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Effect of Replacing Soybean Meal with Processed Kidney Bean Meal on Egg Production and Economics of White Leghorn Layers

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Abstract

An experiment was conducted in Haramaya University to find out the effect of replacing Soybean meal (SBM) by processed kidney bean (PKB) on egg production, feed intake and economic benefit for white leghorn layers. Hundred eighty white leghorn layers of similar initial body weight of 1121.17 g ± 24.92 and age of 6.5 months and 30 cocks were randomly distributed into five treatments using complete randomized design (CRD). PKB replaced SBM at a rate of 0 (control), 25, 50, 75 and 100% for T1, T2, T3, T4 and T5, respectively. The recommended level of SBM (26%) in the ration was used as a base of replacement. Feed intake (FI), Hen Day Egg Production (HDEP), egg weight and egg mass were recorded daily. Economic replacement was assessed at the end of the experiment. The result of chemical analysis showed that Crude Protein (CP) and Metabolizable Energy (ME) content of PKB was 28% and 32182.2 Kcal respectively, which was lower than SBM but higher than noug seed cake (NSC). This indicates that the substitution capacity of PKB for SBM was better than NSC. There was no significant (P>0.05) effect on final body weight and body weight change. Average daily feed intake (FI) was showed significant difference (P<0.05) among the treatments. The higher mean daily FI per bird was recorded in T4 and T5 as compared to the rest treatments. The percent hen day egg- production, egg weight and egg mass for layers fed 100% PKB was significantly (P<0.05) lower than those fed PKB up to 50%. Whereas Feed Conversion Ratio (FCR) is significantly lower in T5 as compared to the rest treatments. As a result of PKB replaced for SBM, profit generated in the order of T3>T2>T1>T4>T5 and Mmarginal Rate of Rreturn (MRR) indicated profitability of PKB replacement upto 75% and beyond this replacement a decrease in economy of production by 1.83 units.

Keywords: Processed kidney bean; Soybean meal; Replacement; Feed intake; Egg production; White leghorn layer

Introduction

The major poultry production practices in Ethiopian is the village poultry production system which is characterized by small size of unimproved indigenous flock per household, low input and output [1-3]. The proportion of indigenous, exotic and cross breed is 96.46%, 0.57% and 2.97%, respectively [4]. However, contribution of intensive commercial poultry industry to the supply of poultry meat and eggs in Ethiopia has been very small. The overall per capital per year consumption of egg and meat in Ethiopia is only about 0.12 and 0.14 kg, respectively [5]. Poor production and productivity of poultry is due to the absence of improved breed, poor management and standards of feeding in terms of both quantity and quality. However, nutrition is the most important aspect of livestock production that can be used to enhance animal productivity and reduce the cost of production [6]. Poor feeding, management practices, limited quantity and quality of standard feed are the major constraints limiting poultry production in Ethiopia [7]. Much of the success in poultry enterprise depends upon the feeding program. Feed is the single largest item of all costs that determines failure or success in poultry production. Cereal grains, which make up the bulks of poultry ration, are low in protein contents and deficient in some critical amino acids such as lysine, methionine, and tryptophan. To provide adequate nutrient to poultry, cereals grains should be supplemented with proteins that complement their amino acid deficiency [8]. Commercial poultry production is dependent primarily on soybean meal as main protein source for practical diet formulation. However, soybean production in the country is small and the price of soybean grain and cake is extremely high. Thus it demands alternative protein source that locally and cheaply available are needed.

Evaluation and nutritional characterization of alternative protein ingredients that are locally available and relatively economical to improve commercial poultry production and increase its efficiency is an urgent requirement [9-11]. One of aternative protein source is Kidney bean. Kidney bean is one of the neglected tropical legumes that can be used to fortify cereal-based diets. Elsewhere, it is potential component of diets of pigs and poultry, because of its high contents of protein, energy and its amino acids content that is similar to that of soybean except for a lower level of methionine [12,13]. Kidney beans are a grain crop mainly produced in Ethiopia for human consumption and export. It grows in most of the agro-ecology zones of low and mid altitude areas of the country. However, information on the use of kidney bean in poultry ration in Ethiopia is scarce and there is no readily available guideline for producers with regard to safe and economic level of inclusion. Therefore, the present study was carried out with objective of evaluating the effect of replacing soybean meal with kidney bean on white leghorn layer egg production, feed convertion ratio and economic merit of replacement.

