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Original article

Effect of sequential feeding and feed form on laying hens fed whole sorghum

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ABSTRACT

This study was conducted to monitor the performance of ISA Brown layers under different feeding systems using sorghum. The effect of feeding nutritionally different diets in sequential or loose-mix systems on the performance of three hundred and sixty (360) laying hens from 23rd to 42nd weeks of age was investigated. The birds were assigned to four (4) treatment groups of ninety (90) birds each. The treatments were control maize (ground), control sorghum (ground), loose-mix and sequential. Sequential feeding was found to reduce total feed intake, compared to both loose-mix and the two control treatments. Egg production was lower ($P<0.05$) in the sequential treatment while egg weight, egg mass and final body weight were higher ($P<0.05$). Feed conversion ratio was better ($P<0.05$) in the sequential feeding. The study concluded that sorghum can be used as a replacement for maize part per part in feeding layers and that feeding whole sorghum grains loosely-mixed or sequentially had no negative effects on the performance of laying hens and are thus potential alternatives to the conventional feeding system.

1. Introduction

The use of whole grains would not only save cost of grinding and mixing (Pousga et al., 2005), but is also accompanied by increased efficiency of feed utilization (Karunajeewa, 1978). McIntosh et al. (1962) showed that grinding or pelleting wheat, barley, oats or maize did not result in a consistent increase in ME constant of poultry feeds. Moreover, it was found that whole wheat yielded more metabolizable energy than ground or pelleted wheat. Where the cost of feedstuffs is high and diet-mixing machinery expensive, as is the case in most developing countries, it may be more economical to transport only a protein concentrate and add this to a locally grown energy source (whole grains), such as sorghum, which will reduce feed cost by reducing the cost of grinding (Olver and Malan, 2000). Whole grains can be fed simultaneously with protein concentrates in different systems namely; fed using different containers (choice feeding); mixed together and fed in a single container (loose-mix); or fed at different times of the day (sequential feeding) (Noirot et al., 1998). Sequential feeding has been reported to increased efficiency of feed utilisation (Henuk and Dingle, 2002) as well as an improvement in total feed intake and production parameters (Blair et al., 1973). However, other studies have reported low feed intake when hens are fed sequentially (Leeson and Summers, 1978; Reichmann and Connor, 1979; Robinson, 1985; Lee and Ohh, 2002). Sequential feeding when compared to the conventional mash feeding system, similar egg production values were reported (Leeson and Summers, 1978; Reichmann and Connor, 1979; Lee and Ohh, 2002) or lower (Robinson, 1985). These studies used diets that differed greatly in energy, protein and calcium sources, therefore obtained varied performances in terms of feed intake, egg production, egg weight and feed efficiency in birds fed sequentially compared to those fed conventionally. Umar Faruk et al. (2010) observed similar feed intake and egg production using conventional, loose mix or sequential feeding systems and observed that sequential feeding largely improved feed efficiency. It is therefore against this backdrop the present study was conducted to evaluate the impact of sequential feeding of sorghum on the performance of laying hens in north central Nigeria.

2. Materials and methods

Three hundred and sixty 23-weeks old ISA Brown pullets, averaging 1489g were used in the experiment. The birds were divided into four treatments of 90 birds each. Each treatment consisted of 15 replicates, with six birds per replicate. The treatments include: T1 (control) maize based mash diet, T2 sorghum based (control sorghum) mash diet, T3 (loose-mix) containing whole (unground) sorghum, which was mixed with the remaining portion of the diet and fed as a whole diet and T4 (sequential) which also contained whole (unground) sorghum; but unlike in T3 the whole grain was first fed in the morning (at 8.00am) while the remaining portion of the diet was fed in the afternoon (by 1.00pm) after collecting the sorghum left over. The birds were housed in cages (25cm × 35cm), with 3 birds per compartment. The experimental birds were fed iso-caloric (2,600 kcal ME) and iso- nitrogenous (18.9%) diets (Table 1). Water was served *ad libitum* and the birds were kept on 16hr light regime throughout the experimental period i.e. from 6am to 10.00pm daily. The feeding trial lasted for twenty (20) weeks.

