

Original Research Article

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Effect of Linseed Oil Supplementation on Egg White Quality, Yolk Index and Economics of Feeding Linseed Oil to Laying Hens

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ABSTRACT

A study was carried out to find out the effect of supplementing different levels of linseed oil in the laying hens' diet on egg white quality, yolk index and economics of feeding, during a period of 16 weeks. One hundred forty White Leghorn layers were randomly allocated into seven experimental groups having 5 replications of 4 birds in each and sited in individual cages from 22 to 38 weeks of age. The laying hens of control group (T₁) were fed a basal diet formulated as per BIS (2007) standards. The layers of treatment groups T₂, T₃, T₄, T₅, T₆ and T₇ were fed basal diet supplemented with linseed oil at levels of 1, 2, 2.5, 3, 3.5 and 4%, respectively. The results of the study depicted that the result findings depicted that with respect to the whole period there was no significant increase in the yolk index percent by inclusion of different levels of linseed oil in either of the dietary treatments in the basal ration of hens. Albumin index values were significantly (P<0.05) higher in hens of treatment group T₄ (2.5% Linseed oil), T₅ (3% linseed oil), T₆ (3.5% linseed oil) and T₇ (4% linseed oil) as compared to the control and other lower dietary supplemental (T₂ and T₃) treatment groups. Whereas, no significant difference was observed among T₁, T₂ and T₃. Haugh unit's result reveal that during the whole period of experiment, hens in treatment groups T₄ and T₇ show significant (P<0.05) difference as compared to the control T₂, and T₅ experimental groups. Feed cost value for per kg egg mass production decrease in treatment groups T₄ (2.5% linseed oil), with a reduction in cost per kg of egg mass production for Rs. 5.17 in treatment groups T₄ (2.5% linseed oil) in comparison to T₁ (non-supplemented maize based control diet). Thus we can conclude from this study that linseed oil supplementation significantly increase albumin index and Haugh unit but decrease in feed cost per kg egg mass production no effect on yolk index. However no significant results were found in case of yolk index.

Keywords

Linseed oil supplementation, Egg white.

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Introduction

Egg is a biological structure intended by nature for reproduction. It protects and provides complete diets for the developing embryo and serves as the principal source of food for the first few days of the chick's life. Lipids are an important component of feeds not only for their high content of energy but also for the content of essential fatty acids,

fat-soluble vitamins and protein. Oil plants and some legumes can serve as a source of oils to be used for supplementation of diets for poultry. Currently, flax (*Linum usitatissimum*) is a very intensively studied plant. Similar to other plant oils, linseed oil also contains linoleic acid, which is an essential fatty acid required by the body. It is

also rich in α -linolenic acid that belongs to the group of n-3 fatty acids. The composition of fatty acids in egg depends on that of the feed, always reflecting the content of fatty acids that predominate in the respective oil plant (in oil). Diet can affect the ratio of saturated and unsaturated fatty acids in the egg yolk. Diet supplemented with linseed oil particularly affects the concentrations of α -linolenic acid (Beynen, 2004), oleic acid, n-3 fatty acids and docosahexaenoic acid (Celebi and Macit, 2009). Linseed oil was found to increase the content of n-3 fatty acids. However, some studies have shown that linseed oil leads to an increase in the concentration of α -linolenic acid, which is associated with the decreasing content of docosahexaenoic and eicosapentaenoic acids. Due to flax oil supplementation of diet for layers particular type of oil could be included as supplement to feeding mixtures for layers in order to support the development of functional foodstuffs. Cholesterol in eggs decreases. As the concentration of n-3 fatty acids is elevated, eggs may be viewed as functional foodstuff. Some researchers reported that n-3 polyunsaturated acids reduce the risk of developing cardiovascular diseases and cancer. The intake of these acids can help prevent breast cancer. These acids are also important for healthy development of the brain and immune system function.

