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Nutritional Values of Partially Replacing the Commercial Soybean Meal by Raw, Full-Fat Soybean in Diets of Layers

Mammo Mengesha Erdaw[1,a], Shambel Taye[1,b,*]

[1]*Ethiopian Institute of Agricultural Research, based in DebreZeit Agricultural Research Center, Bishoftu, Ethiopia*
[*]*Corresponding author*

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ABSTRACT

The aim of this study was to investigating the effects of partially replacing the commercial soybean meal (SBM) by locally produced raw, full-fat soybean (RFFSB) in diets of layers. After cleaning, the tested ingredient (RFFSB) was hammered to pass through a 0.2-mm sieve. Then, four experimental diets were formulated by replacing the SBM by RFFSB at 0, 15, 30 or 45% (equivalents to 0, 30, 60 or 90 g/kg of diet, respectively). Before the commencement of this feeding trial, birds were uniformly managed and fed as per their requirements (i.e., starter, grower and pullet diets). This feeding trial was started when birds' age was 24 weeks. Every treatment was replicated 4 times and 17 laying birds per replicate. The results revealed that replacing the commercial SBM by raw soybean (up to 45%) in the layer diets had no negative effects on the final live BWT and also on the vital organ developments, such as pancreas, duodenum, intestines and gizzard. Hen-day egg production, hen-housed egg production and egg quality measuring parameters were not significant affected by that of partially replacing the commercially SBM by the raw soybean. It is concluded that without compromising the productivity and health, a hammered RFFSB can replace (up to 45%) the commercial SBM in diets of the laying hens.

[a] *mammomerdaw@gmail.com* *https://orcid.org/0000-0003-1545-7081* | [b] *olyaadshambel@gmail.com* *https://orcid.org/0000-0002-2113-6340*

Introduction

Progress of chicken production as well as egg consumption, in developing countries, including Ethiopia has not yet been as expected. Lack of quality and quantity of chicken feeds, mainly lack of the protein-source ingredient is one of the constraints for such low chicken production and productivity. As reviewed by Erdaw et al. (2016), commercial soybean meal (SBM), which is one of the best protein-source ingredients, is available as a byproduct (after extracting the oil) or as a full-fat product (without extracting the oil). Full-fat soybean can also be prepared from the raw soybean or after heating. The raw full-fat soybean (RFFSB), however, contains a variety of anti-nutritional factors (ANFs) which can impair the proper utilization of nutrients in soybeans by animals, particularly by the mono-gastric animals, in general and by the chickens, in particular (Mammo, 2019).

Protease inhibitors, lectins and phytate are those properly characterized ANFs in the raw soybean seed, so far (Pettersson and Pontoppidan, 2013). Protease (trypsin) inhibitors can interfere with the biological activity of an endogenous protease and thereby reduce the digestion of proteins (Nahashon and KilonzoNthenge, 2013). A nutritive value of RFFSB is negatively affected by the presence of ANFs (Liu et al., 1998; Erdaw and Beyene, 2018; Mammo, 2023), especially by trypsin inhibitors and lectins. As reported by Erdaw (2016) seed of raw soybean contains around 13498 rypsin inhibitor (TIU/g) as compared to 5743 (TIU/g) for the commercial SBM.

Consumption of the raw beans, including soybean beans increased the size of the pancreas and the duodenum and reduced feed intake and growth of the chicks. Scholars (Mogridge et al., 1996; ASA, 2004; Erdaw et al., 2019) reported that diets, containing raw beans reduced the feed consumption and live weight and also decreased the feed conversion indices.

The raw soybean inclusion, with share of 8% in the mixtures significantly reduced the number of eggs laid (Petričević et al., 2014). Differences, in body weights, food consumption, occurrence of defective eggs and the relative weight of the pancreas were not significantly influenced by feeding a graded levels of the two varieties of raw soybeans or by their interaction effects (Petričević et al., 2014).

