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DOI: https://doi.org/10.64388/IREV9I10-1716391

Feed Form and Feed Source Effects on Growth and Laying Performance, Egg Quality, And Follicular Variables in Layer Chickens

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Abstract- Feed form and source could influence feeding behaviour, feed intake, nutrient bioavailability, and productive performance of laying hens. This 40 weeks study evaluated the effects of feed form and feed source on production performance, egg quality traits, and follicular variables in layer chicks. Ninety day-old Isa Brown layer chicks were allocated to three dietary treatments in a completely randomized design namely, commercial pellet (CP), commercial mash (CM), and farm-mixed mash (FMM). Each treatment had three replicates of 10 chicks each. Data on growth and laying performance, egg quality, follicle type, number, and weight were analyzed using the independent samples t-test. Results showed that pellet-fed chicks had significantly higher hen-day egg production (HDEP) at weeks 17–20, 29–32, 33–36, and 37–40 ($p \leq 0.05$), and greater egg weight in the later production phase. Pellet feed consistently supported superior Haugh unit scores, and albumen, and yolk heights. On the other hand, chicks fed farm-mixed mash experienced a late-cycle egg production decline (42.07 ± 1.21% HDEP at weeks 37–40 versus 72.15 ± 1.31% for chicks fed commercial mash; $p < 0.001$), which was also associated with a diminished pre-hierarchical follicle pool. It is concluded that pellet feed confers significant commercial advantages in laying performance and internal egg quality. While farm-mixed rations may offer some cost-benefits during rearing, this advantage may be eroded by late phase egg production decline. Farm mixing of feed for laying hens may therefore, be disadvantageous in the long run in layer programmes unless nutrition precision, quality, and adequacy is consistently maintained throughout the rearing and laying phase.

Index Terms- Egg Quality, Feed Form, Feed Source, Follicular Variables, Layer Chickens, Production Performance.

I. INTRODUCTION

In commercial poultry production, feed constitutes the single largest operating cost, typically representing 65–75% of total production expenditure (Agunbiade et al., 2020). Beyond cost, the physical form of the feed and the source from which rations originated could profoundly influence nutrient bioavailability, feed intake regulation, digestive physiology, and productive performance (Abdollahi et al., 2013). A rigorous, simultaneous evaluation of these two variables, feed form and feed source, across the complete egg production cycle is therefore of considerable scientific and commercial importance, particularly in tropical smallholder contexts where both pellet use and on-farm feed mixing are common.

Feed form refers to the physical presentation of the ration, principally as mash, crumbles, or pellets. Pelleting is a thermo-mechanical process involving grinding, and steam conditioning of feed ingredients followed by extrusion through a die, which modifies the physical, and some chemical structure of feed ingredients (Abdollahi et al., 2013; Thomas et al., 2018). The resulting effects include enhanced starch gelatinisation, partial protein denaturation, reduction of anti-nutritional factors, and destruction of pathogenic microorganisms (Thomas et al., 2018). These physicochemical transformations influence nutrient digestibility, feeding time, selective eating behaviour, and feed wastage (Abdollahi et al., 2013; Wan et al., 2021). The magnitude of these effects, however, is subject to interactions with bird genotype, age of birds, production stage, ingredient composition, and pelleting conditions (Abdollahi et al., 2019; Kiarie & Mills, 2019).

Feed source introduces an equally important dimension of variability. Commercial feed mills, equipped with a more stable ingredient supply chain, ingredient and feed quality assurance systems, and precision mixing infrastructure, deliver more consistent and nutritionally balanced rations than on-farm mixing operations (Adebiyi et al., 2019; You et al., 2024). Conversely, farm-mixed rations offer greater formulation flexibility and potentially lower procurement costs, but may be compromised by ingredient variability, inconsistent ingredient quality, poor ingredient quality evaluation, imprecise weighing, inadequate mixing, and suboptimal microbial quality control (Zinn, 2004; Ricke et al., 2022; Ogundeji et al., 2024). In Nigeria and across sub-Saharan Africa, on-farm feed mixed is widely practiced among smallholder egg producers (Ajayi et al., 2020; Alabi et al., 2020).

The translation of dietary input into productive output in the laying hen is mediated through a complex interplay of metabolic, endocrine, and physiological mechanisms governing ovarian development, folliculogenesis, ovulation, and egg formation. The hypothalamic-pituitary-ovarian (HPO) axis regulates ovarian and follicle development through gonadotropins and is sensitive to nutritional resources, particularly dietary protein, energy, and micronutrients including amino acids, minerals, and vitamins (Renema et al., 2018). Dietary protein, and amino acid quality, and energy density directly influence the ovarian follicular hierarchy, follicle recruitment into the pre-ovulatory hierarchy, the number of hierarchical and pre-hierarchical follicles, follicle weight, and ultimately rate of egg production and egg size (Hartcher & Jones, 2017). The link between nutrition and reproduction is therefore critical throughout the laying cycle.

Despite the growing commercial availability of pellet feeds and the widespread practice of on-farm feed mixing, empirical data systematically comparing these options across the entire production cycle, from rearing through peak and declining lay, remain limited (Nworgu & Ogungbenro, 2017; Oso et al., 2019). This study therefore evaluated the effects of feed form and feed source on production performance, egg quality, and follicular variables in Isa Brown layer chickens reared under tropical conditions.

II. MATERIALS AND METHODS

2.1 Experimental Location and Animals

The study was carried out at the Teaching and Research Farm of the College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria located on latitude 05° 21′ N and longitude 07° 33′ E (Metrological station, NRCI, Umudike, 2017). Ninety day-old Isa Brown pullet chicks, sourced from a reputable commercial hatchery, were used for the study. Appropriate vaccination suitable for the study area and management protocols including observing biosecurity protocols were observed throughout the study.

2.2 Experimental Design and Treatments

The pullet chicks were allocated in a completely randomized design (CRD) to three dietary treatment groups of 30 birds each. Group 1 received a commercial proprietary pellet feed (CP), Group 2 received same commercial proprietary but mash feed (CM), and Group 3 received farm-mixed mash (FMM). Each treatment was replicated three times with 10 birds per replicate pen. The chicks were reared on deep litter until onset of egg production and thereafter, in single hen laying cages measuring 44 x 42 x 36 cm equipped with feeding troughs and water nipples. Feeding of chicks followed standard recommendations for the different stages of growth while water was given ad libitum throughout the study.

