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Effect of using the Local Concentrate as an alternative to the imported concentrate on the performance and egg quality of layers

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Abstract:

A total of 27 White Hisex layer hens (24 weeks old) were used in this study. They were purchased from a company specializing in the production of laying hens. The birds were randomly divided into three treatment groups (A, B, and C), with each group further subdivided into three replicates of three birds each. Group A was fed a diet containing 5% local concentrate, Group B received 7.5% local concentrate, while Group C (control) was fed a diet with 5% imported concentrate. The inclusion of local concentrate at both levels significantly improved egg production and quality parameters compared to the control group. The results revealed that replacing imported concentrate with local concentrate had a significant effect on egg production, egg mass, and egg number, but not on egg weight. Regarding egg quality characteristics, no significant differences were observed in shape index, egg diameter, Haugh unit, shell weight, yolk weight, or albumen weight—except for egg height and yolk color, which showed significant differences ($p \leq 0.05$) among treatment groups. Economic evaluation indicated that replacing imported concentrate with local concentrate at both levels was more cost-effective than the control. The 7.5% local concentrate level proved to be the most economically beneficial. Based on the findings, locally formulated concentrate can be considered a viable alternative to imported concentrate in layer diets, without adverse effects on performance or egg quality.

Keywords:

White Hisex layer hens, local concentrate, egg quality, cost-effectiveness, lying, and performance.

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Introduction:

The poultry production in Sudan faced a feed crisis because of the high cost of production, which was attributed to the rise in feed ingredient costs, mainly imported concentrates (Mukhtar et al., 2010). Thus, there is an urgent need for nutritious and affordable feeds, using other crops and agricultural by-products that are less costly than conventional feedstuffs. Sudan imported foreign concentrate with hard currency amounting to about 101,021 tons for layers during 2019. The overall gross cost was about 6,465,344 Uru million dollars at a price of 3 US$/ton, which has had an adverse effect on the national economy.

Now, there have been many attempts from nutritionists to replace the imported concentrate with different locally available protein sources and to completely replace imported concentrate by synthetic alternatives. The objective of this study is to reduce the cost of production. Therefore, the present study aimed to assess the comparison between local concentrate installation by fish meal with imported concentrate on the egg production and quality of layers.

Materials and Methods:

A total of 105 hens at the production stage were purchased and randomly divided into 3 groups (A, B, and C) with 5 replicates and 7 hens per each replicate. Hens in Group A were fed a diet supplemented with layers' imported concentrate, as the control group, while hens in Groups B and C were fed on diets supplemented with locally formulated concentrate at levels of 5% and 7.5%, respectively. The experiment continued for one year.

The experimental parameters covered egg production and qualities, and an economical appraisal. Sudan is blessed with many rivers together with the Red Sea. Huge quantities of fish offal and fish meal, estimated at more than ten thousand tons, can be produced (Seham et al., 2015). Good local concentrate mixtures can be formulated from local plant proteins (sesame, groundnut cake, and sunflower), supplemented with animal protein (fish), imported synthetic essential amino acids (such as lysine and methionine), and vitamin premixes—leading to economic production.

The experimental study was conducted to assess the substitution of imported concentrate by locally formulated concentrate on layer hens’ egg production, egg quality characteristics, and economic production.

This study was conducted at the Department of Animal Production, College of Agricultural Studies, Sudan University of Science and Technology. The ambient temperature ranged between 28 to 37°C.

A total of 27 White Hisex layer hens (24 weeks old) were used in the study. They were purchased from a company specialized in the production of laying hens. Birds were reared and raised under similar management and housing conditions and were vaccinated against Newcastle disease (NCD), infectious bronchitis (IB), Gumboro, and fowl pox. They were debeaked during the rearing period at the age of 17 weeks.

Birds were randomly divided into three treatments (A, B, and C). Each treatment group was subdivided into three replicates of 3 birds each and then individually weighed.

Birds were kept in an open wire mesh-sided poultry house. The house was cleaned and disinfected before the commencement of the experiment.

One battery cage stairs and 20 small units of dimensions (30×30×30 cm) were used for housing the birds in the open-sided house. Tubular feeders and tubular waterers were used for feeding and watering the birds.