Table 1
Gross and chemical composition of the experimental diets.

	Treatments*			
Ingredients	**T1**	**T2**	**T3**	**T4**
Maize	41.0	0	0	0
Sorghum	0	41.0	41.0	41.0
Groundnut cake	18.0	18.0	18.0	18.0
Wheat Offal	29.35	29.35	29.35	29.35
Limestone	9.7	9.7	9.7	9.7
Bone meal	1.2	1.2	1.2	1.2
Vitamin/mineral Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.13	0.13	0.13	0.13
Lysine	0.12	0.12	0.12	0.12
Total	100	100	100	100

Calculated chemical composition (%)				
Energy kcal/kg ME	2,600	2,600	2,600	2,600
Crude protein %	18.9	18.9	18.9	18.9
Crude fibre %	4.2	4.2	4.2	4.2
Available phosphorus	0.4	0.4	0.4	0.4
Calcium	3.6	3.6	3.6	3.6
Ether extract	3.7	3.7	3.7	3.7
Lysine	0.8	0.8	0.8	0.8
Methionine	0.4	0.4	0.4	0.4

* T1 = (Control maize) T2 = (Control Sorghum) T3 = (Loose-mix sorghum) T4 = (Sequential sorghum)

3. Results

3.1. Proximate composition of the experimental diets fed to laying hens

Table 1 showed the analysed chemical composition of the experimental diets. The DM content of the experimental diets (Table 2) was found to be almost the same across the diets. The similarity might be due to the same quantities of the feed ingredients used across the treatment diets. The crude protein values of 17.38%, 17.31%, 17.50% and 17.31% for control maize, control sorghum, loose-mix and sequential diets respectively were close to the value used (18%) in the diet formulation. The high ash content of loose-mix (T3) did not have a corresponding high CF content in the diet. Ether extract or lipid content of the diets was the same across the treatment diets. The NFE content of the diets was comparable though with little numerical variation across the treatment diets.

Table 2
Proximate composition of the experimental diets (%).

	Treatment diets			
Parameter	T1 (Control maize)	T2 (Control sorghum)	T3 (Loose-mix)	T4 (Sequential)
Dry Matter	94.4	94.0	94.1	93.1
Crude Protein	17.4	17.3	17.5	17.3
Crude Fibre	5.7	5.7	4.3	6.0
Ether Extract	4.5	4.3	4.9	4.2
Ash	11.3	10.3	19.2	16.2
NFE	61.2	62.4	54.1	56.3

3.2. Performance characteristics

Feed intake was significantly lower ($P<0.05$) in T4 compared to other treatments (Table 3). Feed intake was significantly lower ($P<0.05$) for birds fed under the sequential feeding system. In sequential feeding however, the birds fed more on the balancer diet served in the evening, but this still made the birds to consume about 12-13% less of the total feed.

Average egg production was significantly higher in T1 (66.80%) compared to the other treatments namely; T2 (61.70%), T3 (62.10%) and T4 (59.80%).

Egg weight was similar in all the treatments except sequentially fed birds ($P<0.05$). Calculated egg mass was significantly ($P<0.05$) lower in T2 (40.23) than what was recorded in T1 (46.15), T3 (43.51) and T4 (46.35). Feed conversion ratio was significantly better ($P<0.05$) with control maize T1 (1.76), than T2 (1.89), T3 (1.90) and T4 (1.91) as shown in Table 3.

Initial body weight did not differ between the treatments. However, final body weight was significantly higher ($P<0.05$) for birds fed sequentially (T4) (1733.30g) and those fed the control maize diet (T1) (1732.70g) compared to the other treatments (T2 and T3) that recorded 1690.70g and 1650.20g respectively. The average daily weight gain for the individual treatments are said to be statistically similar across all the treatments (Table 3).