2.3 Experimental Ration

Commercial pellet and mash feeds were obtained from a reputable commercial feed distributor. The farm-mixed mash was formulated using locally sourced ingredients, namely maize, wheat offal, soya bean cake, fish meal, palm kernel cake, bone meal, lysine, methionine, and a vitamin-mineral premix, following standard layer nutrition guidelines (NRC, 1994).

2.4 Data Collection

Growth Performance

Chicks were weighed on arrival at the experimental site, at the end of brooding (week 7) and thereafter, at two weekly intervals to determine growth performance. Body weight gain was calculated as the difference between two consecutive body weight measurements. Feed intake was determined as the difference between quantity given and left over quantity over a 24 h period while feed conversion ratio was calculated weekly as the gram feed per gram gain over the period.

Egg Production Performance

During the laying phase (weeks 17–40), eggs were collected two times daily, weighed using a digital scale (0.01g sensitivity) and recorded in an egg chart. Hen-day egg production (HDEP, %) was calculated as the number of eggs collected per hen per day, expressed as a percentage.

Egg Quality Determination

Egg quality parameters, namely shell weight, shell thickness, albumen weight, yolk weight, albumen height, yolk height, and Haugh unit score, were evaluated at four-weekly intervals from representative eggs sampled from each experimental group.

Shell weight: This was determined by cracking the egg and separating the shell. The shells were rinsed with warm water, and allowed to dry under room temperature. Thereafter, shell with membranes was weighed using electronic weighing balance and values recorded in grams.

Shell thickness: The egg was cracked and the shell was separated, rinsed with warm water and allowed to dry under room temperature. Thereafter, the thickness of the shell with membranes was measured in mm using a micrometre screw gauge (0.01mm sensitivity).

Albumen and yolk weights: The egg was carefully cracked and the yolk carefully separated from the albumen and rolled on a blotting paper to remove adhering albumen. The yolk and albumen were then weighed separately using an electronic weighing balance (0.01 g sensitivity).

Albumen and yolk heights: These were determined using a digital calliper and recorded in mm.

Haugh unit (HU): This was calculated using the formula by Haugh (1937):

$HU = 100 * \text{Log}(h + 7.57) - (1.7 * W^{0.37})$

Where, h is albumen height, and W is weight of egg.

Follicle Type, Number, and Weight

At weeks 24 and 40, two hens were randomly selected per replicate and humanely sacrificed for collection of follicular data. Ovaries were examined for hierarchical, and pre-hierarchical follicle counts, and individual hierarchical follicle weights were determined using a digital weighing balance. Follicular data were compared between treatments to characterise the reproductive status of hens at onset of lay and end of short term egg production cycle.

2.5 Statistical Analysis

Data were analysed using Student's t-test for pairwise comparisons between CP and CM (feed form effect) and between CM and FMM (feed source effect). Statistical significance was accepted at $p \leq 0.05$.

III. RESULTS AND DISCUSSION

The ingredient compositions of farm mixed rations formulated for the study are presented in Table 1 while proximate composition of the experimental rations are presented in Table 2. Tables 3 and 4 contain the growth performance, feed intake and feed conversion ratio of pullet chicks fed pellet or mash, commercial or farm mixed mash, respectively.

Table 1: Percentage composition of farm mixed rations

	Ration		
Ingredient	Chick mash	Grower mash	Layer mash
Maize	50.0	40.0	45.0
Soya bean cake	19.4	9.0	15.0
Wheat bran	16.0	33.8	22.0
Palm kernel cake	5.0	2.6	5.0
Fish meal	5.0	5.2	5.0
Bone meal	2.4	4.0	2.0
Methionine	0.2	0.2	0.2
Lysine	0.2	0.2	0.1

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DOI: https://doi.org/10.64388/IREV9I10-1716391

Sodium chloride (salt)	0.4	0.4	0.2
Limestone	1.0	4.0	4.3
Vitamin premix	0.4	0.6	0.3
Total	100.0	100.0	100.0

Table 2: Proximate analysis of pellet feed, commercial mash and farm mixed mash

Feed type/analysis	Pellet	Commercial mash	Farm mixed mash
Chick mash			
Moisture	11.1	9.66	10.14
NFE	53.08	53.48	52.45
Crude Protein	18.73	18.64	17.15
Ash	7.32	7.44	8.12
Fat	6.05	6.94	7.87
Crude Fibre	3.72	3.84	4.27
Grower mash			
Moisture	10.27	10.77	10.83
NFE	52.88	52.13	49.87
Crude Protein	19.25	19.17	18.99
Ash	7.26	6.9	8.25
Fat	6.49	6.91	7.86
Crude Fibre	3.85	4.12	4.2
Layer mash			
Moisture	12.11	10.89	12.3
NFE	55.47	53.99	55.05
Crude Protein	17.94	18.03	16.86
Ash	4.9	5.94	5.72
Fat	5.74	6.89	5.92
Crude Fibre	3.84	4.26	4.15

Table 3 presents the growth performance of pullet chicks reared on commercial pellet versus commercial mash feed from day 1 to week 18 of age. Day 1 body weights were identical across both groups (40.00 ± 0.93 g vs. 40.01 ± 1.18 g; $p = 1.000$), confirming that the experimental groups were well-matched at the outset of the experiment. Throughout the rearing period, pellet-fed chicks tended to achieve greater body weights at most evaluation time points, recording 937.53 ± 33.03 g versus 853.00 ± 7.10 g at week 11 ($p = 0.085$) and 1598.78 ± 41.13 g versus 1485.39 ± 59.61 g at week 18 ($p = 0.192$). The only statistically significant difference in growth performance was observed for weight gain at week 11, where pellet-fed chicks recorded significantly higher weight gain than mash-fed chicks (164.73 ± 11.10 g vs. 110.56 ± 6.28 g; $p = 0.013$). The enhanced weight gain in pellet-fed pullets at this time point is consistent with the known physical and thermochemical benefits of pelleting, which promote nutrient bioavailability through starch gelatinisation and partial protein denaturation, improve nutrient intake by reducing selective feeding, and reduce feed wastage (Abdollahi et al., 2013; Thomas et al., 2018). These advantages collectively increase the net nutritional value of pellet feeds per unit of feed consumed (Wan et al., 2021).