The lighting program followed was composed of 12 hours of natural daylight, to which 4 hours of artificial light using 60-watt bulbs were added after sunset, giving a total of 16 light-dark cycle hours.

House temperatures and humidity were measured daily each morning and afternoon and were recorded.

Experimental groups and replicates were fed the experimental diets for 8 weeks after a 2-week adaptation period, after which the birds were weighed and then distributed according to the experimental design. Feed and water were supplied *ad libitum* throughout the experimental period.

The local concentrate used in this experiment was manufactured in the Department of Animal Production factory from fishmeal and some vegetable Sudanese raw materials, used as an alternative to imported concentrate. Three experimental diets were formulated to meet or exceed the requirements of layer hens according to NRC (1994). The diets were iso-nitrogenous and iso-caloric. Birds were fed on 3 dietary treatments.

Preparation of Fishmeal:

The fish was brought in third grade from Al-Fatihab market, cut into thin slices, and put in the sun for two weeks by hanging on wires to dry and to sterilize pathogenic bacteria and salmonella. Then the dried fish fillets were ground using a derrick mill. After that, it was dried in the shade to remove the remaining moisture for three days. After this, the fishmeal was ready for use.

Group A was fed on local concentrate 5%, Group B on local concentrate 7.5%, and Group C on the control diet with imported concentrate 5%.

The experimental diets were analyzed for crude protein, moisture content, crude fat, and crude ash percentages according to the methods of AOAC (1984).

Metabolizable energy of feed ingredients was calculated based on the equation of Ellis (1981). The diets were formulated to meet the requirements established by NRC (1994). Feed and drinking water were provided *ad libitum*.

Table (1): Chemical Analysis of diets:

Components	Dry matter%	Ash %	Crude protein%	Ether Extract%	Crude fiber%
Imported concentrate 5%	90	12	18	4	7
Local concentrate 5%	89	8	18.3	4.1	5.2
Local concentrate 7.5%	90	9.5	19	4.3	6

(Koko research center lab)

Data Collection

Performance Data:

Egg production was calculated daily based on hen-day (HD) parameters, and hygiene was closely observed.

Egg mass = HD production × Average egg weight

External Physical Egg Characteristics:

Egg quality parameters were determined every week using 3 eggs from each treatment group. Physical characteristics included:

- Egg weight was measured using a sensitive balance.
- Egg length and egg diameter were measured in millimeters (mm) using a digital vernier caliper.
- **Shape index = (Egg diameter / Egg length) × 100**

Internal Physical Characteristics (Egg Quality):

- Albumen height and yolk height were measured using a digital vernier caliper.
- Yolk color was evaluated using the Roche Yolk Color Fan.
- The shell, yolk, and albumen were weighed using a sensitive balance.
- Shell thickness was measured at different parts (large end and small end) using a digital vernier caliper.
- Haugh Unit (HU) values were calculated using a computer program. **HU = 100 × log (H + 7.57 - 1.7W^0.37)**

Statistical Analysis:

The data obtained were statistically analyzed using standard procedures of analysis of variance (ANOVA) based on a completely randomized design. Significant differences between treatment means were separated using Duncan's multiple range test at a 5% probability level (Duncan, 1995).

Results

The effect of feeding laying hens diets based on locally formulated concentrate as an alternative to imported concentrate on hen-housed egg production percentage throughout the production period (Table 2) showed a significant difference ($p \leq 0.05$) among treatments. Birds fed on local concentrates (5% and 7.5%) recorded a higher hen-housed egg production percentage, while a lower value was observed in the control group (imported concentrate 5%) throughout the experimental period. However, there was a significant difference ($p \leq 0.05$) between the two groups receiving local concentrate (5% and 7.5%). Birds fed 7.5% local concentrate recorded the highest (H-H) egg production in weeks 25, 26, 27, and 30, while those fed 5% recorded the highest (H-H) egg production in weeks 28, 31, and 32.

Egg Weight:

Results from the experimental treatments on egg weight revealed no significant difference ($p \geq 0.05$) among treatments during the experimental period in daily egg weight.