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Materials and Methods

Management of experimental birds

Experimental house which was partitioned into 15 pens, with wire-mesh and covered with grass litter material of 10 cm depth (floor) was used for the experiment. Before the commencement of the actual experiment, the experimental pens, (2.5*2 m), watering equipments, feeding troughs and laying nests were disinfected, sprayed against external parasites and thoroughly cleaned. The birds were vaccinated against Newcastle disease according to the vaccination program of the farm. 180 White leghorn layers and 30 cocks of similar age (6.5 months) and weight (1121.17 g ± 24.92 g), were assigned in to five treatments using complete randomized design (CRD) each treatment was contain 12 white leghorn layers and 2 cocks and replicated three times. The birds were adapted to experimental diets for 7 days before the start of actual data collection.

Ingredients and experimental rations

The experiment was carried out in Haramaya University Poultry Farm Ethiopia, located at 42° 3' E longitude, 9° 26'N latitude and situated at an altitude of 1980 meter above sea level. The site has mean annual rainfall of 780 mm and the average minimum and maximum temperatures of 8 and 24°C respectively. The feed ingredients used for the formulation of the different experimental rations in this study ware corn grain (CG), wheat short (WS), soybean meal (SBM), noug seed cake (NSC), processed kidney bean (PKB), vitamin premix, limestone, and salt. Kidney bean seed was cleaned from dust and dirt materials. The cleaned seed was soaked in water for five hours, water was poured, and the seed rinsed repeatedly with clean water, transferred into boiling water at 100°C in cooking pot and heated for one hour. Then it was distilled and spread on plastic canvas for sun drying until it gets dry enough to grind. Firewood used as a source of heat energy provider. The temperature during boiling was roughly maintained at 100°C by adding or removing the wood into and out of fire. The CG, SBM, NSC, and PKB were ground at Haramaya University feed mill before mixing. Sample of CG, SBM, NSC, and PKB were taken to analyze their DM, CP, EE, CF and ash (Table 1) following the proximate method of analysis [14,15]. The experiments composed of five rations in which PKB was replaced SBM at a rate of 0, 25, 50, 75 and 100% for T1, T2, T3, T4 and T5, respectively. The rations of the experiments were prepared to be iso-nitrogenous and iso-caloric to contain about 2800-2900 Kcal of metabolizable energy (ME) per Kg of dry matter (DM) and 16-16.5% of crude protein (CP) to meat energy and protein requirement of layers, respectively based on pre analyzed nutrient contents of each feed.

	Treatments				
Feed (%)	**T1**	**T2**	**T3**	**T4**	**T5**
CG	56	53	52	48	37
WS	7	7	7	7	16
SBM	26	19.5	13	6.5	0
PKB	0	6.5	13	19.5	26
NSC	4	7	8	12	14
LS	5.5	5.5	5.5	5.5	5.5
Salt	0.5	0.5	0.5	0.5	0.5
VPM	1	1	1	1	1
Total	100	100	100	100	100

CG=corn grain; WS=wheat short; SBM=soybean meal; PKB=processed kidney bean; NSC=noug seed cake; LS=limestone; VPM=vitamin pre mix; T1 100% SBM: 0% PKB; T2=75% SBM: 25% PKB; T3=50% SBM: 50% PKB; T4=25% SBM: 75% PKB; T5=0% SBM: 100% PKB

Table 1: Proportion of feed ingredient used in formulating experimental rations.

Data collection and measurements

Feed intake: For each replication, the feed offered and refused was recorded and multiplied by respective DM content. The amount of feed consumed was determined as the difference between the feed offered and refused. Mean daily feed intake per bird was determined by employing the following formula:

Mean daily feed intake=Feed of feed-left over/number of experimental birds x duration of experiment in days

Body weight change*:* The experimental birds were weighed individually on the first day of the commencement of the experiment and at the end of the experiment using analytical balance. Average bird weight was calculated as sum of individual weight of birds divided by number of birds. Average body weight gain or loss for each replicate was calculated by subtracting the initial weight from the final weight and dividing by the number of experimental days as shown in the formula presented below.