Despite the numerically superior body weights in pellet-fed chicks, most growth performance parameters including feed intake and feed conversion ratio did not differ significantly between feed forms at any evaluation time point. Feed conversion ratio values were comparable between pellet-fed and mash-fed chicks throughout rearing (e.g., 0.48 ± 0.08 vs. 0.48 ± 0.02 at week 7; $p = 0.947$). The absence of widespread significant differences in growth performance across the rearing period is consistent with findings by Jafar-Nejad et al. (2021), who reported that effects of feed form on growth traits in pullets were not uniformly significant at every measurement interval. The broad similarity in growth performance between feed forms in this study suggests that during the pre-laying rearing phase, both pellet and mash were nutritionally adequate to support pullet development, and that the practical advantages of pelleting may manifest most clearly during the metabolically demanding laying phase rather than during rearing.

Table 3: Growth performance of pullet chicks fed pellet or mash rations

	Commercial feed form		
Variable	Pellet	Mash	p-value
Day 1 body weight	40.00 ± 0.93	40.01 ± 1.18	1.000
Week 7			
Body weight (g)	529.38 ± 41.77	539.44 ± 15.08	0.832
Weight gain (g)	205.15 ± 40.72	229.50 ± 8.35	0.613
Feed intake	52.05 ±	56.66 ±	0.579

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DOI: https://doi.org/10.64388/IREV9I10-1716391

(g/day)	7.39	1.89	
Feed conversion ratio	0.48 ± 0.08	0.48 ± 0.02	0.947
Week 9			
Body weight (g)	772.80 ± 40.78	742.44 ± 17.78	0.533
Weight gain (g)	243.42 ± 13.94	203.00 ± 10.97	0.085
Feed intake (g/day)	84.29 ± 11.37	69.60 ± 3.30	0.282
Feed conversion ratio	0.57 ± 0.09	0.63 ± 0.04	0.595
Week 11			
Body weight (g)	937.53 ± 33.03	853.00 ± 7.10	0.085
Weight gain (g)	164.73 ± 11.10[a]	110.56 ± 6.28[b]	0.013
Feed intake (g/day)	94.10 ± 9.23	101.24 ± 5.31	0.539
Feed conversion ratio	1.10 ± 0.17	1.55 ± 0.04	0.065
Week 13			
Body weight (g)	1165.96 ± 29.46	1110.17 ± 43.21	0.346
Weight gain (g)	228.42 ± 8.07	257.17 ± 27.27	0.369
Feed intake (g/day)	89.77 ± 4.36	130.47 ± 29.76	0.247
Feed conversion ratio	0.81 ± 0.08	0.92 ± 0.18	0.602
Week 15			
Body weight (g)	1324.69 ± 45.34	1302.45 ± 43.98	0.742
Weight gain (g)	158.73 ± 21.21	192.28 ± 1.06	0.254
Feed intake (g/day)	97.25 ± 6.72	117.19 ± 6.63	0.102
Feed conversion ratio	1.21 ± 0.11	1.29 ± 0.14	0.663
Week 18			
Body weight (g)	1598.78 ± 41.13	1485.39 ± 59.61	0.192
Weight gain (g)	274.09 ± 47.52	182.94 ± 25.19	0.165
Feed intake (g/day)	93.41 ± 1.24	100.59 ± 9.65	0.535
Feed conversion ratio	0.75 ± 0.15	1.22 ± 0.11	0.065

a, b: means on the same row with different superscripts are significantly different ($p \leq 0.05$).

Table 4 presents the growth performance of pullet chicks fed commercial mash versus farm-mixed mash. Day 1 body weights were again comparable between groups (40.01 ± 1.18 g vs. 40.00 ± 0.82 g; p = 1.000). Throughout the rearing period, body weights and weight gains were broadly similar between the two groups, with no significant differences observed at any evaluation time point. Final body weights at week 18 were nearly identical (1485.39 ± 59.61 g vs. 1479.09 ± 33.25 g; p = 0.931). This parity in growth outcomes during rearing indicates that the farm-mixed ration was generally adequate in supporting early growth despite inherently lower precision in mixing and potential variability in raw material quality compared to commercial feed (Zinn, 2004; Ricke et al., 2022).

However, Table 4 reveals a notable and consistent pattern in feed intake. Chicks fed commercial mash consumed significantly more feed than farm-mixed mash chicks at weeks 7 (56.66 ± 1.89 g/day vs. 41.57 ± 1.49 g/day; p = 0.003), 11 (101.24 ± 5.31 g/day vs. 71.07 ± 6.88 g/day; p = 0.026), and 15 (117.19 ± 6.63 g/day vs. 83.46 ± 4.62 g/day; p = 0.014). This consistently lower voluntary intake of farm-mixed mash by chicks despite the lower energy values (lower NFE) is a finding of considerable practical significance, as it indicates sub-optimal palatability or sensory properties of the farm-mixed ration, possibly attributable to variable ingredient quality, inconsistent mixing, or differences in particle size and texture (Zinn, 2004; Ogundeji et al., 2024). Feed conversion ratio was also significantly more favourable in farm-mixed mash chicks at weeks 7 (0.38 ± 0.01 vs. 0.48 ± 0.02; p = 0.013), 9 (0.50 ± 0.01 vs. 0.63 ± 0.04; p = 0.040), and 18 (0.75 ± 0.12 vs. 1.22 ± 0.11; p = 0.043). The paradox of lower feed intake alongside equivalent body weights and better feed conversion ratios in farm-mixed chicks

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DOI: https://doi.org/10.64388/IREV9I10-1716391

during the rearing period suggests that these birds achieved similar growth with less feed, presenting an apparent short-term advantage. However, this apparent efficiency may mask the more critical issue of lower absolute nutrient intake arising from reduced feed consumption which may be accumulating as a subclinical nutritional deficit, particularly in protein, energy, and micronutrient reserves, which only becomes fully apparent during the metabolically demanding laying phase (Nworgu & Ogungbenro, 2017). This interpretation is strongly supported by the subsequent observation of a late-cycle egg production collapse in farm-mixed mash-fed hens reported in Table 6, consistent with findings by Adebiyi et al. (2019) who attributed inferior late-lay performance to nutritional inconsistency in on-farm formulated feeds.