Only the hens fed 20% of raw soybeans (i.e., this was the highest included level in the trial) in the diet laid significantly fewer eggs than hens fed no raw soybeans (Latshaw & Clayton, 1976). As the percentage of raw soybeans increased, in the diet, there was a trend towards to the lower egg weight and body weight gains. Pancreas weights increased at an increasing rate of raw soybeans in diets (Latshaw & Clayton, 1976). However, ASA (2004) reported that whenever the age of the chicken advanced their tolerance to the ANFs is increasing.

Locally produced raw, full-fat soybean (grains) is cheaper than the commercial soybean meal (SBM) (i.e., from an informal discussion as well as observations, and from the farmers' workshops). The expensivenessof SBM is further exaggerated in some pocket-areas and also in the places where there are no sufficient oil-extracting plants. Sometimes, a double transportation cost is incurring against the producers. This means, firstly when transporting the raw soybean grain towards to the oil-extracting plant, and also when returning it (i.e., SBM), as the byproducts, back to the chicken producers, as feed. The oil-extracting plants are mostly installed near to the big-cites, which are actually far from the major grain-producing areas. Because of this all facts, this study was, therefore planned to investigate the effects of partially replacing the commercial soybean meal by that of locally produced raw, full fat soybean, and thereby, at least to reduce the feed-cost of laying (matured) hens.

Objective

Evaluate the effects of replacing commercial SBM by raw soybean in diets of layers

Materials and Methods

Tested Ingredient Preparation

Firstly, this feeding trial was approved by Animal Research Ethical Review Committee (Certificate Ref: No: VM/ERC/45/ 03/15/2023), and this trial was also executed in the poultry-house of Debre-Zeit Agricultural Research Center-Bishoftu.

The tested raw full-fat soybean (RFSB) was purchased from the local farmer, in Ethiopia. This test ingredient was then hammered to pass through a 0.2-mm sieve. Subsequently, 4 experimental diets were then formulated; containing such hammered RFFSB, which replaced the commercial SBM at 0, 15, 30 or 45% (equivalents to 0, 30, 60 or 90 g/kg of diet, respectively), which are also indicated as treatments: 1, 2, 3 and 4, respectively. While replacing the commercial SBM by RFFSB the major nutrient requirements were balanced (i.e., the "*iso-nitrogenous* and *iso-caloric" contents* of the diets, across the treatments were kept) by using other related ingredients, for example the meat meal. Feed-win (i.e., as a software) was used to formulate the experimental diets.

A total of 320 Bovan Brown female chicks (one-day-old) were purchased from Alema PLC Farm, Bishoftu-Ethiopia. Based on the requirements of these birds, common commercial diets (i.e., starter, grower and pullet diets) were freely/*adlib* offered. All required vaccinations were given. A 90 days trial was started when the age of the layers was 24 weeks, and then these birds were randomly allocated onto 4 experimental diets. Each experimental diet was also replicated 4 times and 17 laying birds per each replicate. Equal amounts of the experimental diets were weighed and then offered (depending on the number of birds per pen) throughout the trial period. Eggs were collected more than 3 times per day and then recorded.

$$\text{HDEP} = \frac{\text{Number of eggs collected per day}}{\text{Number of hens present at that day}} \times 100$$

HDEP: HDEP% (Hen-day egg production)

$$\text{AEM} = \text{PHDEP} \ \times \text{AEW}$$

AEM: Average egg mass (per hen per day in grams)
PHDEP: Per cent HDEP
AEW: Average egg weight in grams

$$\text{HHEP} = \frac{\text{NELP}}{NHLP}$$

NELP: Number of eggs laid in a period
NHLP: Number of hens present at beginning of laying period

$$HHEP = \frac{TNEDP}{TNHBP}$$

HHEP: HHEP (hen–housed egg production)
TNRFP: Total number of eggs laid during the period
TNHBP Total number of hens housed at the beginning of laying period.

The above formula were used based on TNAU (2023).

Egg Quality Evaluation

Forty-eight eggs, 12 per treatment (3 eggs per pen) were randomly selected on 30th day after the commencement of the trial. Other 2 samplings were also taken on the 60th and 90th days after the commencement of this trial. Totally, 144 eggs were sampled and evaluated for each of the following egg quality measuring parameters.