Body weight gain per day per bird=W2-W1/duration of experiment in days × experimental birds

where,

W1=initial body weight; W2=final body weight

Feed conversion ratio: Feed conversion efficiency was estimated as a ratio of the weight of feed consumed per egg weight, which is

FCR=daily feed consumed (g)/daily egg weight (g).

Egg production: Eggs were collected two times per day from each pen at 8:30 am and 1:30 pm. The sum of the two collections along with the number of birds alive on each day in each pen was recorded. Rate of lay was expressed as the average percentage hen-day and hen-housed egg production based on the average values from each replicate following the method of [16] as follows;

% Hen day egg production=number of eggs collected/number of hen present that day × 100

% Hen day egg production=sum of daily egg count/number of hen housed originally × 100

Egg mass: Daily eggs collected for each replicates were weighed and the average egg weight was computed by dividing the total weight to the number of eggs. The egg mass on daily basis was computed by multiplying average egg weight with percent hen-day egg production for each replicate as described by [17].

EM=P*W, Where EM=Average egg mass; P=hen-day egg production; W=average egg weight.

Partial budget analysis: To determine the economic benefits of replacement of PKB for SBM in white leg horn layer ration, the partial budget analysis developed by [18] and the feed cost was used. The purchasing price of the feed ingredients were taken to calculate the cost of feed consumed and the price of the eggs in the nearby market during the research was under taken as price of egg to calculate the total return. The following formulas were used to determine partial budget. NR= TR-TVC [18]. Where; NR=Net return; TR= Total return; TVC= Total variable cost. The change in net return (ΔNR) was calculated as the difference between the change in total return (ΔTR) and the change in total variable cost (ΔTVC). (ΔNR =ΔTR-ΔTVC). The marginal rate of return (MRR) is used to measure the increase in ΔNR. MRR(%)= $\frac{\Delta NR}{\Delta TVC}\times 100$.

Results

Nutrient composition of ingredients and the treatment

The results of the chemical analysis of ingredients used and nutritional composition of the ration for each treatment are given in (Tables 2 and 3) respectively. The DM contents of PKB obtained in the present study was slightly lower than reported by [19] (93.2%) and [20] (96.8) but similar with [21] (88.00) while CP content was slightly higher than reported by [19-24] which were 20.9%, 23.6%, 24.7%, 25.8% and 26.8%, respectively. The EE content of kidney bean was the same with that reported by [22] but [19] reported lower than the current results while [25] report as very high (4.69) EE content than the present study. The CF content of kidney been used in the present study was comparable to that reported by [20,22,23,26,27] who reported 5.1, 5.0, 6.0, and 4.7%, respectively. The result of chemical composition of kidney bean used i n the present experiment showed comparable ME contents to that noted by [28,26] who reported 3342.2 and 3365 kcal/kg, respectively.

Feed intake

Feed intake (FI) and performance of layers are shown in (Table 4). There was significant difference (P<0.05) in average daily FI among the treatments. The higher mean daily feed intake per bird was recorded in T4 and T5, which is higher than that observed in T1 andT2. The slight decrease in nutrients across the treatment with increased level of PKB could be the reason for increased feed intake in treatments with high level of PKB replacement, because chickens tend to increase feed intake, given there is no other limiting factor exists, to satisfy their nutrient need. Similar effect of increased feed intake as a result of decreased energy and protein were reported by many researchers [21,29-31]. Higher feed intake at high level of PKB replacement could be an indication that feed intake is not hampered by the anti-nutritional factor (lignin and tannin) in PKB, which could be an attribute of the processing employed. In support to the current finding, [32] stated that crude fiber content of the kidney bean is low, which makes it ideal for poultry. Furthermore, they noted that dehulling reduced the contents of trypsin inhibitor and haemagglutinins in kidney bean and caused substantial reduction in tannin. Moreover, [33] noted average feed intake of hens consumed socked and boiled common vetch diet was higher (120.48 g/d) than treatments without it and attributed to detoxification of the anti-nutritional factors by soaking and boiling process of the common vetch.