Table 4: Growth performance of pullet chicks fed commercial or farm mixed rations

	Feed source		
Variable	Commercial mash	Farm-mixed mash	p-value
Day 1 body weight	40.01 ± 1.18	40.00 ± 0.82	1.000
Week 7			
Body weight (g)	539.44 ± 15.08	536.31 ± 23.94	0.917
Weight gain (g)	229.50 ± 8.35	217.42 ± 2.65	0.240
Feed intake (g/day)	56.66 ± 1.89[a]	41.57 ± 1.49[b]	0.003
Feed conversion ratio	0.48 ± 0.02[a]	0.38 ± 0.01[b]	0.013
Week 9			
Body weight (g)	742.44 ± 17.78	742.54 ± 27.96	0.998
Weight gain (g)	203.00 ± 10.97	206.24 ± 4.56	0.799
Feed intake (g/day)	69.60 ± 3.30	61.33 ± 3.54	0.163
Feed conversion ratio	0.63 ± 0.04[a]	0.50 ± 0.01[b]	0.040
Week 11			
Body weight (g)	853.00 ± 7.10	850.67 ± 33.75	0.954
Weight gain (g)	110.56 ± 6.28	108.13 ± 20.47	0.915
Feed intake (g/day)	101.24 ± 5.31[a]	71.07 ± 6.88[b]	0.026
Feed conversion ratio	1.55 ± 0.04	1.32 ± 0.27	0.484
Week 13			
Body weight (g)	1110.17 ± 43.21	1043.91 ± 24.76	0.254
Weight gain (g)	257.17 ± 27.27	193.24 ± 10.02	0.093
Feed intake (g/day)	130.47 ± 29.76	87.71 ± 1.68	0.287
Feed conversion ratio	0.92 ± 0.18	0.83 ± 0.09	0.668
Week 15			
Body weight (g)	1302.45 ± 43.98	1246.83 ± 23.84	0.329
Weight gain (g)	192.28 ± 1.06	202.92 ± 20.16	0.626
Feed intake (g/day)	117.19 ± 6.63[a]	83.46 ± 4.62[b]	0.014
Feed conversion ratio	1.29 ± 0.14	0.86 ± 0.08	0.051
Week 18			
Body weight (g)	1485.39 ± 59.61	1479.09 ± 33.25	0.931
Weight gain (g)	182.94 ± 25.19	232.26 ± 30.99	0.284
Feed intake (g/day)	100.59 ± 9.65	83.26 ± 0.47	0.214
Feed conversion ratio	1.22 ± 0.11[a]	0.75 ± 0.12[b]	0.043

a, b: means on the same row with different superscripts are significantly different ($p \leq 0.05$).

Presented in Tables 5 and 6 are the comparative laying performance of the experimental groups. Feed nutrient content and bioavailability are very important factors that influence laying performance and overall productivity. Feed form exerted a profound and consistent influence on laying performance over the production period (Table 5).

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DOI: https://doi.org/10.64388/IREV9I10-1716391

Pellet-fed hens achieved significantly higher hen day egg production (HDEP) than mash-fed hens at weeks 17–20 (26.19 ± 1.61% versus 15.00 ± 2.28%; $p < 0.001$), 29–32 (88.43 ± 1.14% versus 80.32 ± 0.83%; $p < 0.001$), 33-36 (72.62 ± 2.81% versus 47.27 ± 4.23%; $p < 0.001$), and 37-40 (88.80 ± 1.53% versus 72.15 ± 1.31%; $p < 0.001$). Hen day egg production measures the percentage of eggs produced relative to the number of live hens present on a specific day. It is obtained by multiplying the number of eggs collected in one day by 100 and dividing the product by the number of live hens. It is an important parameter for monitoring the health of a flock, productivity, and profitability (Kim & Kang, 2022). The sustained advantage of pellet feed during the late production phase (weeks 33-40) is a finding of considerable practical and economic significance. The ability of pellet-fed birds to sustain HDEP at 88.80 ± 1.53% through week 40, compared with 72.15 ± 1.31% for mash-fed birds, represents a difference of approximately 16.65%, equivalent to 0.117 additional eggs per hen per day. Over a flock of 5,000 hens across four weeks, this equates to approximately 3,276 additional eggs (109.2 crates), with commensurately significant commercial value. This sustained performance reflects the cumulative nutritional advantages of enhanced nutrient bioavailability throughout the egg production cycles, in order to support the maintenance of the follicular hierarchy during late lay when ovarian senescence progressively competes with egg production signals (Johnson, 2015).

The relationship between feed form and egg weight was less consistent. Mash-fed birds produced significantly heavier eggs at weeks 17–20 (47.58 ± 0.97 g versus 42.25 ± 0.52 g; $p < 0.001$) and 21–24 (50.24 ± 0.61 g versus 48.77 ± 0.38 g; $p = 0.045$). This inverse relationship between HDEP and egg weight is a well-established biological trade-off in avian reproduction, reflecting the finite daily allocation of nutrients and other resources to egg number (clutch size) and egg mass (Hartcher & Jones, 2017). Pellet-fed birds, by directing greater metabolic resources towards egg frequency, produced somewhat lighter eggs in early lay. From weeks 29 onwards, however, pellet-fed birds achieved comparable or significantly higher egg weights alongside superior HDEP, demonstrating that the overall nutritional advantage of pellet feed was sufficient to sustain both dimensions of productive performance simultaneously in mid-to-late lay. This convergence, where both egg number and egg weight ultimately favour pellet feed, underscores the magnitude of the nutritional benefits conferred by thermal processing over the extended production period.