Table 3
Performance characteristics of laying birds fed diets containing maize or sorghum fed as loose mix or sequentially between 23 and 42 weeks of age.

	Experimental diets				
Measurement	**T1 (Control maize)**	**T2 (Control sorghum)**	**T3 (Loose-mix)**	**T4 (Sequential)**	**SEM**
Av. Feed intake (g/b/d)	117.70[a]	116.45[a]	117.50[a]	113.79[b]	0.48
Av. Egg prod (%)	66.80[a]	61.70[b]	62.10[b]	59.80[b]	1.10
Egg weight (g)	58.60[b]	59.00[b]	60.00[b]	62.20[a]	0.40
Egg mass	46.15[a]	40.23[b]	43.51[a]	46.35[a]	1.02
Feed Conversion Ratio	1.76 [a]	1.89 [b]	1.90 [b]	1.91 [b]	0.64
Body weight (g/b)					
Initial weight	1482.10	1482.80	1494.90	1494.20	10.23
Final weight	1732.70[a]	1690.70[b]	1650.20[c]	1733.30[a]	11.70
Daily weight gain	1.8	1.5	1.1	1.7	0.04

a,b,c: Means along the same row with different superscripts are significantly different (P<0.05).

3.3. Cost of feed

Table 4 showed the cost of the feed fed to the experimental birds. Cost of feed/egg was significantly lower (P>0.05) for T4 (₦3.45) compared to the cost incurred in T1 (₦ 4.15), T2 (₦ 3.69) and T3 (₦ 3.71 ₦/egg).

Table 4
Cost of feed, cost of feed consumed and cost of egg.

	Treatments					
Parameter	**T1**	**T2**	**T3**	**T4**	**P Value**	**SEM**
Cost of feed (₦*/kg)	61.6	59.8	59.2	59.2	<.601	0.45
Cost of feed consumed (₦/b/d)	7.25[a]	6.97[b]	6.96[b]	6.74[c]	<.001	0.03
Cost of feed/egg (₦/b)	4.15[a]	3.69[b]	3.71[b]	3.45[c]	<0.01	0.07

a,b,c: Means along the same row with different superscripts are significantly different (P<0.05). * 1 USD (Dollar) equivalent to 350 ₦ (Naira).

4. Discussion

4.1. Proximate composition of the experimental diets for laying hens

The DM content of the experimental diets (Table 2) was found to be almost the same across the diets. The similarity might be due to the same quantities of the feed ingredients used across the treatment diets. The DM content was higher than the values reported by Bashar (2008). The crude protein values of 17.38%, 17.31%, 17.50% and 17.31% for control maize, control sorghum, loose-mix and sequential diets respectively were close to the value used (18%) in the diet formulation. There was slightly high fibre level in sequential (T4) diet compared to the rest of the treatments. The high ash content of loose-mix (T3) did not have a corresponding high CF content in the diet. Rather in this analysis, increased ash content in T3 might be due to the whole grain mixed in the diet. The ash values were higher than the values obtained by Bashar (2008). Ether extract or lipid content of the diets was the same across the treatment diets as reported elsewhere (Donkoh and Attoh-Kotoku, 2009). This may be attributed to equal energy level used, and maize and sorghum contain were reported to have low oil content (Adams and Jensen, 1987; Aduku, 1993). The NFE content of the diets was comparable though with little numerical variation across the treatment diets, but values were similar to those reported by (Bashar, 2008).

4.2. Performance characteristics

Feed intake was significantly lower (P<0.05) for birds fed under the sequential feeding system. The low feed intake was probably as a result of the introduction of whole grains, this was similarly observed by Umar Faruk et al. (2008) who fed whole and a protein concentrate diet to laying hens using millet. Another reason could be that whole grains yielded more metabolizable energy than ground or pelleted grains (McIntosh et al., 1962).