It has been reported that the external and internal quality traits of the eggs in hens had significant effects on the hatchability of incubated and fertile eggs, and weight and development of the laying chicks. In the egg processing enterprises, the weight of eggshell, albumen and the yolk that form the egg as well as their rates affect the amount and price of the product. The aim of this study was to evaluate the effect of the inclusion of different levels of linseed oil on egg white quality, yolk index and economics of feeding linseed oil to laying hens.

Materials and Methods

A total of one hundred and forty single comb White Leghorn hens of commercial strain, 22-23 weeks of age, in the first phase of their production cycle with an average weight of 1737 ± 44.28 g were randomly divided in to seven treatment groups, having five replications with four birds in each replication. The laying hens of control group (T₁) were fed a basal diet formulated as per BIS (2007) standards, its ingredient and composition has been given in Table 1. The layers of treatment groups T₂, T₃, T₄, T₅, T₆ and T₇ were fed basal diet supplemented with linseed oil at levels of 1%, 2%, 2.5%, 3%, 3.5% and 4%, respectively. Hens were fed the experimental diet for sixteen weeks of experimental period beginning at 22 weeks of age and continued up to 38 weeks of age. The hens were offered feed and water *ad libitum* through linear feeder and waterers. Chemical composition (%DM basis) and metabolizable energy (Kcal/Kg) of feed ingredients used in formulating the experimental diets and Composition and mixing rate of feed additives/ supplements and has been given in Table 2 and 3 respectively. The data were analyzed using completely randomized design (Snedecor and Cochran, 1994).

Analysis of feed ingredients

Feed ingredients used in the diet formulations were analyzed for the proximate nutrients (AOAC, 2007). The chemical composition of different feed ingredients is presented in Table 2.

Experimental diets

The basal diet of laying hens was formulated as per BIS (2007) standards. The ingredient composition and chemical composition of the layers' control ration (T₁), has been given in Table 3 and chemical composition in Table 4.

Treatments

T₁: Basal diet (Control) as per BIS (2007) specifications.

T₂: Basal diet+ 1 % Linseed oil

T₃: Basal diet +2% Linseed oil

T₄: Basal diet + 2.5% Linseed oil

T₅: Basal diet +3.0 % linseed oil

T₆: Basal diet + 3.5% linseed oil

T₇: Basal diet + 4.0% linseed oil

Feed additives and supplements were premixed and then mixed with weighed quantity of feed ingredients to make a homogenous mixture of rations.

Albumin index

Maximum length and the maximum width of thick albumin were measured with the help of Vernier Caliper for average width of albumin.

The height of thick albumin was taken between the yolk and the outer border of thick albumin avoiding the chalaza.

Albumin height was measured with the help of tripod Spherometer with a least count of 0.001 mm after adjusting for the zero error on the plain glass plate. The albumin index was measured by using the following formula.

$$\text{Albumin index percent} = \frac{\text{Average height of albumin}}{\text{Average width of albumin}} \times 100$$

Yolk index

The height of the yolk was measured with the help of tripod spherometer and width by Vernier caliper. The formula used to calculate yolk index was:

$$\text{Yolk index percent} = \frac{\text{Average height of yolk}}{\text{Average width of yolk}} \times 100$$

Haugh unit

Haugh unit is the product of log of albumin height and egg weight and it is calculated by following formula given by Raymond Haugh:

$$\text{Haugh Unit} = 100 \log (H + 7.57 - 1.7W^{0.37})$$

Where,

H = Albumin Height,

W = Egg Weight

Results and Discussion

Albumin Index

The collective mean values (22-38 weeks) of percent albumin index were 9.26, 9.30, 9.31, 9.32, 9.45, 9.43 and 9.50 percent (Table 5) in treatment groups T₁, T₂, T₃, T₄, T₅, T₆ and T₇, respectively. The results depicted that percent albumin index was not affected by the supplementation of linseed oil in the ration of layers in either of the dietary treatments. The differences in percent albumin index were also non-significant during progressive weeks of age. However, with respect to the whole period of experiment, albumin index values were significantly (P<0.05) higher in hens of treatment group T₄ (2.5% Linseed oil), T₅ (3% linseed oil), T₆ (3.5% linseed oil) and T₇ (4% linseed oil) as compared to the control and other lower dietary supplemental (T₂ and T₃) treatment groups. Whereas, no significant difference was observed among T₁, T₂ and T₃. Based on the statistical analysis in the present study it was found that, the mean values of albumin index percent increased (P<0.05) by 2.6%, 1.83%, 2.05% and 0.65% in hens of treatment groups T₇, T₆, T₅ and T₄, respectively. Similarly, the haugh unit values also differ significantly (P<0.05) between different dietary treatment groups and show similar trend as that of albumin index when linseed oil was included at higher levels in the

ration of layers. Haugh unit is a measurement of the internal quality of an egg, which is correlated to its weight and albumin height. Results of the present study revealed that during the whole period of experiment, hens in treatment groups T₄ and T₇ show significant (P<0.05) difference as compared to the control and other dietary experimental groups. Results of present study are in full agreement with the findings of Aziza *et al.*, (2013)

Haugh unit

The collective mean values (22-38 weeks) of Haugh unit were 83.93, 87.05, 89.42, 91.97, 87.08, 90.18 and 91.89 (Table 6) in treatment groups T₁, T₂, T₃, T₄, T₅, T₆ and T₇, respectively. Although, no particular trend of significance was observed during various periods under different dietary treatments. During 22-24 and 24-26 weeks period hens in treatment groups T₄, T₆ and T₇ showed

significant (P<0.05) increase in haugh unit as compared to T₁ and T₂. Similar results were obtained during weeks 30-32, 32-34 and 34-36. The minimum value of haugh unit was at 22 weeks of age and maximum at 32 weeks of age in different dietary treatments. Further, results reveal that during the whole period of experiment, hens in treatment groups T₄ and T₇ show significant (P<0.05) difference as compared to the control T₂, and T₅ experimental groups. The Haugh unit increased significantly (P < 0.05) in birds fed with flaxseed meal in the present study. The results of present study are in agreement with those of Hazim J. Al-Daraji *et al.*, (2010) who reported that 2, 4 and 6% linseed supplementation significantly (P < 0.01) increased the albumin height and Haugh unit. Whereas the results are in contrary to those of Jiang *et al.*, (1991b), Scheideler *et al.*, (1998) and Grobas *et al.*, (2001) found no change in haugh unit value in the hens fed linseed enriched diets.

Table.1 Ingredient and chemical composition of ration for layers of control group

Feed ingredients	Percentage
Maize	50
Groundnut cake	7
Soybean Meal	13
DORP	12
Rice Polish	5
Fish Meal	6
Mineral Mixture	3
Salt	0.5
Shell Grit	3.5
Chemical composition	%DM basis
CP	19.04
CF	6.74
EE	3.61
NFE	62.81
Ash	7.80
Metabolizable energy*(Kcal/Kg)	2697.17

*Calculated value (BIS, 2007), Feed additive included Spectromix-10g (Each g contained vitamin A- 82,500 IU, vitamin D₃ 12,000 IU, vitamin B₂- 50mg, and vitamin K- 10mg.), Spectrimix-BE-10g (Each g contained vitamin B₁- 80mg, vitamin B₆ -16mg, Niacin- 120mg, vitamin B₁₂- 80mg, Calcium Pantothenate- 80mg, vitamin E -160mg, L-lysine HCl- 10mg, DL-Methionine -10mg, and Calcium- 260mg) per 100 Kg of ration.