The comparison between commercial and farm-mixed mash (Table 6) revealed an initial competitive but ultimately divergent production trajectory. Farm-mixed mash-fed hens briefly achieved superior HDEP at weeks 21–24 (50.16 ± 1.38% versus 43.07 ± 1.87%; $p = 0.003$), a period corresponding to the ascending phase of the production curve. However, from weeks 29–32 onwards, hens fed commercial mash clearly outperformed counterparts fed farm-mixed rations and this divergence was statistically significant at weeks 29–32 (80.32 ± 0.83% versus 67.26 ± 0.58%; $p < 0.001$), and 37–40 (72.15 ± 1.31% versus 42.07 ± 1.21%; $p < 0.001$) at which a difference of approximately 30% was recorded in favour of pellet-fed hens. These findings strongly corroborate Nworgu and Ogungbenro (2017) and Adebiyi et al. (2019) who documented inferior late-lay performance in hens consuming on-farm formulated feeds. The authors attributed the inferior performance of hens on on-farm feeds to nutritional inconsistency.

Table 5: Laying performance of hens fed commercial pellet or mash rations

Variable	Pellet	Mash	p-value
Weeks 17-20			
HDEP (%)	26.19 ± 1.61[a]	15.00 ± 2.28[b]	0.001
Egg weight (g)	42.25 ± 0.52[b]	47.58 ± 0.97[a]	0.001
Weeks 21-24			
HDEP (%)	44.23 ± 1.87	43.07 ± 1.87	0.663
Egg weight (g)	48.77 ± 0.38[b]	50.24 ± 0.61[a]	0.045
Weeks 25-28			
HDEP (%)	77.24 ± 1.47	78.41 ± 1.65	0.597
Egg weight	53.28 ±	54.20 ±	0.170

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DOI: https://doi.org/10.64388/IREV9I10-1716391

(g)	0.38	0.55	
Weeks 29-32			
HDEP (%)	88.43 ± 1.14^{a}	80.32 ± 0.83^{b}	0.001
Egg weight (g)	56.50 ± 0.39	57.73 ± 0.51	0.056
Weeks 33-36			
HDEP (%)	72.62 ± 2.81^{a}	47.27 ± 4.23^{b}	0.001
Egg weight (g)	57.91 ± 0.25^{a}	56.15 ± 0.65^{b}	0.015
Weeks 37-40			
HDEP (%)	88.80 ± 1.53^{a}	72.15 ± 1.31^{b}	0.001
Egg weight (g)	58.80 ± 0.36^{a}	56.21 ± 0.48^{b}	0.001

^{a,b} Means within a row bearing different superscripts differ significantly (p ≤ 0.05). HDEP = Hen-Day Egg Production.

Table 6: Laying performance of hens fed commercial or farm-mixed mash rations

Variable	Commercial Mash	Farm-Mixed Mash	p-value
Weeks 17-20			
HDEP (%)	15.00 ± 2.28	18.77 ± 1.16	0.147
Egg weight (g)	47.58 ± 0.97^{a}	43.31 ± 0.37^{b}	0.001
Weeks 21-24			
HDEP (%)	43.07 ± 1.87^{b}	50.16 ± 1.38^{a}	0.003
Egg weight (g)	50.24 ± 0.62	49.88 ± 0.27	0.590
Weeks 25-28			
HDEP (%)	78.41 ± 1.65	79.95 ± 0.56	0.381
Egg weight (g)	54.20 ± 0.55^{a}	52.89 ± 0.19^{b}	0.027
Weeks 29-32			
HDEP (%)	80.32 ± 0.83^{a}	67.26 ± 0.58^{b}	0.001
Egg weight (g)	57.72 ± 0.51^{a}	53.91 ± 0.20^{b}	0.001
Weeks 33-36			
HDEP (%)	47.27 ± 4.23	48.00 ± 1.01	0.868
Egg weight (g)	56.15 ± 0.65^{a}	54.44 ± 0.28^{b}	0.010
Weeks 37-40			
HDEP (%)	72.15 ± 1.31^{a}	42.07 ± 1.21^{b}	0.001
Egg weight (g)	56.21 ± 0.48	55.17 ± 0.49	0.137

^{a,b} Means within a row bearing different superscripts differ significantly (p ≤ 0.05). HDEP = Hen-Day Egg Production.

Table 7: External and internal egg quality parameters of hens fed commercial pellet or mash rations

Variable	Pellet	Mash	p-value
Week 23			
Egg weight (g)	51.34 ± 0.11	54.31 ± 0.52	0.098
Shell weight (g)	6.47 ± 0.22	6.34 ± 0.02	0.650
Shell thickness (mm)	0.38 ± 0.01	0.36 ± 0.00	0.205
Albumen weight (g)	31.33 ± 0.31	33.21 ± 0.19	0.052
Yolk weight (g)	13.44 ± 0.12^{b}	15.44 ± 0.03^{a}	0.031
Albumen height (mm)	9.93 ± 0.31	8.45 ± 0.02	0.130
Yolk height (mm)	18.82 ± 0.12^{a}	17.55 ± 0.04^{b}	0.044
Haugh unit	100.97 ± 1.29	93.41 ± 0.21	0.100
Week 27			
Egg weight (g)	53.90 ± 1.48	54.57 ± 2.13	0.823
Shell weight (g)	6.87 ± 0.33	6.71 ± 0.13	0.720
Shell thickness (mm)	0.37 ± 0.01	0.36 ± 0.00	0.500
Albumen weight (g)	32.87 ± 1.84	33.61 ± 0.92	0.763
Yolk weight (g)	15.23 ± 0.43	15.12 ± 0.18	0.842
Albumen height (mm)	9.28 ± 0.12^{a}	8.25 ± 0.08^{b}	0.026
Yolk height (mm)	18.48 ± 0.08^{a}	17.36 ± 0.04^{b}	0.018

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DOI: https://doi.org/10.64388/IREV9I10-1716391