Presentation of the feed as pellets, crumbs and whole grains as in this study, is known to reduce feed consumption time with an increase in the frequency of feather pecking and mortality as a consequence. Similar findings were made by Robinson (1985); Lee and Ohh (2002) who studied oats/sorghum sequentially fed with a protein concentrate; and a high energy/protein and a low Ca^{+} diet in the morning followed by a low energy/protein and high Ca^{+} in the afternoon were fed respectively. In sequential feeding however, the birds fed more on the balancer diet served in the evening, but this still made the birds to consume about 12-13% less of the total feed. The laying hen adapts to its feed intake relatively well to the energy value of its feed, as the hen is influenced by the form and method in which the feed is presented. The higher concentrate intake in sequentially fed birds could be attributed to the protein and mineral content which were fed by the time of the day (afternoon) in which feed intake in laying hens is influenced by egg-forming cycle as well as photoperiod. This is also observed by Choi et al. (2004) and Umar Faruk et al. (2010). Therefore, it was observed that sequentially fed birds consumed more balancer ration in the afternoon, probably owing to the calcium requirement in eggshell formation, especially on egg forming days. Birds fed sequentially consumed more balancer ration compared to those fed the loose-mix diet. Blair et al. (1973) observed an increased balancer ration intake when birds were fed sequentially, and in especially when there is a high intake of protein concentrate. However, a contrary observation was made by Leeson and Summers (1978) as well as Reichmann and Connor (1979) in sequential feeding using an energy-rich diet in the morning and a protein concentrate in the afternoon, with a lowered concentrate intake. In this study, the high balancer ration intake with sequential feeding agrees with the findings of Ballard and Biellier (1969); Nys et al. (1976); Keshavarz (1998); Choi et al. (2004) and recently Umar Faruk et al. (2010) working with laying hens. Despite the lowered feed intake in sequentially fed birds when compared to the other treatments, similar or even better performance (Table 3) was recorded. This was also observed by Leeson and Summers (1978); Riechmann and Connor (1979) and Umar Faruk et al. (2010). The researchers attributed their observations to probably lower maintenance requirements as a result of lower body weights in sequentially fed birds. However, in this work, sequentially fed birds recorded higher body weights compared to the rest of the treatments. Therefore, enhanced performance could be as a result of a better efficiency and utilization of nutrients evidenced in feed conversion ratio and efficiency of feed per egg.

The loose-mix treatment was observed to have had equal or higher feed intake among the sorghum treatment diets. This might be due to the particle size of the grain mixed with the protein concentrate, which might have attracted particle selection, thereby increasing feed intake. This is in consistence with the earlier findings of Picard et al. (1997); Umar- Faruk et al. (2008) and Safaa et al. (2009).

There was inconsistencies in body weight results of the birds from previous works when birds were fed sequentially, with either increase or decrease of weight gain by the birds. Nir et al. (1995) and Amerah et al. (2007) all reported heavier body weights and better feed efficiency when fed whole/coarse wheat and sorghum diets compared to those fed medium coarse to finely ground mash diets. In this study however, body weight was found to be similar between the treatments at the beginning of the experiment, but was significantly higher (1733.30 g/d) in the sequential feeding and Control (1732.70 g/d) at the end of the experiment, as compared to Control Sorghum (1690.70 g/d) and loose-mix (1650.20 g/d).

Improved body weight in the sequential feeding in this study was as a result of better feed efficiency exhibited by the hens. In contrast, Douglas et al. (1990); Hassan et al. (2003) all reported depressed weight gain and feed efficiency when fed broilers coarser particle diets of either maize or sorghum and chicks fed diets with low or high tannin contents, and Umar Faruk et al. (2010) who fed whole wheat sequentially to layers. Birds fed loose-mix had lower body weight gain numerically among the sorghum based diets. This could be explained by relatively less feed efficiency in loose-mix feeding as mentioned somewhere (Umar Faruk et al., 2010).