Egg Mass:

The results of the experimental treatments showed a significant difference ($p \leq 0.05$) among treatments in egg mass (Table 2). Birds fed on local concentrate (5% and 7.5%) recorded higher egg mass, while the control group (imported concentrate 5%) showed lower values throughout the experimental period. However, there was no significant difference ($p \geq 0.05$) between the two groups fed with local concentrate (5% and 7.5%).

Table (2): Effect of local concentrate as alternative imported concentrate on the (H-H) egg production and egg mass during 25-32 weeks:-

	Egg Production %				Egg Mass Gm			
Treatment / weeks	A	B	C	SE±	A	B	C	SE±
25th	60.410^b	63.495^a	57.320^c	0.1644	61.660^a	60.090^a	57.050^b	0.0200
26th	61.950^b	63.495^a	60.360^c	0.0524	64.660^a	63.170^a	59.450^b	0.0200
27th	65.085^b	66.675^a	61.950^c	0.0412	55.075^a	55.470^a	52.400^b	0.0623
28th	69.870^a	65.090^b	63.495^c	0.0261	60.140^a	61.125^a	58.470^b	0.3617
29th	79.380^a	79.380^a	76.375^b	0.0122	61.230^a	59.900^a	56.010^b	0.8982
30th	84.165^b	88.895^a	82.620^c	0.0714	55.075^a	55.470^a	52.400^b	0.0623
31th	98.505^a	96.815^b	90.490^c	0.0790	64.660^a	63.170^a	59.450^b	0.0200
32th	92.075^a	90.485^b	87.350^c	0.0428	61.660^a	60.090^a	57.050^b	0.0200

* **A:** Local concentrate 5 % , **B:** concentrate 7.5 % , **C:** imported concentrate

S.E±: standard error

Egg Quality Characteristics:

The effect of feeding laying hens diets based on locally formulated concentrate as an alternative to imported concentrate on egg quality characteristics was studied in this experiment.

Egg Shape Index:

Results of the experimental treatments on egg shape index of laying hens revealed no significant difference ($p \geq 0.05$) among treatments during the experimental period.

Egg Height:

The effect of locally formulated concentrate as an alternative to imported concentrate on egg height (Table 3) revealed a significant difference ($p \leq 0.05$) among treatment groups in weeks 26, 29, and 30, where the group fed 5% local concentrate and the control group showed higher egg height compared to the group fed 7.5% local concentrate. However, no significant differences ($p \geq 0.05$) were observed among treatment groups in weeks 25, 27, 28, 31, and 32.

Egg Diameter:

Results of the experimental treatments on egg diameter were illustrated in Table 3. The results revealed no significant difference ($p \geq 0.05$) among treatment groups during the experimental period, except for weeks 26 and 30. In week 26, the group fed 5% local concentrate had the lowest egg diameter, whereas in week 30, the group fed 7.5% local concentrate showed a higher egg diameter compared to other treatment groups.

Egg Haugh Unit (HU):

No significant differences ($p \geq 0.05$) were observed among all treatment groups in egg Haugh Unit (HU) during the experimental period, except for weeks 26 and 30. In these weeks, the groups of chicks fed on diets with local concentrate (5% and 7.5%) recorded significantly ($p \geq 0.05$) better HU values than the group fed on the imported concentrate (5%) (Table 3).

Table (3): Effect of local concentrate as alternative imported concentrate on the egg height, egg diameter and egg HU during 25-32 weeks:-