Haugh unit	97.52 ± 0.14[a]	92.33 ± 0.18[b]	0.002
Week 31			
Egg weight (g)	54.51 ± 1.34	59.29 ± 1.46	0.138
Shell weight (g)	6.52 ± 0.16	7.35 ± 0.11	0.064
Shell thickness (mm)	0.36 ± 0.00	0.37 ± 0.01	1.000
Albumen weight (g)	32.75 ± 0.47[b]	36.21 ± 0.35[a]	0.032
Yolk weight (g)	14.91 ± 0.42	15.37 ± 1.33	0.788
Albumen height (mm)	9.53 ± 0.14	8.72 ± 0.49	0.329
Yolk height (mm)	18.50 ± 0.20	18.19 ± 0.55	0.670
Haugh unit	98.51 ± 0.31	93.48 ± 2.09	0.245
Week 35			
Egg weight (g)	59.75 ± 0.39	57.88 ± 4.61	0.755
Shell weight (g)	8.14 ± 0.28	7.48 ± 0.81	0.557
Shell thickness (mm)	0.36 ± 0.01	0.37 ± 0.01	0.712
Albumen weight (g)	36.31 ± 0.08	35.10 ± 1.36	0.538
Yolk weight (g)	15.22 ± 0.17	16.13 ± 0.84	0.468
Albumen height (mm)	9.52 ± 0.14	8.99 ± 0.20	0.171
Yolk height (mm)	18.32 ± 0.06	18.57 ± 0.17	0.359
Haugh unit	97.28 ± 0.71	95.22 ± 0.15	0.200
[a,b] Means within a row bearing different superscripts differ significantly ($p \leq 0.05$).			

Table 8: External and internal egg quality parameters of hens fed commercial or farm-mixed mash rations

Variable	Commercial Mash	Farm-Mixed Mash	p-value
Week 23			
Egg weight (g)	54.31 ± 0.52	50.82 ± 1.88	0.299
Shell weight (g)	6.34 ± 0.02	5.84 ± 0.41	0.440
Shell thickness (mm)	0.36 ± 0.00	0.37 ± 0.01	0.500
Albumen weight (g)	33.21 ± 0.19	31.67 ± 1.04	0.500
Yolk weight (g)	15.44 ± 0.03[a]	13.81 ± 0.09[b]	0.024
Albumen height (mm)	8.45 ± 0.02	9.32 ± 0.31	0.214
Yolk height (mm)	17.55 ± 0.04	18.20 ± 0.42	0.362
Haugh unit	93.41 ± 0.21	98.42 ± 0.93	0.103
Week 27			
Egg weight (g)	54.57 ± 2.13	53.11 ± 3.33	0.753
Shell weight (g)	6.71 ± 0.31	6.59 ± 0.95	0.920
Shell thickness (mm)	0.36 ± 0.00	0.37 ± 0.01	0.500
Albumen weight (g)	33.61 ± 0.92	31.96 ± 1.36	0.432
Yolk weight (g)	15.12 ± 0.18	14.51 ± 1.00	0.653
Albumen height (mm)	8.25 ± 0.08[b]	9.20 ± 0.05[a]	0.014
Yolk height (mm)	17.36 ± 0.04	18.43 ± 0.38	0.214
Haugh unit	92.33 ± 0.18	97.36 ± 0.56	0.051
Week 31			
Egg weight (g)	59.29 ± 1.46	56.17 ± 3.81	0.560
Shell weight (g)	7.35 ± 0.11	7.50 ± 0.48	0.802
Shell thickness (mm)	0.37 ± 0.01	0.37 ± 0.01	1.000
Albumen weight (g)	36.21 ± 0.35	33.50 ± 2.44	0.465
Yolk weight (g)	15.37 ± 1.33	15.02 ± 0.84	0.848
Albumen height (mm)	8.72 ± 0.49	8.92 ± 0.07	0.751
Yolk height	18.19 ± 0.55	17.84 ±	0.572

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DOI: https://doi.org/10.64388/IREV9I10-1716391

(mm)		0.04	
Haugh unit	93.48 ± 2.09	95.27 ± 1.23	0.553
Week 35			
Egg weight (g)	57.88 ± 4.61	58.00 ± 0.62	0.983
Shell weight (g)	7.48 ± 0.81	7.35 ± 0.01	0.902
Shell thickness (mm)	0.37 ± 0.01	0.37 ± 0.00	0.500
Albumen weight (g)	35.10 ± 1.36	35.14 ± 0.46	0.984
Yolk weight (g)	16.13 ± 0.84	15.32 ± 0.08	0.509
Albumen height (mm)	8.99 ± 0.20	9.39 ± 0.02	0.283
Yolk height (mm)	18.57 ± 0.17	18.16 ± 0.08	0.204
Haugh unit	95.23 ± 0.15[b]	97.10 ± 0.05[a]	0.033

a'b Means within a row bearing different superscripts differ significantly (p ≤ 0.05).

The follicular type, count and weight at weeks 24 and 40 for the experimental groups are presented in Tables 9 and 10. No statistically significant differences in follicular variables were observed between pellet- and mash-fed hens, or between hens fed commercial mash and farm-mixed mash, at either evaluation time points. Nevertheless, the numerical trends provide biologically important context for interpreting the laying performance outcomes. At week 24, pellet-fed hens carried numerically more hierarchical follicles than hens fed mash (4.00 versus 3.00), directly representing the active ovulation queue and functioning as the primary correlate of ovulation frequency and laying rate (Johnson, 2015). The numerically greater hierarchical follicle count in pellet-fed birds at mid-lay is consistent with the significantly higher HDEP by this group at weeks 17–20 and their sustained production advantage through weeks 29–40. Critically, the parallel observation that ovary weight tended to be higher in mash-fed birds (1.94 ± 0.03% versus 1.29 ± 0.45% p = 0.285 for week 24 and 4.18 ± 0.73g versus 3.40 ± 0.27g, p = 0.469 for week 40) suggests that pellet-fed birds carried more but lighter pre-ovulatory follicles, indicative of a more active ovulatory cycle, whereas the larger ovary weight in mash-fed birds may reflect greater follicular mass of individual hierarchical follicles. This distinction has implications for per-egg nutrient deposition and egg size, and is consistent with the observation that mash-fed birds produced heavier but fewer eggs in early lay.