Table.2 Chemical composition (%DM basis) and metabolizable energy (Kcal/Kg) of feed ingredients used in formulating the experimental diets

Ingredients	CP	CF	EE	Ash	ME*	Cost/100kg
Maize	9	2	4	1.5	3300	1719
GNC	44	10	1	8	2400	2959
Soyabean meal	44	6.5	0.8	6	2250	3643
Rice polish	12.7	5	14	8	2700	1287
DORP	16	14	0.5	12.5	1800	894
Fish meal	45	1	7	22	2180	5373

* calculated value (BIS, 2007)

Table.3 Composition and mixing rate of feed additives/ supplements

Additives/supplements	Composition	Mixing rate/ctl
Spectromix Powder	Each g contained vitamin A- 82,500 IU, vitamin D ₃ - 12,000 IU, vitamin B ₂ - 50mg, and vitamin K- 10mg.	10 g/ quintal
Spectromix-BE powder	Each g contained vitamin B ₁ - 80mg, vitamin B ₆ - 16mg, Niacin- 120mg, vitamin B ₁₂ - 80mg, Calcium Pantothenate- 80mg, vitamin E -160mg, L-lysine HCl- 10mg, DL-Methionine -10mg, and Calcium-260mg	10 g/ quintal
Mineral mixture	Mineral mixture for poultry: composition (w/w): moisture- 3% (maximum), Calcium- 32% (minimum), Phosphorus- 6% (minimum), Manganese- 0.27% (minimum), Iodine- 0.01% (minimum), Zinc- 0.26% (minimum), Fluorine- 0.03% (maximum), Copper- 0.001% (minimum) and Iron- 0.001% (minimum).	3Kg/quintal

Table.4 Chemical composition of ration for layers of different treatment groups

Chemical composition	% DM basis						
	T1	T2	T3	T4	T5	T6	T7
CP	19.04	19.10	19.07	19.06	19.08	19.05	19.03
CF	6.74	6.23	6.16	6.03	5.78	5.66	5.47
EE	3.61	4.25	4.67	5.34	5.73	6.19	7.05
Ash	7.80	8.04	7.93	8.11	8.02	7.89	7.96
NFE	62.81	62.38	62.17	61.39	62.58	61.21	60.49
ME* Kcal/Kg	2697.17	2757.59	2816.83	2846.01	2874.92	2903.54	2931.89

* calculated value

Table.5 Mean values of Albumin Index percent during progressive age (weeks) under different dietary treatments

Weeks/ Treatment	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	CD
22 – 24	8.11 ±0.10	8.23 ±0.04	8.13 ±0.08	8.18 ±0.11	8.04 ±0.08	8.36 ±0.12	8.41 ±0.18	NS
24 – 26	8.23 ±0.07	8.38 ±0.02	8.21 ±0.10	8.16 ±0.13	8.12 ±0.02	8.42 ±0.07	8.35 ±0.11	NS
26 – 28	8.42 ±0.09	8.57 ±0.15	8.62 ±0.11	8.41 ±0.05	8.26 ±0.07	8.53 ±0.04	8.37 ±0.00	NS
28 – 30	9.53 ±0.01	9.07 ±0.06	9.33 ±0.02	9.14 ±0.11	9.31 ±0.01	9.18 ±0.07	9.19 ±0.06	NS
30 – 32	9.63 ±0.04	9.87 ±0.06	9.79 ±0.05	9.93 ±0.14	9.91 ±0.05	9.79 ±0.01	10.05 ±0.06	NS
32 – 34	9.94 ±0.05	9.84 ±0.03	9.98 ±0.04	9.97 ±0.06	10.60 ±0.03	10.15 ±0.07	10.43 ±0.04	NS
34 – 36	10.10 ±0.05	10.35 ±0.01	10.13 ±0.09	10.36 ±0.02	10.54 ±0.03	10.11 ±0.02	10.58 ±0.03	NS
36 – 38	10.12 ±0.06	10.14 ±0.08	10.33 ±0.07	10.47 ±0.05	10.84 ±0.11	10.92 ±0.03	10.69 ±0.01	NS
Mean	9.26 ^b ±0.04	9.30 ^b ±0.03	9.31 ^b ±0.06	9.32 ^b ±0.06	9.45 ^a ±0.06	9.43 ^a ±0.05	9.50 ^a ±0.04	0.08

The mean values in same row with different superscripts differ significantly (P< 0.05).