	Egg Height				Egg Diameter				Egg Hu			
Treatment	A	B	C	SE±	A	B	C	SE±	A	B	C	SE±
25th	54.523^{a}	58.420^{a}	53.933^{a}	3.2997	40.557^{a}	39.793^{a}	40.217^{a}	0.6225	91.515^{a}	93.319^{a}	90.576^{a}	2.5218
26th	59.520^{a}	53.847^{b}	58.42^{ab}	2.1605	40.81^{a}	38.693^{b}	41.317^{a}	0.8624	92.135^{ab}	93.650^{a}	88.133^{b}	1.9426
27th	54.10^{a}	52.66^{a}	55.03^{a}	1.9164	39.87^{a}	40.047^{a}	41.910^{a}	1.2053	91.140^{ab}	92.743^{a}	83.862^{b}	3.4096
28th	57.23^{a}	55.03^{a}	56.22^{a}	2.8621	41.483^{a}	40.893^{a}	40.807^{a}	0.8606	88.855^{a}	88.001^{a}	87.246^{a}	2.8535
29th	58.33^{a}	54.95^{b}	55.11^{b}	1.2807	41.993^{a}	40.637^{a}	41.653^{a}	1.1991	85.831^{a}	89.277^{a}	80.418^{a}	4.8161
30th	56.30^{a}	56.72^{a}	53.34^{b}	1.1232	41.400^{ab}	42.500^{a}	39.707^{b}	0.9919	90.688^{a}	86.409^{a}	80.733^{b}	2.3108
31th	56.55^{a}	55.37^{a}	56.05^{a}	1.5129	41.653^{a}	41.403^{a}	42.167^{a}	0.7185	92.586^{a}	88.726^{a}	85.571^{a}	2.9772
32th	54.69^{a}	54.52^{a}	54.35^{a}	0.7560	39.963^{a}	40.810^{a}	39.797^{a}	0.7178	86.520^{a}	88.343^{a}	85.055^{a}	5.0704

* **A:** Local concentrate 5 % , **B:** concentrate 7.5 % , **C:** imported concentrate

S.E±: standard error

Egg shell weight:

Egg Shell Weight:

No significant (p ≥ 0.05) differences were observed between all tested groups in egg shell weight. However, the groups of chicks fed on diets containing local concentrate (5% and 7.5%) recorded higher shell weights than the group of chicks fed on the imported concentrate (5%) during the experimental period.

Egg Wide Shell Thickness:

Results of the experimental treatments on egg wide shell thickness of laying hens revealed no significant difference (p ≥ 0.05) among all treatment groups during the experimental period.

Egg Peak Shell Thickness:

Results of the experimental treatments on egg peak shell thickness of laying hens, as presented in Table 4, showed no significant difference (p ≥ 0.05) among all treatment groups during the experimental period, except for week 30. In this week, the group fed 7.5% local concentrate had significantly higher egg peak shell thickness compared to the group fed 5% local concentrate.

Table (4): Effect of local concentrate as alternative imported concentrate on the daily peak thickness during 25-32 weeks:-

Treatment	Daily egg peak thickness at different age							
	25th	26th	27th	28th	29th	30th	31th	32th
A	0.4233a	0.4233a	0.2540a	0.5080a	0.6773a	0.3687b	0.3387a	0.4233a
B	0.2540a	0.2540a	0.3387a	0.4233a	0.5927a	0.4173a	0.2540a	0.4233a
C	0.3387a	0.4233a	0.4233a	0.4233a	0.5927a	0.2233ab	0.4233a	0.3387a
SE	0.0978	0.0978	0.0978	0.0978	0.1197	0.1197	0.0978	0.1197
LSD	0.2392	0.2392	0.2392	0.2392	0.2930	0.2930	0.2392	0.2930
MEAN	NS	NS	NS	NS	NS	S	NS	NS

* **A:** Local concentrate 5 % , **B:** concentrate 7.5 % , **C:** imported concentrate

S.E±: standard error

Discussion

Egg Production:

The effect of feeding laying hens diets based on locally formulated concentrate as an alternative to imported concentrate on hen-housed egg production percentage throughout the production period (Table 2) showed a significant difference ($p \leq 0.05$) among treatments. Birds fed on local concentrate (5% and 7.5%) gave a higher value of hen-housed egg production, and a lower value was obtained from the control diet (imported concentrate 5%) throughout the experimental period. However, a significant difference ($p \leq 0.05$) was observed between the two groups of local concentrate (5% and 7.5%). The birds fed on 7.5% recorded the highest (H-H) egg production in weeks 25, 26, 27, and 30, while birds fed on 5% recorded the highest (H-H) in weeks 28, 31, and 32.