Nutrient composition (% for DM and % DM for others)						
Feed type	**DM**	**CP**	**EE**	**CF -**	**Ash**	**ME kcal/kg**
CG	89.5	8.7	4.3	8.0	6.21	3230.5
bWS	90.3	12	3.3	6.2	6.8	3303.1
SBM	90.2	38	7.0	9	7.8	3215
PKB	87.5	28	0.9	6	7.0	3182.2
NSC	91.5	26	6.0	21.0	10	2006.0

CG=Corn grain; WS=Wheat short; SBM=Soybean meal; PKB=processed Kidney bean; NSC=Noug seed cake; DM=dry matter; CP=Crude protein; EE=ether extract; CF=crude fiber; ME=methabolizable energy

Table 2: Ingredient used in the study and its nutrients compositions.

Nutrient composition (% for DM and % DM for others)								
Treatments	**DM**	**CP**	**EE**	**CF**	**Ash**	**Ca**	**P**	**ME kcal/kg**
T1	91.85	18	5.64	6.26	9.96	3.4	0.39	3296.20
T2	91.56	17.8	5.63	6.36	9.97	3.26	0.38	3286.40
T3	91.17	17.6	5.58	6.52	9.98	3.28	0.38	3269.00
T4	90.21	16.3	5.40	6.56	9.98	3.01	0.36	3255.70
T5	89.86	16.0	4.90	6.86	10.20	2.79	0.32	3192.90

DM=dry matter; CP=crude protein; EE=ether extract; CF=crude fiber; SBM= soybean meal; PKB processed kidney bean; T1 100% SBM: 0% PKB; T2=75% SBM: 25% PKB; T3=50% SBM: 50% PKB; T4=25% SBM: 75% PKB; T5=0% SBM: 100% PKB

Table 3: Nutritional composition of treatment diets containing different levels of processed kidney bean as a replacement for soybean meal

	Treatment						
Parameters	T1	T2	T3	T4	T5	SEM	SL
FI (g/hen/d)	86.93^{ab}	84.00^{b}	89.33^{ab}	90.80^{a}	90.50^{a}	1.33	*
Initial BW (g/bird)	1101.87	1124.10	1106.83	1161.23	1111.87	24.92	NS
Final BW (g/bird)	1152.80	1172.9	1146.07	1215.83	1166.20	24.95	NS
BW change (g/bird)	50.96	48.87	39.23	54.6	54.33	15.96	NS
BW gain (g/hen/day)	0.047	0.045	0.036	0.051	0.050	1.85	NS
HDEP (%)	49.0^{a}	51.3^{a}	53.0^{a}	46.0^{ab}	39.0^{b}	2.3	*
HHEP (%)	49.00^{ab}	48.70^{ab}	53.00^{a}	43.0^{bc}	39^{c}	2.3	*
Egg weight (g)	50.27^{a}	50.20^{a}	52.37^{a}	49.50^{ab}	48.30^{b}	0.98	*
EM (g/hen/day)	24.7^{a}	25.73^{a}	27.17^{a}	22.83^{ab}	18.93^{b}	1.33	*
FCR (feed (g) egg (g)	4.03^{b}	3.70^{b}	3.76^{b}	4.50^{b}	5.73^{a}	0.38	*

a-c mean in a row without common superscript significant; SEM=standard error; SL=significance level=*=significant (P<0.05); NS=non-significant; FI=feed intake; BW=body weight; MBW=mean body weight; HDEP=hen day egg production; HHEP=henhouse egg production; EM=egg mass; FCR=feed conversion ratio; SBM= Soy bean meal; PKB= processed kidney bean T1=100% SBM: 0% (PKB); T2=75% SBM: 25% PKB; T3=50% SBM: 50% PKB; T4=25% SBM: 75% PKB; T5=0% SBM: 100% PKB.

Table 4: Feed intake, body weight change and egg laying performance of white leghorn layers fed processed kidney bean as a replacement for soybean meal.

Body weight change

The results obtained from the present study indicated that initial, final and mean daily body weight gain of laying hens distributed among the five dietary treatments was not significantly different (P>0.05). The pullets were matured and much change in body weight was not expected. The little variation in the magnitude of average daily gain could be due to the composition of the feed and efficiency of the birds to change the feed consumed into product. Thus, T3 that produced more egg used the feed mainly for production, while T4 and T5 changed the feed consumed to weight, since they produced less number of eggs compared to T3 groups. The result of the current study is in agreement with the finding of [34] who noted diversion of nutrients from body weight gain to egg formation in layers to satisfy the nutrient demand for egg production demand.