Table.6 Mean values of Haugh Unit during progressive age (weeks) under different dietary treatments

Weeks/ Treatment	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	CD
22 – 24	73.64 ^d ±2.81	76.06 ^{cd} ±1.31	79.26 ^{bc} ±0.98	84.02 ^a ±1.06	80.44 ^{ab} ±0.92	83.85 ^a ±1.49	82.75 ^{ab} ±1.87	4.27
24 – 26	79.63 ^c ±1.24	80.09 ^c ±0.48	82.91 ^{bc} ±0.89	87.90 ^a ±2.18	82.78 ^{bc} ±0.58	86.12 ^{ab} ±1.06	87.08 ^a ±1.02	3.44
26 – 28	83.43 ^d ±0.07	88.84 ^b ±0.24	92.61 ^a ±0.36	93.19 ^a ±0.24	83.47 ^d ±0.63	85.75 ^c ±1.00	89.10 ^b ±0.78	2.02
28 – 30	81.23 ^d ±1.04	87.57 ^{ab} ±0.18	87.70 ^{ab} ±0.33	88.27 ^{ab} ±0.86	85.31 ^c ±0.73	86.95 ^{bc} ±0.33	89.20 ^a ±0.30	1.80
30 – 32	86.12 ^c ±0.55	88.11 ^{bc} ±0.33	94.39 ^c ±0.30	93.78 ^d ±0.28	95.47 ^a ±0.55	93.93 ^b ±0.47	91.83 ^{ed} ±0.31	1.14
32 – 34	89.90 ^d ±0.51	91.81 ^c ±0.58	94.59 ^b ±0.40	96.72 ^a ±0.14	92.54 ^c ±0.35	96.71 ^a ±0.27	97.76 ^a ±0.97	1.60
34 – 36	85.94 ^c ±0.65	91.74 ^c ±0.20	91.94 ^c ±0.34	96.87 ^a ±0.21	90.27 ^d ±0.42	95.23 ^b ±0.26	96.61 ^a ±0.40	1.15
36 – 38	86.10 ^c ±0.89	86.33 ^c ±1.32	89.61 ^{abc} ±0.87	93.34 ^a ±0.62	87.47 ^c ±2.83	88.71 ^{bc} ±0.39	91.67 ^{ab} ±1.36	4.05
Mean	83.93 ^d ±0.96	87.05 ^c ±0.95	89.42 ^{bc} ±0.91	91.97 ^a ±0.77	87.08 ^c ±0.83	90.18 ^{ab} ±0.88	91.89 ^{ab} ±0.97	2.49

The mean values in same row with different superscripts differ significantly (P< 0.05).

Table.7 Mean values of yolk index per cent during progressive age (weeks) under different dietary treatments

Weeks/ Treatment	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇	CD
22 – 24	42.59 ±0.39	42.69 ±0.23	42.43 ±0.23	42.34 ±0.17	42.34 ±0.28	42.58 ±0.22	42.38 ±0.08	NS
24 – 26	43.47 ^b ±0.37	44.47 ^a ±0.11	44.47 ^a ±0.21	44.63 ^a ±0.16	44.20 ^{ab} ±0.35	44.37 ^a ±0.31	44.48 ^a ±0.40	0.84
26 – 28	46.54 ±0.17	46.40 ±0.60	46.48 ±0.45	46.60 ±0.52	46.42 ±0.27	46.34 ±0.22	47.27 ±0.19	NS
28 – 30	45.29 ±0.11	45.38 ±0.38	45.63 ±0.40	45.86 ±0.40	44.96 ±0.74	45.19 ±0.50	46.19 ±0.34	NS
30 – 32	44.72 ±0.56	45.32 ±0.61	45.51 ±0.55	45.34 ±0.21	44.93 ±0.63	45.11 ±0.59	44.70 ±0.74	NS
32 – 34	46.29 ^{bc} ±0.21	47.03 ^{ab} ±0.18	47.05 ^{ab} ±0.10	47.28 ^a ±0.21	44.53 ^c ±0.68	46.78 ^{ab} ±0.29	47.29 ^a ±0.10	0.97
34 – 36	46.95 ±0.47	46.83 ±0.65	46.99 ±0.54	47.27 ±0.78	47.25 ±0.19	47.54 ±0.08	48.07 ±0.04	NS
36 – 38	47.21 ^{cd} ±0.25	46.93 ^d ±0.44	47.50 ^{cd} ±0.18	48.49 ^a ±0.22	47.66 ^{bcd} ±0.35	47.91 ^{abc} ±0.18	48.38 ^{ab} ±0.15	0.76
Mean	45.38 ±0.28	45.63 ±0.27	45.76 ±0.28	45.98 ±0.31	45.41 ±0.30	45.73 ±0.29	45.14 ±1.09	NS