At week 40, individual hierarchical follicle weights for follicles 1 and 2 were numerically greater in birds fed commercial mash compared with birds fed farm-mixed rations (11.00 ± 1.00 g versus 7.00 ± 5.00 g for F1; 7.00 ± 1.00 g versus 5.00 ± 3.00 g for F2), though high variability rendered differences non-significant. F1 follicle weight or size is a reliable indicator of ovulation imminence and pre-ovulatory follicle quality; larger F1 follicles are associated with greater yolk deposition rates and larger eggs (Renema et al., 2018). The numerically larger F1 in birds fed commercial mash is consistent with their significantly greater egg weights during mid-to-late lay. Most critically, ovary weight at week 40 showed a striking numerical difference between birds fed commercial mash (4.18 ± 0.73%) and farm-mixed mash birds (1.32 ± 0.88%; p = 0.108), likely failing statistical significance due to limited replication at this time point. This approximately threefold difference in ovary mass is of serious biological consequence. Ovarian regression – manifested as reduction in ovary weight, follicle number, and follicle size – is the primary mechanism underlying declining egg production in late lay (Johnson, 2015). The dramatically lower ovary weight in farm-mixed birds by week 40 is consistent with their precipitous late-cycle HDEP collapse (42.07 ± 1.21% versus 72.15 ± 1.31% for commercial mash; p < 0.001). The contrast between the broadly comparable follicular profiles observed at week 24 and the markedly divergent ovarian state at week 40 reveals the insidious temporal dynamics of sub-clinical nutritional deficiency: cumulative modest shortfalls in protein and other nutrients accumulate progressively across the production cycle, initially insufficient to manifest as measurable differences but ultimately precipitating accelerated ovarian senescence that becomes fully apparent only in the final production phase.

Table 9: Follicular variables of laying hens fed commercial pellet or mash feeds

	Feed form		
Variable	Pellet	Mash	p-value
Week 24			
Ovary weight (%)	1.29 ± 0.45	1.94 ± 0.03	0.285
Hierarchical follicle (no.)	4.00 ± 0.00	3.00 ± 0.00	1.000
Pre-hierarchical yellow follicle (no.)	2.00 ± 0.00	2.00 ± 0.00	1.000
Pre-hierarchical white follicle (no.)	3.00 ± 1.00	4.50 ± 0.50	0.312
Hierarchical follicle 1 (g)	10.50 ± 1.50	12.50 ± 0.50	0.333
Hierarchical follicle 2 (g)	9.50 ± 1.50	9.00 ± 1.00	0.808
Hierarchical follicle 3 (g)	6.50 ± 1.50	6.50 ± 0.50	1.000
Week 40			
Ovary weight (%)	3.40 ± 0.27	4.18 ± 0.73	0.469
Hierarchical follicle (no.)	3.00 ± 0.00	4.00 ± 1.00	0.423
Pre-hierarchical yellow follicle (no.)	3.00 ± 1.00	2.00 ± 0.00	0.423
Pre-hierarchical white follicle (no.)	4.50 ± 1.50	5.00 ± 4.00	0.918
Hierarchical follicle 1 (g)	10.50 ± 4.00	11.00 ± 1.00	0.698
Hierarchical follicle 2 (g)	6.00 ± 1.00	7.00 ± 1.00	0.553
Hierarchical follicle 3 (g)	2.50 ± 0.50	4.50 ± 1.50	0.333

Table 10: Follicular variables of laying hens fed commercial or farm mixed mash ration

	Feed source		
Variable	Commercial mash	Farm-mixed mash	p-value
Week 24			
Ovary weight (%)	1.94 ± 0.03	2.01 ± 0.06	0.389
Hierarchical follicle (no.)	3.00 ± 0.00	4.50 ± 0.00	0.095
Pre-hierarchical yellow follicle (no.)	2.00 ± 0.00	2.00 ± 0.00	1.000
Pre-hierarchical white follicle (no.)	4.50 ± 0.50	5.50 ± 0.50	0.293
Hierarchical follicle 1 (g)	12.5 ± 0.50	11.5 ± 0.50	0.293
Hierarchical follicle 2 (g)	9.00 ± 1.00	9.00 ± 0.00	1.000
Hierarchical follicle 3 (g)	6.50 ± 0.50	6.50 ± 0.50	1.000
Week 40			
Ovary weight (%)	4.18 ± 0.73	1.32 ± 0.88	0.108
Hierarchical follicle (no.)	4.00 ± 1.00	2.16 ± 1.16	0.316
Pre-hierarchical yellow follicle (no.)	2.00 ± 0.00	1.00 ± 0.58	0.272
Pre-hierarchical white follicle (no.)	5.00 ± 4.00	7.67 ± 2.19	0.562
Hierarchical follicle 1 (g)	11.00 ± 1.00	7.00 ± 5.00	0.569
Hierarchical follicle 2 (g)	7.00 ± 1.00	5.00 ± 3.00	0.623
Hierarchical follicle 3 (g)	4.50 ± 1.50	5.00 ± 0.00	0.879

IV. CONCLUSION

This study provides evidence that feed form and feed source exert significant influences on production performance, egg quality, and follicular variables in layer chickens over the production phases. Pellet feed and to a lesser degree commercial mash, conferred consistent and practical advantages in hen-day egg production especially at the onset of lay and at late production phase, while also supporting superior egg quality. Hens fed farm-mixed mash experienced a significant late-cycle egg production decline, diminished follicular mass and a smaller pre-hierarchical follicle pool, which may point to accumulated effects of sub-clinical nutritional inadequacy. Farm mixing of feed may be disadvantageous to laying programmes in the long-run unless nutritional precision, particularly adequate and consistent protein, energy, and micronutrient supply throughout the laying phase is ensured. Future research should identify the specific dietary factors responsible for late-cycle production decline in farm-mixed feed fed hens.

REFERENCES

[1] Abdollahi, M. R., Ravindran, V., & Svihus, B. (2013). Pelleting of broiler diets: An overview with emphasis on pellet quality and nutritional value. Animal Feed Science and Technology, 179(1–4), 1–23. https://doi.org/10.1016/j.anifeedsci.2012.10.014

[2] Abdollahi, M. R., Ravindran, V., & Svihus, B. (2019). Physical processing of feed in relation to gastrointestinal tract development, gut health and performance of poultry. In Improving Gut Health in Poultry (pp. 31–57). Burleigh Dodds Science Publishing.