The higher egg production in layers fed diets containing FWM might be due to higher levels of lysine, methionine, and a combination of other amino acids (Sohail et al., 2003); a positive correlation of methionine and lysine with egg production (Uma, 2000); manipulation of essential amino acids increased egg number (Gous and Nonis, 2010); or egg mass followed the same trend as egg production when dietary levels of lysine increased from 0.50 to 0.64% (Fakhraei et al., 2010). These results are contrary to the findings of Kjos et al. (2001), who reported that the inclusion of up to 5% fish silage did not affect egg production. Rose (1974) also found no difference in egg production when birds were fed fish meal.

Egg Weight:

Results revealed no significant difference ($p \geq 0.05$) among treatments in daily egg weight. This is consistent with the findings of Al-Daraji et al. (2011), who noted that fish oil supplementation positively affects quail egg weight. Gous and Nonis (2010) found that manipulation of essential amino acids such as lysine caused little change in mean egg weight. These results differ from Feijó et al. (2016), who reported increased egg weight and internal and external content quality with the inclusion of alternative energy foods in laying hen diets.

Similarly, Park and Rao (2011) observed significant differences ($p < 0.05$) in egg weight with different treated fish sources.

Egg Mass:

There was a significant difference ($p \leq 0.05$) among treatments in egg mass. Birds fed on local concentrate (5% and 7.5%) gave a higher value, while the control group (imported concentrate 5%) recorded the lowest throughout the experimental period. However, no significant difference ($p \geq 0.05$) was found between the two local concentrate groups. These findings are directly related to egg production, as egg mass is calculated from both production and egg weight (Feijó et al., 2016). The improvement in egg mass may be due to higher methionine and lysine content, which increases both egg production and egg mass. These findings align with studies by Fakhraei et al. (2010) and Hanna et al. (2013), who noted significant egg mass improvements with amino acid supplementation.

Egg Number:

A significant difference ($p \leq 0.05$) was observed among treatments in egg number, except during weeks 26, 28, and 29. No significant difference ($p \geq 0.05$) was found between the 5% and 7.5% local concentrate groups. The increase in egg number among hens fed local concentrate may be attributed to higher levels of lysine, methionine, and essential amino acids (Sohail et al., 2003; Uma, 2000; Gous and Nonis, 2010).

Egg Quality

Shape Index, Diameter, and Haugh Unit:

No significant differences ($p \geq 0.05$) were observed in shape index, egg diameter, or Haugh Unit. However, egg height showed a significant difference ($p \leq 0.05$) among treatment groups (Table 3). These results contrast with Tanuja et al. (2017), who reported no significant changes in shape index, Haugh Unit, or albumen index with fish silage. Hazim et al. (2011) and Rowghani et al. (2007) found higher Haugh Unit values in quails and hens fed fish oil and fish meal. Amao et al. (2010) and Gunawardana et al. (2008) reported no significant changes in Haugh Unit with different protein levels.

Shell Characteristics (Weight, Wide Thickness, Peak Thickness):

No significant differences ($p \geq 0.05$) were observed in egg shell weight, wide shell thickness, or peak shell thickness among all treatment groups. These results disagree with Amao et al. (2010), who found increased shell weight when fish meal levels increased from 1% to 4%.

Yolk Weight and Color:

No significant differences ($p \geq 0.05$) were observed in egg yolk weight and height, except in weeks 26 and 31, where the local concentrate groups (5% and 7.5%) had significantly better results ($p \leq 0.05$). However, yolk color showed a significant difference ($p \leq 0.05$) throughout the period, with the imported concentrate group recording better color. These findings are consistent with Panda and Singh (1990). Results contradict Amao et al. (2010), who found no difference in yolk color, and Hazim et al. (2011), who reported increased yolk weight with fish oil diets. Yolk color is influenced by xanthophylls, precursors of vitamin A (Smith, 1996).

Egg Albedo (Weight and Height):

No significant differences ($p \geq 0.05$) were found among treatments in albumen weight and height. These results differ from Al-Daraji et al. (2011), who reported no change with fish oil inclusion in quail diets, and from Amao et al. (2010) and Hazim et al. (2011), who found higher albumen height with increased fish meal or oil levels.

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