The mean values in row with different superscripts differ significantly (P< 0.05).

Table.8 Average feed cost (Rs) per kg egg mass production during progressive age (weeks) under different dietary treatments

Weeks/ Treatment	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	T ₇
22 – 24	72.48	77.64	83.22	66.91	89.53	82.68	97.66
24 – 26	64.95	87.68	81.62	73.17	77.69	80.40	83.39
26 – 28	82.27	100.17	81.50	85.71	86.57	74.33	78.83
28 – 30	85.77	91.76	101.85	78.88	86.64	86.08	77.70
30 – 32	88.16	89.97	97.86	82.13	93.34	87.31	89.37
32 – 34	90.03	88.31	87.57	82.87	94.41	91.49	88.05
34 – 36	94.45	91.03	94.60	77.08	88.89	85.45	89.83
36 – 38	93.74	96.25	95.75	83.75	99.03	96.83	88.30
Mean	83.98	90.35	90.49	78.81	89.51	85.57	86.64
Profit/ loss	0	-6.37	-6.51	5.17	-5.33	-1.59	-2.66

Yolk index

The cumulative mean values (22-38 weeks) of percent yolk index were 45.38, 45.63, 45.76, 45.98, 45.41, 45.73 and 45.14 (Table 7) in treatment groups T₁, T₂, T₃, T₄, T₅, T₆ and T₇, respectively. During the period 24-26 weeks of age, percent yolk index showed significant (P<0.05) increase in the T₂, T₃, T₄, T₆ and T₇ treatment group hens fed with different levels of the linseed oil. The differences in percent yolk index also differed significantly (P<0.05) during 32-34 and 36-38 weeks of age. However, the result findings depicted that with respect to the whole period there was no significant increase in the yolk index percent by inclusion of different levels of linseed oil in either of the dietary treatments in the basal ration of hens. In the present study yolk index was not affected due to dietary supplementation of hens with different levels of linseed oil in layers. Scheideler and Froning (1996) found a decrease in egg yolk size of hens from hens fed 5 to 15 % flaxseed and 1.5% fish oil and suggested that these results were due to the effect of PUFA on the estrogen activity of the hen.

Economics of feeding different levels of linseed oil in the ration of layers

Feed costs (Rs.) in terms of per kg of egg mass production during progressive weeks of age are given in (Table 8). The cumulative mean values of feed cost per kg of egg mass production were Rs. 83.98, 90.35, 90.49, 78.81, 89.51, 85.57 and 86.64 in treatment groups T₁, T₂, T₃, T₄, T₅, T₆ and T₇, respectively. The results showed that feed cost value for per kg egg mass production decrease in treatment groups T₄ (2.5% linseed oil), with a reduction in cost per kg of egg mass production for Rs. 5.17 in treatment groups T₄ (2.5% linseed oil) in comparison to T₁ (non-supplemented maize based control diet). Thus, the result findings clearly indicate

that highest net profit was obtained in hens of treatment group T₄ only. Omar *et al.*, (2014) investigated that Using 1% Fish oil only or 1% Fish oil + 1% Linseed oil in laying hen diets improved the economical efficiency comparable to the control group. The best feed cost/kg egg was recorded by the group fed diet 1% Fish oil + 1% Linseed oil.

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