Egg production

The total egg produced pretreatment, eggs produced per hen; HDEP and HHEP significantly differ among treatments. The total egg produced by the layers fed diet in which PKB replaced 100% of the SBM was significantly (P<0.05) lower compared to the layers fed T1, T2 and T3. The number of eggs produced by T5 hens was lower by about 22.4% as compared to the control diet. This might have been because of the low amount of crude protein, calcium, phosphorus and the crude fat content of this treatment ration as compared to the control. Essential amino acids and protein intake linearly increased with increase of protein content in diets [35]. Varying the crude protein levels significantly increased egg number. Highest egg number was recorded in birds fed 17% crude protein compared to 14% CP and

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12% CP [36]. Similar to the present finding, complete replacement of CP for SBM with CP from Wolffia meal, which is legume, significantly reduced HDEP by about 10.3% compared to the control diet [37]. A 100% replacement of PKB for SBM showed the deficiency of kidney bean in protein, essential amino acids and minerals content since its complete substitution for SBM resulted in lower egg production than the control. Similar to this finding, [38], found significant reduction in HHEP and HDEP at highest level of inclusion of extracted coconut meal and at higher replacement levels of cooked Lablab purpureus respectively. The result of this study in line with the result of [37], did not found significant effect of Wolffia meal replacement for SBM up to 75% on egg production, but ME intake and egg production decreased beyond 75% of inclusion. This probably may be due to the change in the profile of amino acid supplied to layers from a diet with limited or no SBM that may include a negative impact on the egg production performance of layers.

In general, the present overall mean HDEP and HHEP was lower than that reported by [37] and [39] who found 70.03 ± 2.24 HDEP and 72.53 ± 0.95% HHEP when Wolffia Meal and Cooked Lablab beans substituted SBM respectively. Whereas, [40] reported too higher (92.4%) HDEP for white leghorn layers compared to current results. Such difference is due to the strain of the bird and other factors such as the weather of that particular time of experiment and variation in chemical composition of the ingredients used.

Weekly HDEP and HHEP had increased from first to four weeks in almost all treatments and reached peak in week five of the experiment (Figures 1 and 2). After the fifth week, the production started to fluctuate and then showed the tendency to increase in production during the last two weeks of the experiment except in T5. In most of the weeks the HDEP and HHEP was lower for T5 than other treatments. As it can be observed from the figures, egg production increased after the decline following peak egg production. Thus, to capture the optimum

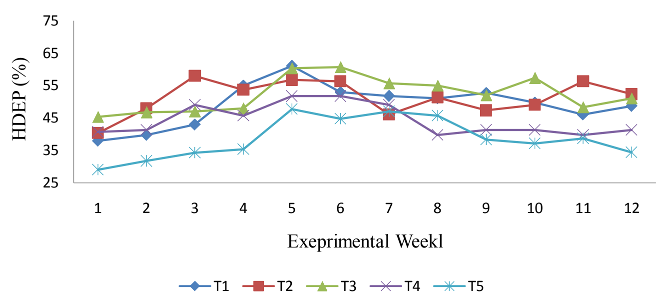

Figure 1: Weekly hen day egg production (HDEP) in birds fed ration containing processed kidney bean as a replacement for soybean.

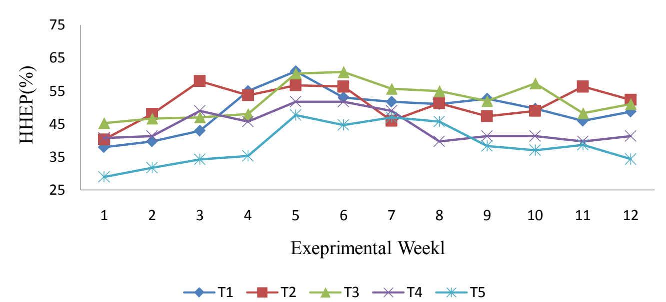

Figure 2: Weekly hen housed egg production (HHEP) in birds fed ration containing processed kidney bean as a replacement for soybean meal.

productivity of the animals used in the present experiment, future work may consider longer period of research.