The external egg quality parameters were assessed in terms of egg weight and egg shape index. After breaking the egg, near to the sharpen end, and carefully separating and dropping the contents, internal egg quality measuring parameters were measured, in terms of shell weight, shell thickness, yolk weight, yolk height and yolk color. Shell thickness was measured by the digital caliper while removing the internal membranes. While measuring this thickness, the average value was taken from blunt, middle, and sharp points of the egg.

The yolk color was determined by comparing the color of a properly mixed yolk sample placed on a colorless glass with the color strips of Roche color fan measurement, which consists of 1 to 15 strips ranging from pale to orange-yellow. Shape index was computed using the following formula.

Egg weight was collected weekly by weighing all eggs per pen. Sensitive balance of 0.000lg to 20Kg capacity was used.

$$\text{Egg yolk index} = \frac{\text{Egg yolk height}}{\text{Yolk diameter}}$$

One per pen and 4 birds per treatment were randomly weighed and humanly slaughtered to evaluating the effects of partially replacing the commercial SBM by raw soybean on the development of internal organs. Some of the vital internal organs, such as pancreas, duodenum, intestines and gizzard were weighed and then evaluated as g/100 g of the corresponding sampled BWT of the bird.

Statistical Analysis

Descriptive statistics and ANNOVA were used to analyze the data using SPSS (IBM 26). The differences were considered to be significant at $p < 0.05$, and the significant differences between mean values were also separated using the Duncan's test.

One hen per pen, totally 4 birds per treatment were sampled and killed to evaluating the internal organ development. Intestine was measured with the contents. Commercial soybean meal (SBM) was replaced by raw, full-fat soybean at 0, 15, 30 or 45%, equivalent to 0, 30, 60 or 90 g/kg of the diets. NS= non-significant.

Results and Discussions

Chemical composition for the samples of raw soybean and commercial SBM are shown in Table 2. Maximum ether extract and apparent metabolizeable energy were recorded from samples of raw soybean as compared to the commercial SBM. The result showed that samples of raw soybean had more values of ether-extract/oil (14.7) and AME (12.6 MJ/kg) as compared to the commercial SBM (1.9 and 9.0), respectively. This current results agree with Erdaw (2016), who reported that full-fat soybean contains more (20.9%) fat (ether extracts) than other preparations, for example SBM.

Results due to the effects of the raw soybean supplementation, on the organ development of the layers are shown in Table 3. As shown in Table 3, replacing the commercial SBM by raw soybean (up to 45%) in the matured (i.e., starting from 24 weeks of age) layer diets had no negative effects in the final live BWT and also on the vital organ developments, such as pancreas, duodenum, intestine and gizzard.

These results are in line with Petričević et al. (2014), who reported that differences in body weights, food consumption, occurrence of defective eggs and the relative weight of the pancreas were not significantly influenced by the studied raw soybean or by their interaction effects.

The current results contradict with other research-scholars (Latshaw & Clayton, 1976; ASA, 2004; Erdaw and Beyene, 2018; Mammo et al., 2019), who reported that pancreas and duodenum weights increased at an increasing level of raw soybeans. The reason why these current results had no influences on the vital organ development might be due to the age of the layers (>24 weeks), which enabled them to resists the negative effects of anti-nutrients in the raw soybean.

Table 1. Ingredients (kg) and nutrient compositions

	T_1	T_2	T_3	T_4
Maize	65.5	64.5	65.6	63.5
Wheat middling	10	10	8.6	10
Soybean meal	20	17	14	11
Raw full-fat SB	0	3	6	9
Bone and meat meal	0	1	1.3	2
Limestone	2	2	2	2
Salt	0.4	0.4	0.4	0.4
Methionine	0.2	0.2	0.2	0.2
Lysine	0.4	0.4	0.4	0.4
Premix	0.5	0.5	0.5	0.5
Total	100	100	100	100
Major nutrient composition				
Crude protein (CP), %	16.154	16.105	16.129	16.285
Metabolizeable energy, in kcal/kg	2808.22	2813.255	2839.628	2834.405