Egg weight was also higher in sequential feeding than found in the other two sorghum based diets. The present findings is in agreement with the earlier findings of Olver and Malan (2000) who reported that the hens offered the choice fed diet laid heavier eggs. Results of our study further indicates that the significantly low feed intake in the sequential treatment did not affect the birds' performances in terms of percent lay, egg weight, egg mass and even body weight. Blair et al. (1973), Reichmann and Connor (1979), Lee and Ohh (2002) and Umar Faruk et al. (2010) all reported similar performances when hens were experimented with sequential feeding. Leeson and Summers (1978) however, reported an increase in egg production due to increase in protein and energy intake of birds fed sequentially. Egg weight was similar (Blair et al., 1973) or lower (Leeson and Summers, 1978; Robinson, 1985; Lee and Ohh, 2002) in sequential compared with conventional feeding. The latter authors reported decreased egg weight of birds fed in loose-mix. Morris and Gous (1988) also reported reduced egg weight and rate of lay when protein intake was reduced.

FCR considerably improved (18%) and maintained similar production indices with sequential diet during the experimental period compared with control sorghum or loose-mix, despite the reduced feed intake. Different explanations may account for this observed improvement in feed efficiency in birds fed diets with whole grain particles. First, a greater proportion of whole grain resulted in a longer residence time within the gizzard, leading to enhanced digestion and thus better feed efficiency. Secondly, a greater proportion of the whole grains might stimulate greater gizzard activity, leading to more efficient grinding with production of greater quantities of finer particles that are more readily digested. Thirdly, that with greater requirement for gizzard action to decrease particle size, efficiency is decreased, a greater proportion of coarser material enters the small intestine and that this coarser material in some way stimulates digestive efficiency and is itself digested more readily (Amerah et al., 2008). Therefore, physical form of diets presumably influences gizzard development as whole or pelleted feed increases the ability of birds to grind feed and ease digestion. However, grain type or form influences, to some extent, the protein concentrate intake which may lead to inefficient utilization of protein and other nutrients.

4.3. Cost of production

From the results (Table 4), it is evident that hens fed sequentially performed economically better, considering their lower feed intake, percent egg production, the lower cost of the diet itself and the cost of feed per egg produced.

Reduction of feed cost and an optimally enhanced production performance of sequentially fed birds in this study confirms other researchers (Pousga et al., 2005; Umar Faruk et al., 2010) findings, suggesting that the bird is capable of balancing its own diet when offered an array of ingredients, by closely monitoring individual nutrient intake, to metabolic requirement at specific times of the day, there seems to be an overall saving in nutrient and feed intake. However, this improved efficiency must be considered in relation to the physical and mechanical problems related to simultaneously offering two or more diets to laying hens.

5. Conclusion

Based on the results of this study, it can be concluded that sequential feeding recorded better efficiency and utilization of nutrients, higher body weight, per cent lay, egg weight, and egg mass compared to other treatments. An 18% improvement in FCR was observed with sequential diet compared with control sorghum or loose-mix. Hens fed sequentially appeared to have better economic performance when the comparatively lower feed intake, higher per cent egg production, lower cost of the diet itself and the cost of feed per egg produced are all taken into consideration. Finally, within the framework of the constraints imposed by the location of this study, sorghum is a potentially suitable substitute for maize in the diet of laying hens.

Recommendations

To consolidate the observable gains presented by the findings of this study, more studies are required especially in the following areas:

- The present study fed diets that are relatively low in energy (2600kcal/kg), it is therefore necessary to evaluate these feeding systems using different energy levels so as to establish the optimal dietary energy level that can similarly lead to production optimality.
- There is also the need to investigate these feeding systems using different varieties of sorghum and in particular under varying tannin contents.

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