Egg weight and egg mass

Egg weight and egg mass obtained in all treatments can be categorized as moderate in magnitude (Table 4). Nevertheless, total replacement of SBM with PKB significantly ($P<0.05$) reduced egg weight and egg mass. The differences in egg weight could be an attribute to variation in nutritional composition of the diets due to the nutrient amount in PKB. In accordance with the current result, higher egg weight was obtained in layers fed 18% CP as compared to those fed with 16.5% or 15% CP diet [29,41] , Also reported that egg weight increased by increasing dietary protein. The calcium level is also decreasing from T1 to T5 in the present study, which may also be the reason for variation in egg weight. The variation seen in egg mass was because of differences in HDEP and egg weight, since it is the product of egg weight and HDEP [42]. Reported that egg mass follow the pattern of egg production, which is in line with the current finding. Likewise [43] , reported that hens that consumed diet with low CP produced fewer eggs and as a result, had lower egg mass compared with diets consisting higher CP. Compared to previous finding for the same breed, the present result is close to the overall mean egg weight and egg mass recorded by [15,21].

Feed conversion ratio

The feed conversion ratio (FCR) of layers fed diet containing different levels of PKB was significantly different ($P<0.05$). The FCR of the layers was lower in T5 than the other treatments that have similar FCR values. This agree with the finding of [44] who obtained improved FCE in birds fed raw and dehulled African yam bean meals than those received diet containing SBM alone.

The lowest result of FCR of T5 could be because of high amount of feed consumed and less production of egg and lower egg weight. This shows that the efficiency of PKB replacement for soybean should be up to 75% to avoid a negative effect on egg production nor feed conversion, while 100% replacement cause reduction of both egg production and efficiency of changing the feed to products. Similarly [45] noted variation in FCR and stated that FCR is highly dependent on the number of eggs produced (51%) followed by feed consumption (31%). Likewise, increased nutrient density (energy, amino acids, Ca and available P) linearly improved FCR from 2.12 to 1.91 resulting in a 9.9% improvement in feed conversion [46,47] also reported that increased blood Ca^{++} concentration improved FCR per dozen of eggs (Appendix).

Partial budget analysis

The economic return in terms of partial budget for birds under different treatments is presented in Table 5. Higher profit is generated in the order of T3>T2>T1>T4>T5. The highest net profit generated in T3 is because of high egg production and decrease in feed cost used as a result of low cost of kidney bean compared to SBM. The least benefit was obtained from T5 due to least production in egg and increased feed cost compared to output. Even though, the net return obtained from layer fed T5 diet is positive it was not found economically feasible as compared to layers kept under the rest four treatments. Because as it can be seen from the MRR one unit addition of PKB in the diets decreases the net profit generation by 1.83 units. Therefore, considering this situation and production, PKB can replace the SBM up to 75% without affecting egg production, egg quality, fertility, hatchability and chick quality. On the other hand based on Economic benefit 50%

	Treatments				
Parameters	T1	T2	T3	T4	T5
Feed consumed (kg)	260.8	252.3	268.0	272.3	271.4
Feed cost/treatment (Birr)	2224.62	2013.35	2103.80	2058.59	1764.1
Transport + kidney bean treatment cost	104.3	101.9	151.6	178.00	202.00
Total cost (Birr)	2328.92	2115.25	2255.4	2236.59	1966.10
Egg produced	1472.0	1457.0	1530.0	1327.0	1060
Gross income (Birr)	3675.0	3642.5	3822.5	3317.5	2650
Net income (Birr)	1346.08	1527.24	1569.60	1080.91	683.90
Change in net return	-	181.17	223.52	-265.16	-662.18
Change in total variable cost	-	-213.67	-73.52	-92.34	-362.18
MRR (ratio)	-	-0.84	-3.04	2.87	1.83

MRR: marginal rate of return; PKB=processed kidney bean meal; SBM=soybean meal; T1=0% PKB: 100% SBM; T2=25% PKB; 75% SBM; T3=50%PKBM; 50% SBM; T4=75% PKB; 25% SBM; T5=100% PKB; 0% SBM.

Table 5: Feed consumed, production cost and economic benefit of replacing soybean meal with kidney bean (all costs were presented by Ethiopian Birr).

replacement of SBM by PKB can be recommended.

The current finding is in agreement with different authors findings. For example, up to 50% of dietary soybean meal safely replaced with sorrel seed meal in laying hens without adverse effects on their performance thereby reduced cost of egg production has been noted [48]. Additionally [49] noted that the inclusion of legumes in the diet of layers reduce cost of production and as a result enhanced profitability.

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