.36	0.35
AFRF$_1$	0.31	0.34	0.33
AFRF$_2$	0.32	0.34	0.33
RF$_1$RF$_1$	0.32	0.33	0.33
RF$_1$AF	0.31	0.34	0.33
RF$_2$RF$_2$	0.32	0.34	0.33
RF$_2$AF	0.32	0.33	0.33
Mean	0.32^b	0.34^a	
SEM	FR = 0.004^{ns}		
	TP = O.002*		
	FR x TP = 0.006^{ns}		

ab Mean on the same column not followed by the same superscript are significantly different from each other at ($P<0.05$) ns = non –significant; FR = Feeding regimen; TP = Time period; Rt = Restriction time; Pt = Post- restriction time

restriction procedure, however, the overall economic analysis does not lend any justification to excessive restriction. It can be concluded that feed restriction as a management procedure should not exceed 20% as a commercial viable option for pullet in the humid tropic ecological zone of southeastern Nigeria.

Recommendation: Alternating restriction with *ad libitum* feeding during laying is most beneficial in egg production. Restriction at twenty percent (20%) from point-of-lay (POL) to four weeks after 50% hen day production (HDP) and returning to *ad lib* feeding appears to be most desirable practice to be adopted by farmers involved in commercial egg production.

However, it is also recommended that the birds be allowed to run through a full laying period after they have been returned to *ad libitum* feeding so as to assess the full effect of the restriction on the long run.

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