Table 2. Chemical composition of raw full fat soybean and commercial SBM

Parameters	Raw full fat soybean	Commercial SBM
Dry matter	92.4	91.5
Crude proteins	38.2	42
Crude fiber	6.2	3.8
Ether extract	14.7	1.9
Calculated AME (MJ/kg)	12.6	9

Table 3. Effects of partially replacing the comm. SBM by raw soybean, in their diets on the organ development of sampled birds of layers (g/100g)

Treatments	BWT per bird	Intestines	Pancreas	Duodenum	Gizzard
1	1805	4.8	0.27	0.89	4.71
2	1767.5	4.4	0.25	1.02	4.68
3	1890	4.7	0.25	0.78	3.83
4	1897.5	4.5	0.26	0.85	4.19
SEM	0.4	1.6	18.36	0.21	0.01
Significance	NS	NS	NS	NS	Ns

Table 4. Effects of partially replacing commercial SBM by raw soybean, in layer-diets, on egg production and qualities

Treatments	BWT, g/ bird	HHEP, %	HDEP, %	Egg WT,g	Egg shape index	Egg shell thickness	Egg yolk index	Egg yolk colour	Egg shell WT, g
1	1605	78.5	80.7	61.5	77.5	0.37^{b}	0.45	1.29^{ab}	6.02^{b}
2	1567	73.1	75.8	63.2	75.2	0.42^{a}	0.47	1.20^{b}	6.83^{a}
3	1589	73.1	75.4	62.5	78.1	0.42^{a}	0.46	1.51^{ab}	6.65^{ab}
4	1565	72.7	75.4	61.7	76.2	0.39^{ab}	0.46	1.59^{a}	6.37^{ab}
SEM	55.9	5.9	1.6	0.4	1.0	0.19	0.01	0.05	0.10
Significance	NS	NS	NS	NS	NS	0.027	NS	0.009	0.029

BWT = body weights; HHEP = hen-housed egg production; HDSP = hen day egg production.; WT = weight; HHEP = hen-housed egg production; HDEP = hen-day egg production. Commercial soybean meal (SBM) was replaced by raw, full-fat soybean at 0, 15, 30 or 45%, equivalents to 0, 30, 60 or 90 g/kg of the diets. [a,b] means that the same superscripts in the columns are non-significant. NS = non-significant; SEM = standard error of mean

Findings on egg production and quality that were influenced by the effects of partially replacing the commercial SBM by raw soybean in layer-diets are shown in Table 4. Partially replacing the commercial SBM by raw soybean in diets of layers had no significant effects on average BWT, HHEP, HDEP and on the major egg quality measuring parameters, such as average egg WT, egg shape index and egg yolk index; however, there were significant differences on egg-shell Wt, egg-yolk color and egg shell thickness. These current results are against to that of Petričević et al. (2014), who reported that 8% of raw soybean supplementation, in the mixtures significantly reduced the number of eggs laid. The current result is also contradicting with Latshaw & Clayton (1976), who reported that only the hens fed on diets, containing 20% raw soybeans laid significantly fewer eggs than hens fed no raw soybeans.

Although the commercial SBM was replaced by the raw soybean at 45%-in the layer diets, egg production as well as egg quality was not significantly affected. The main reason for these findings might be due to the advancement of the age that enabled the layers to successfully resist the negative impacts of ANFs in the raw soybean. This thought is supported by ASA (2004) that reported as tolerance to the ANFs depends on the age of the birds.

Conclusion and Recommendations

Replacing the commercial SBM by RFSB (up to 45%) in diets of laying hens (mainly starting at 24 weeks of age) did not significantly influence both the egg production and egg qualities, as compared to the control group. It is therefore recommended to replace the commercial SBM by raw soybean, up to 45% in diets of laying hens. It is also specially recommended to replace the SBM by RFFSB in diets of laying hens when there is no accessibility/unavailable of the commercial SBM or when the SBM is relatively expensive.

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