[3] Adebiyi, O. A., Makinde, O. A., & Ironkwe, M. O. (2019). Effect of feed form and dietary nutrient density on performance of commercial layers in a tropical environment. Journal of Applied Poultry Research, 28(2), 342–350.

[4] Agunbiade, J. A., Adeyemi, O. A., Ashiru, O. M., Awojobi, H. A., Taiwo, A. A., Oke, D. B., & Adekunmisi, A. A. (2020). Replacement of fishmeal with maggot meal in cassava-based layers' diets. Journal of Poultry Science, 44(3), 278–283.

[5] Ajayi, F. O., Bamidele, O., Hassan, W. A., Ogundu, U., Yakubu, A., Alabi, O. O., Akinsola, O. M., Sonaiya, E. B., & Adebambo, O. A. (2020). Production performance and survivability of six dual-purpose breeds of chicken under smallholder farmers' management practices in Nigeria. Archives Animal Breeding, 63(2), 387–408.

[6] Alabi, O. O., Ajayi, F. O., Bamidele, O., Yakubu, A., Ogundu, E. U., Sonaiya, E. B., Ojo, M. A., Hassan, W. A., & Adebambo, O. A. (2020). Impact assessment of improved chicken genetics on livelihoods and food security of smallholder poultry farmers in Nigeria. Livestock Research for Rural Development, 32(5), 77.

[7] AOAC International. (2016). Official methods of analysis of AOAC International (20th ed.). AOAC International.

[8] Gao, Z., Zhang, J., Li, F., Zheng, J., & Xu, G. (2021). Effect of oils in feed on the production performance and egg quality of laying hens. Animals, 11(12), 3482.

[9] Hartcher, K. M., & Jones, B. (2017). The welfare of layer hens in cage and cage-free housing systems. World's Poultry Science Journal, 73(4), 767–782.

[10] Haugh, R. R. (1937). The Haugh Unit for Measuring Egg Quality. The US Egg and Poultry Magazine, 45, 552–555, 572–573.

[11] Jafar-Nejad, S., Farhangi, M., Omrani, F., & Sharifi, S. D. (2021). Effect of feed form and nutrient density on growth performance, blood parameters, and intestinal traits in broiler breeder pullets. Poultry Science, 100(9), 101327.

[12] Johnson, A. L. (2015). Reproduction in the female. In C. G. Scanes (Ed.), Sturkie's Avian Physiology (6th ed., pp. 635–665). Academic Press.

[13] Kiarie, E. G., & Mills, A. (2019). Role of feed processing on gut health and function in pigs and poultry: Conundrum of optimal particle size and hydrothermal regimens. Frontiers in Veterinary Science, 6, 19.

[14] Kim, C. H., & Kang, H. K. (2022). Effects of energy and protein levels on laying performance, egg quality, blood parameters, blood biochemistry, and apparent total tract digestibility on laying hens in an aviary system. Animals, 12(24), 3513.

[15] Koçer, B., Bozkurt, M., Küçükyılmaz, K., Ege, G., Akşit, H., Orojpour, A., Topbaş, S., Tüzün, A. E., Bintaş, E., & Seyrek, K. (2016). Effects of particle sizes and physical form of the diet on performance, egg quality and size of the digestive organs in laying hens. European Poultry Science, 80.

[16] National Research Council. (1994). Nutrient requirements of poultry (9th rev. ed.). National Academy Press.

[17] National Root Crops Research Institute (NRCI) (2017). Meteorological Station, NRCI, Umudike.

[18] Nworgu, F. C., & Ogungbenro, S. A. (2017). Assessment of the performance of layer chickens and economic evaluation of commercial versus farm-formulated feeds in humid tropics of Nigeria. International Journal of Poultry Science, 16(4), 147–154.

[19] Ogundeji, A. B., Osanyinlusi, O., & Adeoti, A. (2024). Feed cost optimisation of table egg production in Nigeria. Malaysian Journal of Applied Economics, 13(1), 1–15.

[20] Oso, A. O., Awoniyi, A. T., & Sobayo, R. A. (2019). Effect of pellet versus mash diets on performance, blood chemistry, and organ morphology of laying hens. Tropical Animal Health and Production, 51(5), 1137–1145.

[21] Park, J., Kim, S., Lee, H., & Choi, Y. (2025). Effects of feed form on eggshell quality and calcium metabolism in commercial laying hens. Poultry Science, 104(1), 103415.

[22] Renema, R. A., Robinson, F. E., & Zuidhof, M. J. (2018). Reproductive efficiency and metabolism of female broiler breeders as affected by genotype, feed allocation, and age at photostimulation. Poultry Science, 78(4), 479–491.

[23] Ricke, S. C., Dittoe, D. K., & Richardson, K. E. (2022). Application of microbial analyses to feeds and potential implications for poultry nutrition. Poultry Science, 101(5), 101784.

[24] Thomas, M., van Vliet, T., & van der Poel, A. F. B. (2018). Physical quality of pelleted animal feed 3. Contribution of feedstuff components. Animal Feed Science and Technology, 70(1–2), 59–78.

[25] Wan, Y., Ma, R., Khalid, A., Chai, L., Qi, R., Liu, W., Li, J., Li, Y., & Zhan, K. (2021). Effect of the pellet and mash feed forms on the productive performance, egg quality, nutrient metabolism, and intestinal morphology of two laying hen breeds. Animals, 11(3), 701.

[26] Yenice, G., Kaynar, O., Ileriturk, M., Hira, F., & Hayirli, A. (2025). Feed form and its effects on shell quality, nutrient utilization, and laying performance across the production cycle. Poultry Science, 104(3), 103621.

[27] You, J., Ellis, J. L., Tulpan, D., & Malpass, M. C. (2024). Recent advances and future technologies in poultry feed manufacturing. World's Poultry Science Journal, 80(3), 643–655.

[28] Yunitasari, F., Jayanegara, A., & Ulupi, N. (2023). Performance, egg quality, and immunity of laying hens due to natural carotenoid supplementation: A meta-analysis. Food Science of Animal Resources, 43(2), 282–304. https://doi.org/10.5851/kosfa.2022.e76

[29] Zinn, R. A. (2004). A guide to feed mixing. University of California, Davis, Department of Animal Science.